Surface water source heat pumps: Code of Practice for the UK

Harnessing energy from the sea, rivers, canals and lakes

CIBSE  HPA  GSHP association

CP2  2015
Surface Water Source Heat Pump – Code of Practice

[Foreword to be added after consultation]

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Part 1 – General

I. Introduction

1.1 Overall purpose

Surface Water Source Heat Pumps (SWSHPs) play an important part of the UK’s future energy strategy. The 2008 *Climate Change Act* established the world’s first legally binding climate change target; the aim is to reduce the UK’s greenhouse gas emissions by at least 80% (from the 1990 baseline) by 2050. Moving to a more energy efficient, low-carbon economy will help to meet this target and ensure the UK becomes less reliant on fossil fuels and consequently less vulnerable to energy price rises.

In the policy paper *The Future of Heating: Meeting the Challenge* (2013) the Government sets out a framework for ensuring there is affordable, secure and low carbon heating which includes the use of SWSHPs.

In November 2014 Amber Rudd MP, Parliamentary Under Secretary of State for Climate Change, announced a package of actions to overcome the barriers to the deployment of SWSHPs. These include:

- working with the Environment Agency (EA) to streamline processes so it is easier to apply for the relevant permissions;
- working with industry to drive up technical standards through a code of practice, and to help those looking to install water source heat pumps navigate the planning and consenting processes; and
- running roadshows and other events to raise awareness of this technology among potential developers.

As part of this package of actions, the Department of Energy and Climate Change (DECC) has produced a Water Source Heat Map (see Appendix E). This map identifies the thermal potential of rivers, estuaries, canals and coastal waters in England and highlights the presence of existing environmental constraints. It is designed to support local authorities, communities and developers in investigating waterbodies with the best heat potential in their areas of interest.

The map has assessed local waterbody conditions, such as annual temperature and flow rates of rivers, estuaries, canals and coastal locations in England. Almost all English rivers and estuaries have been analysed for this project.

DECC sees the map being used as a first point of inquiry, prior to commencing any detailed feasibility studies. Users can zoom into the map to investigate waterbodies with the best heat potential in their areas of interest.
Alongside the Water Source Heat Map, DECC has published a guidance paper *Navigating the Way: A customer journey for potential developers* (see Appendix F). This document is a high level overview of the main stages required to install an open loop SWSHP and is intended to complement this CIBSE Code of Practice.

SWSHPs have the potential to provide heat on a large scale, especially in densely populated urban areas, however there are currently very few large scale SWSHP systems in the UK.

The strategic aims for the deployment of SWSHP system are:

- To reduce CO₂ and other greenhouse gas emissions
- To reduce overall cost of providing heating and/or cooling
- To use natural resources sustainably to reduce or replace consumption of fossil fuels

The Code of Practice is therefore written to:

- improve the quality of feasibility studies, design, construction, commissioning and operation by setting minimum requirements and identifying best practice
- deliver energy efficiency and environmental benefits
- promote long-lasting SWSHPs in which customers and investors can have confidence.

This Code of Practice is written to compliment the CIBSE Heat Networks: Code of Practice for the UK *Raising standards for heat supply 2015*. 
1.2 Who the Code of Practice is for

The Code of Practice is aimed at owners and developers, designers, installers and operators of SWSHP systems; architects and engineers specifying SWSHP systems; and main and sub-contractors involved with installer companies supplying SWSHP systems or designs.

The Code of Practice should also prove useful to regulatory organisations, such as the Environment Agency and for anyone considering a SWSHP installation.

1.3 The structure of the Code of Practice

The Code of Practice is written to cover all stages of the development cycle from Preparation and Briefing through Feasibility, Design, Construction and Installation, Commissioning, Operation and Maintenance and finally Decommissioning.

The Code of Practice is structured by:

- the typical sequence of a project by stage;
- for each project stage a number of objectives are set; and
- for each Objective a number of minimum requirements are defined to achieve the objectives.

All of the minimum requirements will need to be met if the project is to comply with the Code of Practice. It may be used only for a particular stage, but the greatest value will be gained when it is followed for all stages of the project.

The project stages are outlined in the SWSHP Plan of Work (see figure 2) and are colour coded throughout the document.

The Plan of Work also shows the key responsibilities and how these relate to the overarching goals which are set out in the next section.

To ensure the success of a SWSHP project each stage needs to be considered and implemented with an integrated approach. This can be challenging due to the fragmented nature of the industry, for example, it is usual for the feasibility work and detailed design to be carried out by a consultant, although sometimes the detailed design and the construction is by a design and build contractor, with the operation and maintenance contracted out to a separate facilities management or operating company.

The Code of Practice is designed to be prescriptive and minimum requirements are set to achieve minimum acceptable standards. Best practice has been identified for a number of objectives and should be considered.

Each stage of the project will have complied with the Code of Practice when it has been demonstrated that all minimum requirements have been met.
Surface Water Source Heat Pump (SWSHP) Plan of Work

Goals

A. To deliver low environmental impact from abstraction and discharge
B. To deliver a high performance system with a high coefficient of performance
C. To achieve optimum flow and return temperatures
D. To deliver a practical and compliant system which effectively uses engineering solutions to overcome barriers
E. To deliver a reliable system with a long life and low maintenance requirements
F. To deliver effective metering and monitoring of the SWSHP
G. To deliver a safe, high quality scheme where risks are managed

Strategic aims:
To reduce CO₂ and other greenhouse gas emissions
To reduce the overall cost of providing heating and/or cooling
To use natural resources sustainably to reduce or replace consumption of fossil fuels

Stages
1. Preparation and brief
2. Feasibility
3. Design
4. Construction
5. Commissioning
6. Operation + maintenance
7. Decommissioning

Responsibilities

Developer/owner
Designer
Constructor
Operator

Figure 2 – Typical Plan of Work for a SWSHP project (diagram reproduced courtesy of Phil Jones)
1.4 Goals

The principal ways in which the high level aims are achieved is through a number of overarching Goals which need to be considered at each stage of the project.

A. **To deliver low environmental impact from abstraction and discharge**

Although the overarching aim of a SWSHP system is to benefit the global environment and help move to a more energy efficient, low-carbon economy, the impact on the local environment needs to be carefully managed. The Environment Agency and other regulatory bodies set requirements which must be followed to ensure the risk of any negative impact from abstraction and discharge is mitigated. The intake and return design should be based on the given flow and load requirements for the development and also comply with the requirements set by the relevant regulatory body.

B. **To deliver a system with high efficiency**

To ensure the SWSHP system as energy efficient as possible the distribution temperatures should be as low as possible in heating and as high as possible in cooling. In addition great care shall be taken to ensure that all parasitic energy loads especially such as circulating pumps, are minimised.

C. **To achieve optimum flow and return temperatures.**

SWSHP systems work most efficiently when the temperature difference or $\Delta T$ between the source and sink (flow) temperature is smallest. Therefore if installing in an existing building, insulation and draft proofing will probably need to be updated. Existing distribution equipment emitters may also need to be modified to work effectively with the new temperatures.

D. **To deliver a practical and compliant system which effectively uses engineering solutions to overcome barriers**

The barriers to the installation of a SWSHP system frequently include physical obstacles which must be overcome. For example pumping distances between the source and sink or wildlife which must be protected. In the majority of cases, an engineering solution can overcome these barriers and examples can be found throughout the Code of Practice.

E. **To deliver a reliable system with a long life and low maintenance requirements**

SWSHP systems can be specified to have a long life and require little maintenance. To ensure this is achieved, the source side needs to be carefully designed to ensure filtration systems work with minimum human intervention.
F. To deliver effective metering/monitoring of the SWSHP

Instrumentation such as flow, temperature and pressure sensors and associated monitoring
hardware and software is invaluable to monitoring and recording the performance of the
installation. It can appear high cost at the design and development stage, however it is
frequently found to be cost effective since it enables any issues with the installation to be
quickly and effectively identified and rectified. In addition, an abstraction licence or discharge
permit will require monitoring or measurement and reported to the relevant regulatory body.

G. To deliver a safe, high quality scheme where risks are managed

At all stages of the scheme safety, quality and risk need to be addressed and the adoption of
national and international standards is recommended:

- ISO 9001 for quality management
- ISO 14001 for environmental management
- ISO 18001 for occupational safety
- ISO 31000 for risk management
- BSI PAS 55

1.5 Responsibilities

A typical project involves several parties who need to work together. The responsibilities of the
organisations shall be made clear for each stage of the project. The Code of Practice should be
adopted by all involved in the project and not a contractual requirement on just one party.

Each project will be different but the following table describes the typical responsibilities that may be
carried out by each organisation:

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central and Local Government</td>
<td>Central government sets overall policy, develops appropriate incentive mechanisms and works to remove barriers</td>
</tr>
<tr>
<td></td>
<td>Local government promotes the strategic vision and develops and implements supporting policies at a local level including planning approval and the enforcement of building regulations</td>
</tr>
<tr>
<td>Environment Agency, Natural Resources Wales, Scottish Environmental Protection Agency, Northern Ireland Environment Agency and statutory bodies</td>
<td>The Environment Agency is responsible for:</td>
</tr>
<tr>
<td></td>
<td>- water quality and resources;</td>
</tr>
<tr>
<td></td>
<td>- fisheries;</td>
</tr>
<tr>
<td></td>
<td>- flood and coastal risk management;</td>
</tr>
<tr>
<td></td>
<td>- conservation and ecology;</td>
</tr>
<tr>
<td>Environment Agency, Natural Resources Wales, Scottish Environmental Protection Agency, Northern Ireland Environment Agency and statutory bodies</td>
<td>The Environment Agency is responsible for:</td>
</tr>
<tr>
<td></td>
<td>- water quality and resources;</td>
</tr>
<tr>
<td></td>
<td>- fisheries;</td>
</tr>
<tr>
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<td>- flood and coastal risk management;</td>
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<tr>
<td>Environment Agency, Natural Resources Wales, Scottish Environmental Protection Agency, Northern Ireland Environment Agency and statutory bodies</td>
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<td></td>
<td>- water quality and resources;</td>
</tr>
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<td></td>
<td>- fisheries;</td>
</tr>
<tr>
<td></td>
<td>- flood and coastal risk management;</td>
</tr>
<tr>
<td></td>
<td>- conservation and ecology;</td>
</tr>
</tbody>
</table>
- Some inland river, estuary and harbour navigations; and
- regulating the activities that may impact on these responsibilities, including the installation of SWSP

NRW, SEPA and NIEA have similar responsibilities for Wales, Scotland and Northern Ireland respectively. For statutory bodies that may need to be consulted, see Appendix C

<table>
<thead>
<tr>
<th>Owner / Developer</th>
<th>Arranges finance and prepares project brief</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Appoints:</td>
</tr>
<tr>
<td></td>
<td>- Feasibility study consultant</td>
</tr>
<tr>
<td></td>
<td>- Project team including</td>
</tr>
<tr>
<td></td>
<td>- Project Manager</td>
</tr>
<tr>
<td></td>
<td>- Planning and legal advisor</td>
</tr>
<tr>
<td></td>
<td>- Principal Designer</td>
</tr>
<tr>
<td></td>
<td>- Designer</td>
</tr>
<tr>
<td></td>
<td>- Construction specialist</td>
</tr>
<tr>
<td></td>
<td>- Maintenance contractor</td>
</tr>
</tbody>
</table>

Ensures the SWHP is commissioned correctly and is operated in accordance with recommendations (or instruct their facilities manager to do so)

<table>
<thead>
<tr>
<th>Feasibility study consultant</th>
<th>The feasibility study consultant carries out a clear and accurate feasibility study in line with Code of Practice and other relevant standards and guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project manager</td>
<td>The project manager is responsible for overall coordination and delivery of the project and ensures that the project team works together effectively</td>
</tr>
<tr>
<td>Principal Designer</td>
<td>Advises and assists the client and project team with their responsibilities under health and safety legislation</td>
</tr>
<tr>
<td>Designer</td>
<td>The designer prepares the detailed design of the heat pump and source side installation</td>
</tr>
<tr>
<td>Planning and legal advisor</td>
<td>Advises on planning and regulatory compliance and applies for consents and permits as necessary. Commissions environmental reports. Negotiates with adjoining land owners and other parties for access to water source where required</td>
</tr>
<tr>
<td>Construction contractor</td>
<td>Is responsible for the construction of the SWHP systems using specialist suppliers and subcontractors as required. Specialist activities may include:</td>
</tr>
<tr>
<td></td>
<td>- Heat pumps</td>
</tr>
</tbody>
</table>

DRAFT
<table>
<thead>
<tr>
<th>Role</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commissioning specialist</td>
<td>The commissioning specialist develops commissioning procedures and a commissioning plan to ensure the design intent is realised</td>
</tr>
<tr>
<td>Operator and maintenance contractor</td>
<td>Maintains plant room and equipment in accordance with planned maintenance schedules and operates the system in accordance with the design. Operator training and specialist maintenance may be sub-contracted to the SWSHP supplier</td>
</tr>
</tbody>
</table>
II. Scope

This Code of Practice sets out how a task should be undertaken. It is not intended to provide installation guidance or to set standards. It does not consider how a heat pump works in any detail but focuses on the use of surface water as a thermal resource and other issues which may have a direct effect on this application. It does not cover water held in aquifers, mines, caverns etc. i.e. ground water.

The Code of Practice is intended to be used for larger projects however smaller scale jobs, for example a single domestic dwelling, will also benefit.

Surface Water Source Heat pumps

When heating, surface water source heat pumps (SWSHPs) operate by extracting low grade heat from a body of water and upgrade it to a useful temperature for use in local heat networks or single buildings providing a low-carbon source of renewable heat. SWSHPs can also be used for cooling by absorbing heat from a building or other similar load and transferring it into the water body.

In the Code of Practice the surface water body is referred to as the source and the building or other use as the load.
Types of Heat Pump

The scope of the Code of Practice does not assess the advantages and disadvantages of the different types of heat pump but some understanding is necessary even at feasibility study stage to ensure a machine with the correct functions and performance parameters are selected.

The following table shows the various types of heat pump and where they may or may not be used:

<table>
<thead>
<tr>
<th>Heat Pump Type</th>
<th>Typical Application</th>
<th>Not Suitable for</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Temperature Heat Pump (&lt;52°C @-7 °C ambient)</td>
<td>Space heating with low temperature heat emitters</td>
<td>Domestic (Sanitary) Hot Water</td>
</tr>
<tr>
<td>High Temperature Heat Pump (&gt;65°C @-7 °C ambient) e.g. Cascade dual refrigerant; Vapour Injection Gas Absorption</td>
<td>Space Heating with ordinary or high temperature heat emitters and Domestic (sanitary) Hot Water</td>
<td>Low temperature space heating applications without DHW</td>
</tr>
<tr>
<td>Gas Absorption (e.g. lithium bromide/water)</td>
<td>High temperature; Ground source</td>
<td>Reverse cycle(heating &amp; cooling) ground source</td>
</tr>
<tr>
<td>Gas Adsorption (e.g. Zeolite)</td>
<td>Higher temperature applications N.B. technology not fully developed</td>
<td>High efficiency applications</td>
</tr>
</tbody>
</table>

Most Heat Pumps found in SWSHP applications use a vapour compression cycle where the compressor is driven by a motor, usually an electric motor. Heat pumps using a ‘Sorption process (Absorption or Adsorption) are becoming increasingly common. Although ‘Sorption heat pumps at first appear significantly less efficient than electric vapour compression units this is not always the case when the total primary energy required to generate electricity is taken into account. They can also be applied to higher delivery temperature applications.

‘Sorption heat pumps use heat as a primary motive energy this can be in the form of gas fired or recovered heat.

There are two types:

*Adsorption* transfers heat by using the changing temperature/vapour pressure relationship between two chemicals that do not chemically combine (e.g. water/zeolite).

*Absorption* transfers heat by using the changing temperature/vapour pressure relationship between two chemicals which can chemically combine and be separated again (e.g. lithium bromide/ water or ammonia/water).

Vapour compression cycle heat pumps vary primarily by using different refrigerants or combinations of refrigerants which perform differently according to the temperature range they work within. Recent climate change legislation has resulted in many changes to the refrigerants available but suitable alternatives are gradually evolving. There are also some “add on” devices which may be used to enhance or modify performance e.g. desuperheaters & hot gas injection.
The following table refers to the simple notations used to aid understanding within the heat pump community. Please note: Brine, i.e. a salt solution, although rarely used, remains the common notation for all low temperature (<5°C) thermal transfer fluids whatever their chemistry. Alternative notation used for ‘brine’: \( W_{\text{af}} \); \( W_{(<5^\circ\text{C})} \).

<table>
<thead>
<tr>
<th>Notation</th>
<th>Heat Source</th>
<th>Delivery Medium</th>
</tr>
</thead>
<tbody>
<tr>
<td>A/W</td>
<td>Air</td>
<td>Water</td>
</tr>
<tr>
<td>W/W</td>
<td>Water</td>
<td>Water</td>
</tr>
<tr>
<td>B/W</td>
<td>Brine</td>
<td>Water</td>
</tr>
</tbody>
</table>

**Heat Networks**

Heat Pumps are frequently used with Heat Networks. These may be either load side where conditioned water is distributed for use at the supply temperature or source side where the water is distributed through the network at source temperature and converted to a useable temperature by a heat pump local to the point of use.

![Figure 5a: SWSHP on a source side loop (reverse return)](attachment://figure5a.png)
Temperature varies according to temperature (approximately 3 °C to 25 °C in summer)

Heating/cooling demand 1

Heating/cooling demand 2

Heating/cooling demand 3

Figure 5a: SWSHP on a source side loop (direct return)

~35°C up to 90°C

Water source

~30 °C up to 80 °C

Electricity source

Heat pump

Note:
Heat pumps in heating mode deliver the best coefficient of performance when the delta T between source and load temperatures are minimised. Low temperature systems e.g. underfloor heating, encourage these lower delta Ts.

Temperatures up to 90 °C can be achieved for retrofit projects supplying say existing district heating network. This is normally achieved using alternative refrigerants e.g. ammonia, but this can sometimes reduce efficiency.

Heating/cooling demand 1

Heating/cooling demand 2

Heating/cooling demand 3

Figure 6a: SWSHP on a load side loop (district heating network) - direct return
Heat pump terminology

Closed loop systems are commonly used in ground source heat pumps where they collect or reject heat via an intermediate heat transfer fluid circulated through a buried heat exchanger remote from the heat pump. Similarly a suitable heat exchanger may also be immersed in a body of water for use in SWSHP systems.

Open loop systems remove water from the source and pass it through a heat exchanger inside, or very close to, a heat pump so the unit exchanges heat with water directly. Open loops are used for both surface and ground water installations.
The Code of Practice addresses both open loop and closed loop heat pumps that use bodies of surface water as a heat source or heat sink. It is written for open loop, surface water systems and highlights information specifically for closed loop systems at the end of each objective. Information on evaluating the best option for a particular site is addressed at Stage 2 Feasibility (see objective 2.2).

Sink or load side

The Code of Practice primarily looks at the source side of a SWSHP installation, it doesn’t address air or hydronic distribution systems on the load side since whatever heat generator is to be installed the load side will use broadly the same design, construction and maintenance procedures.

However sensible hydronic design is a crucial component of the overall system performance and heat pumps have some particular characteristics which if observed can increase efficiency as well as give other benefits:

- The closer the source and sink temperatures the more efficiently the heat pump will operate. Thus low temperature heating and high temperature cooling equipment should be specified and heat delivered at the lowest viable temperature.
- Different refrigerants can be used to tune the heat pump to a particular application
- Heat pump evaporators and condensers frequently have flow, pressure and temperature constraints / parameters which must be observed for optimum efficiency
- Pressure drops must be designed to be as low as possible to reduce the energy required to drive the pumps. This parasitic pumping load can compromise the performance of the entire installation (60kPa is a realistic target pressure drop across a closed loop source side circuit)
- Short cycling is best avoided and so units are often limited to 3 or 4 starts per hour so the hydronic arrangements will need to allow for this possibly with buffering or thermal energy storage
- Underfloor Heating is sometimes considered an essential component of a Heat pump installation however other types of heat emitter may be used e.g. an Air Handling Unit heating the air. The key is to operate effectively with a low temperature water supply.

Heating Strategy

Given the design load expected to be satisfied by the heat pump the design should include consideration of thermal mass, internal and solar heat gains as appropriate. As with all heating (and cooling) installations the peak power is important to ensure that sufficient heating is available to keep the premises warm on the coldest day.

If the heat pump is sized to fully cover the entire peak heat load itself this would be a monovalent system but alternatively the heat pump may be sized to provide only the base load when additional heat generators are used to satisfy the peaks. This would be a bi- or multi-valent system (see Objective 2.4).
In addition to peak power, accurate annual energy demand profile information is critical in designing a vertical or horizontal ground heat exchanger as the ground needs time to recharge. However SWSHPs are more forgiving. If an open loop system is adopted, the design can be more flexible as more heat is available by increasing the flow rate or flow duration through the evaporator. Closed loop SWSHPs are also more flexible than ground source being limited by the size, depth, flow and other characteristics of the surface water body.

It is recommended the annual energy demand profile is calculated for the load as well as peak power as without it the feasibility study and its recommendations may not identify the best solution.

In Open Loop systems Source water temperatures below 3 or 4°C can cause freezing in the evaporator so any design will need to allow for this.

A Closed Loop heat exchanger normally contains a Thermal Transfer Fluid (TTF). This is a mixture of biocides, corrosion inhibitors and an antifreeze agent. The antifreeze component ensures that the TTF continues to circulate at lower water temperatures.

In some systems the immersed heat exchanger may contain the primary refrigerant when it acts directly as the evaporator. These are called Direct Exchange (DX) systems and are unusual in the UK largely because of the high risk of damage or corrosion leading to leakage of the refrigerant.
III. Legislation

This section outlines the legislation that is likely to impact on a SWSHP project. It is not intended to be comprehensive nor in sufficient detail to test compliance. It is essential readers consult the latest regulations.

It should be noted that some regulations are devolved to the administrations of Scotland, Wales and Northern Ireland and there are important differences.

Health and Safety Legislation

Although the Health and Safety at Work Act is fundamental, the Construction Design Management Regulations (CDM) shall govern all stages from design through to operation. The Control of Substances Hazardous to Health (COSHH) Regulations 2002 and the Dangerous Substances and Explosive Atmospheres Regulations (DSEAR) 2002 may apply. During the operating phase the control of legionella risk is an important consideration and the HSE Code of Practice L8 (HSE, 2013) shall be followed. The EU Fluorinated Greenhouse Gas (F gas) Regulation and The Pressure Equipment Directive shall be considered.

Planning legislation

The installation of a SWSHP is usually considered to be permitted development and does not need an application for planning permission. Installing a SWSHP in the grounds of a non-domestic building, the total surface area covered by the installation (including any pipes) must not exceed 0.5 hectares (Town and Country Planning Act 1990, amendment 2012)

The Town and Country Planning (Environmental Impact Assessment) Regulations 2011 can apply even when the project is considered permitted development. These regulations apply the EU directive on the assessment of the effects of certain public and private projects on the environment (usually referred to as the Environmental Impact Assessment Directive) to the planning system in England.

For coastal developments, a Coastal Concordat has been developed in England to provide a framework within which the processes for the various consents, permissions and licences can be better coordinated with a single point of entry when several bodies have a regulatory function.

Planning permission may be required for temporary works for storage of materials and other construction purposes. Permissions will be needed from any land and riparian rights owner in addition to planning permission, for example the Canal and River Trust or Crown Estates

Planning approval may impose other construction conditions, for example dealing with removal of waste, storage of materials, dust and noise nuisance. There may be a requirement to comply with the Considerate Contractors scheme.
Environmental Regulations

Environmental Permit and Abstraction Licence

The Environment Agency is responsible for issuing Environmental Permits and Abstraction Licences in England. For most installations, a groundwater or surface water point source discharge activity environmental permit shall be required under the Environmental Permitting (England and Wales) Regulations 2010.

An abstraction licence from the Environment Agency will be needed if you want to abstract water from a surface or underground source. To abstract more than 20 cubic metres of water per day for a period of more than 28 days a Full Abstraction Licence is required. All abstraction licences are given a time limit which will be determined by the Environment Agency during consideration and approval of an application. A standard licence period is six to 18 years, the renewal period is for 12 years. The licence period may be lengthened to 24 years if further criteria are met as set out in the Environment Agency guidance notes on Part B8 New ground source or surface water source heating and cooling scheme.

Permission to do work on or near a watercourse

The Water Act 2014 (previously the Water Resources Act 1991 and associated byelaws) requires you to apply for permission from the Environment Agency or relevant statutory body for works in, over, under or adjacent to rivers.

Salmon and Freshwater Fisheries Act 1975

The Salmon and Freshwater Fisheries Act 1975 (SAFFA) is legislation aimed at the protection of freshwater fish, with a particularly strong focus on salmon and trout. There are many activities that could constitute an offence under SAFFA including direct mortality, barriers to migration and degradation of habitats.

The Eels Regulations 2009

The Eels (England and Wales) Regulations 2009 afford new powers to the Environment Agency to implement measures for the recovery of European eel stocks and have important implications for operators of abstractions and discharges.

Conservation of Habitats and Species Regulations 2010

The Conservation of Habitats and Species Regulations 2010 transpose the obligations of the EU Habitats Directive in England and Wales. It requires any plan or project which is likely to have a
significant effect on a site with a special nature conservation order, either individually or in combination with other plans or projects, is subject to an appropriate assessment.

**EU Water Framework Directive (WFD)**

Much of the work in managing and protecting rivers, lakes, coastal waters and other water bodies is governed by the EU’s Water Framework Directive (WFD). The Environment Agency is responsible for monitoring and reporting on the objectives of the Water Framework Directive (WFD) on behalf of government in England, SEPA for Scotland, NRW for Wales and NIEA for Northern Ireland. SWSHP schemes must not prevent achievement of Water Framework targets and objectives, maintaining river temperatures within the relevant temperature boundaries for the water body set out in UK TAG guidance.

It is recommended to consult the relevant environment agency at the early stages of the project to determine the specific characteristics of the proposed water body and any potential challenges to obtaining the relevant permits and licences. The environment agencies will also assess potential cumulative effects if other SWSHP are operating in close proximity.

**Building Regulations**

Part L (2013) of the Building Regulations deals with the conservation of fuel and power in domestic and commercial buildings. The legislation covers new-build and refurbishment projects. Under Part L, compliance for dwellings is calculated using the Standard Assessment Procedure (SAP) taking into account Target Fabric Energy Efficiency (TFEE). The TFEE standards are not applied to non-dwellings but include the Target Emission Rate (TER).

In addition to Part L 2013, section 9 of the Government’s Domestic Building Services Compliance Guide deals extensively with heat pumps. The guide covers ground source, water source and air source heat pumps.

**EU and Government Schemes and Incentives**

*Renewable Heat Incentive and Feed-in-tariffs*

The Renewable Heat Incentive (RHI) is a UK Government scheme set up to encourage uptake of renewable heat technologies amongst householders, communities and businesses through financial incentives and includes SWSHP systems. Ofgem has published guidance setting out the eligibility criteria and how to apply [see appendix D].

*Energy Technology List (ETL)*

The Energy Technology List (ETL) is a register of products that may be eligible for 100% tax relief under the Enhanced Capital Allowance (ECA) scheme for energy saving technologies. The Carbon Trust manages the list and promotes the ECA scheme on behalf of government. Water source (internal water loop only) split and multi-split systems including variable refrigerant flow (VRF) are eligible under the scheme.
Green Deal and Energy Company Obligation (ECO)

Heat pumps are agreed measures under the Green Deal, a financial mechanism to eliminate the need to pay upfront for energy efficiency measures and instead provides reassurances that the cost of the measures should be covered by savings on the electricity bill. ECO places legal obligations on the larger energy suppliers to deliver energy efficiency measures to domestic energy users and operates alongside the Green Deal.

Carbon Reduction Commitment (CRC) Energy Efficiency Scheme

The CRC Energy Efficiency Scheme (or CRC Scheme) is designed to incentivise energy efficiency and cut emissions in large energy users in the public and private sectors across the UK. Under the CRC Scheme large national energy users are required to report on their energy use and make a payment that is related to the carbon emissions associated with the energy used. The scheme treats heat supply from a SWSHP as zero carbon emissions which potentially provides a useful but small benefit to the scheme. Local Authorities and universities will be within the remit of the CRC.

EU Emissions Trading System (EUETS)

If the Energy Centre has more than 20MW thermal input, then it will need to be included within the EUETS. This will require payments based on the fuel used however there are free allocations for heat pump systems. An opt-out provision was set by DECC’s legislation for small emitters and hospitals in the UK for the Phase 3 of the EUETS.

Heat Network delivery support

DECC has established up a Heat Network Delivery Unit (HNDU) to provide grant funding and guidance to local authorities in England and Wales to support local authorities exploring heat network opportunities.
IV. Applications – Challenges and Opportunities

SWSHP systems are not a new technology for the UK. In 1943 the offices of Norwich Electricity Department were heated by a two-stage SO$_2$ compressor, taking heat from the River Wensum. Today, there are many examples of water source heat pump systems in use in the UK and abroad. We include some examples below and a number of case studies in appendix H.

Challenges and Opportunities for the different surface water sources

The Code of Practice considers all surface water sources: Sea, Estuary, River, Canal and Lake which can be used to provide heating and/or cooling. These resources have different characteristics which must be addressed within the design process and will influence the final installation and how it operates. The table below outlines the characteristics of each of the surface water sources:

<table>
<thead>
<tr>
<th>Source</th>
<th>Specific characteristics</th>
<th>Examples</th>
</tr>
</thead>
</table>
| Sea    | • Relatively constant source temperatures  
        • Saline  
        • Stratification  
        • Fish and other marine life including, molluscs, shellfish and crustaceans  
        • Storms and tidal  
        • Detritus, such as plastic bags  | Portsmouth Harbour, UK RNLI |
| Estuary | • Temperature modified by river temperatures  
         • Brackish  
         • Riparian activities can be an issue effecting submerged pipework  
         • Fish and other marine life including, molluscs, shellfish and crustaceans  
         • Tidal  
         • Detritus, such as plastic bags  | Plas Newydd, Anglesey |
| River  | • Temperature dependent on flow, insolation, water source, such as melt water, groundwater etc.  
       • Fish and other marine life including, molluscs, shellfish and crustaceans  
       • Potential for flooding  
       • Riparian activities can be an issue effecting submerged pipework  
       • Detritus, such as plastic bags, shopping trolleys etc.  
       • In urban areas, greater potential for vandalism  | Kingston Heights, London |
| Canal  | • Very slow water movement with temperatures range from 2°C to 25°C across the year  
       • Sludge and accretions  
       • Fish and other marine life including, molluscs, shellfish and crustaceans  | GlaxoSmithKline, London |
The following examples demonstrate how the different surface water sources can be used in SWSHP systems:

**Sea**

**Portsmouth Harbour** is a SWSHP installation which provides heating and cooling to a recently constructed passenger terminal building. It is one of the first seawater based SWSHPs installed in the UK. It uses water from within the adjacent dock as the primary heat source and rejection sink. A prefabricated dockside unit handles the seawater extraction/rejection/filtration and transfers heat to a closed loop that runs from the dockside to the heat pumps in the first floor plant room.
RNLI uses small scale SWSHP for a growing number of its lifeboat stations. Different techniques are used to match the individual requirements of the building and location. The SWSHP installations include a horizontal slinky installed under the shoreline mud in Lancashire (below left) and a “nest” of pipes installed within a caisson (below right); both are refreshed daily by the tide.

Open loop installations use sea water directly and innovative engineering solutions are employed to simplify design, improve reliability and reduce energy consumption. These systems are now being prefabricated and standardised where possible to reduce costs, improve quality and speed installation. They utilise the syphonic effect to significantly reduce the pumping energy required.

The RNLI also use heat pumps in all their Tamar class Lifeboats. Taking heat from the surrounding sea.

**Estuary**

For a SWSHP system using an estuary as a source, changes in water levels, either tidal or seasonal, need to be considered. Usually heat pumps will be located above water level. However a National Trust property, Plas Newydd in Anglesey, installed a shore line pump house containing heat exchangers, pumps and strainers which was designed to be submersible and equipped with a snorkel.
**River**

**Kingston Heights** in London is an example of using river as the water source. Thames water at an average temperature of 10°C is extracted, filtered and pumped to a plate heat exchanger transferring energy to a closed loop mechanical distribution system. This water / glycol mixture is fed to 39 heat pumps with a total capacity of 774kW. Each of these heat pumps feed a number of heat pump boilers with interconnecting refrigerant pipework.

**Canal**

**GlaxoSmithKline HQ, London** is an example of using a canal to provide datacentre cooling. Water is abstracted from the canalised River Brent where it forms part of the Grand Union Canal and pumped into an open loop system passing through a coarse filter and then a heat exchanger. The warmer water is returned via a cascade to the canal/river. On the other side of the heat exchangers is a closed loop feeding a water cooled chiller. This is a typical method by which heat is dissipated in canals.
Lake

King's Mill Hospital in Mansfield is an example of a SWSHP providing heating and cooling using a reservoir. The system comprises of 140 geo-plates placed within the reservoir arranged in seven groups of twenty coupled to a fleet of 42 heat pumps. The system has been designed to supply 5400kW of cooling and up to 5000kW of heating.

Challenges and opportunities of the different applications

SWSHPs can provide heating and/or cooling at a range of scales; from feeding into a heat network that provides heat for an entire town or providing heat to a single dwelling. The table below outlines the characteristics of each of the applications:

<table>
<thead>
<tr>
<th>Application</th>
<th>Specific characteristics</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat Network</td>
<td>• Usually large scale&lt;br&gt;• Can be used as part of multivalent system&lt;br&gt;• If monovalent requires body of water with reliable recharge&lt;br&gt;• Hot water is distributed for use at the supply temperature (30°C to 90°C)&lt;br&gt;• Can be heating and/or cooling</td>
<td>Drammen, Norway</td>
</tr>
<tr>
<td>Source-side Network</td>
<td>• Can be used as part of multivalent system&lt;br&gt;• If monovalent requires body of water with reliable recharge&lt;br&gt;• Water is distributed through the network at source temperature (2°C to 25°C) and converted to a useable temperature by a heat pump local to the point of use</td>
<td>Vassa, Finland</td>
</tr>
<tr>
<td>Multivalent</td>
<td>• Two or more heat generators are used, for example, a gas CHP generator, heat pump and electric resistance heater combination</td>
<td>Vårtan Ropsten, Sweden</td>
</tr>
<tr>
<td>Retrofit</td>
<td>• SWSHP systems usually work best at low distribution temperatures therefore if installing in an existing building, insulation and draft proofing need to be updated and the</td>
<td>Horsham, West Sussex</td>
</tr>
</tbody>
</table>
The following examples demonstrate how the different examples can be used to provide heating and/or cooling for a selection of applications:

**Heat Networks**

The installation in **Drammen, Norway**, a community of 63,000 people and its businesses, is an example of a SWSHP feeding into a heat network. With an installed capacity of 13.2 MW the SWSHP generates enough heat to cover more than 75% of Drammen's annual heat demand. The network requires hot water generation at temperatures of 90°C to allow retrofit to the existing district Heating Network. The heat pump operates at high efficiency, averaging a seasonal CoP of 3.05.

![Awaiting diagram/s](image)

When deep water is used as a resource by a SWSHP **Stratification** needs to be considered. Water has its highest density at approximately 4°C which can mean that in the winter, water at the bottom can be at a higher temperature than the top. This stratification depends on the local conditions, and will vary throughout the year which makes it difficult to predict without a comprehensive survey. In Drammen the water inlet is located at approximately 40m where in Winter the temperature is xx°C and in Summer xx°C, due to cold melt water entering the Fjord.

**Source side network**

**Vaasa** in Finland is an example of a source side network where the thermal transfer fluid is distributed to the individual properties. Special collector pipes have been inserted using horizontal directional drilling into the sediment just below the sea bed. This technique proved much easier and less costly to install than the alternatives and avoids any risk of damage from anchors etc. The individual heat pumps vary in size from 9 kW to 22 kW. The total power available is 400kW. The system supplies approximately 1.2GWh of energy per anum.
Multivalent

Värtan Ropsten in Stockholm, Sweden is an example of a large scale SWSHP system. Six sea water based heat pump units (total 420 MW) were commissioned between 1984 and 1986 and are used for base load production. This is an example of a multivalent system with the use of bio fuel-fired plants (total 200 MW) and oil-fired plants only in times of high energy demand.

Retrofit installations

A large country estate near Horsham, West Sussex is an example of a retrofit installation replacing the oil and LPG heating with a lake system design which offers a combined output of 90kW of heat. This is another example of a source side network with five separate buildings connected to the heating network by over 1000 metres of underground pipe.

The heat pumps use the low grade heat energy from the estate's own lake, with collector pipe laid on the lake bed and circulating an environmentally friendly thermal transfer fluid through the pipes into a
central manifold. It has been operational for two years and consistently achieves a CoP of above 4 which exceeded predicted savings.

Challenges and Opportunities: Open Loop and Closed Loop

SWSHPs can be either closed loop or open loop systems (see II. Scope). The table below outlines the characteristics of open loop, closed loop and mixed technologies:

<table>
<thead>
<tr>
<th>Type</th>
<th>Specific characteristics</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open Loop</td>
<td>• Flexible i.e. abstraction rates can be modified to match demand</td>
<td>GlaxoSmithKline, London</td>
</tr>
<tr>
<td></td>
<td>• Adaptable i.e. can be installed in most surface water locations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Requires filtration and anti-corrosion measures</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Requires abstraction licence and discharge permit from relevant regulatory body</td>
<td></td>
</tr>
<tr>
<td>Closed Loop</td>
<td>• Low maintenance</td>
<td>Stanwick Lakes, Northamptonshire</td>
</tr>
<tr>
<td></td>
<td>• Requires thermal transfer fluid and so works at lower temperatures</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Less stringent regulations for permissions</td>
<td></td>
</tr>
<tr>
<td>Mixed</td>
<td>• Used to overcome barriers such as energy required for pumping, costs</td>
<td>Plas Newydd, Anglesey</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Näsby Parks Castle</td>
</tr>
</tbody>
</table>

The following examples demonstrate the various challenges and opportunities for both closed and open loop systems and how mixed technologies can be used to overcome barriers:

Open Loop

For open loop systems, mitigating the risk to wildlife around the abstraction and discharge ports is of upmost importance. For Kingston Heights in London the intake and return design was based on the given flow and load requirements for the development and the requirements of the various departments of the Environment Agency.
Operational experiences are valuable when assessing the requirements for SWSHP applications. Bio-
fouling can be a serious issue in open loop systems, which is a further consideration in terms of 
secondary filtration and heat exchanger design and performance selection. Intakes from low or no flow 
water bodies require suitably designed self-cleaning screens and where the intake is required to be 
concealed within the river or canal wall this needs to be considered similarly to a low/no flow 
environment.

Stainless steel intake assemblies, with pipe and defender sections above the water level, can be 
attractive to thieves. This is especially a risk in canal intake situations where wading is possible. Secure 
fixing and safe locations can address this.

Non-metallic intake pipe-work has benefits regarding attractive value and non-corrosive, but potentially 
vulnerable to accidental or deliberate damage. Alternatives or suitable defence structures are valuable.

Instrumentation such as flow, temperature and pressure sensors and associated monitoring hardware 
and software can appear high cost at the design and development stage. In fact they are invaluable at 
the commissioning, optimisation and seasonal operation monitoring stages – i.e. a cost to be 
considered an investment in the future

| Closed Loop |

**Stanwick Lakes** is an example of a simple closed loop system using the lake as the water source. 
Situated in the Nene Valley in Northamptonshire it acts as focal point for both conservation and 
education. The eco-friendly Visitors Centre has a floor area of 675M2 with a 50kW heat pump driving 
Underfloor Heating. It uses four submersible rafts with six 25m coils of 32mm SDR11 HDPE per raft.
Mixed technologies

There can be perceived barriers to the installation of a WSHP system, for example pumping distance and the altitude of the building requiring the heat. In the majority of cases, an engineering solution can overcome these barriers and in the case of the National Trust property Plas Newydd in Anglesey the same novel open/closed loop approach system was used as in Portsmouth Harbour.

Notes:
1. Stables Building at 30 m above sea level contains heat pump
2. Connected by 127 m of 2x160 mm HDPE pipes carrying thermal transfer fluid to the shoreline pump house
3. Shoreline pump house contains heat exchangers, pumps and strainers
4. 57 m of 2x200 HDPE pipes carries sea water to the pump house
5. Intake with 200 mm strainer and discharge point

Näsby Parks Castle near Stockholm, Sweden is an example of an interesting blend of two technologies. An open loop abstracting water from a nearby lake is twinned with a vertical borehole installation. The Lake water is pumped around the boreholes in summer to recharge the boreholes depleted during the heating season. This enabled the bore field to be reduced from 80 to 48 boreholes thus reducing the capital cost significantly and increasing operating efficiency. Payback was achieved in 3 years.
Stage 1: Preparation and Briefing

Objectives:

1.1 To commission the Project in accordance with the Code of Practice
1.2 To develop the specification/project brief
This is an example of how the Plan of Work will be used at the beginning of each stage, it will include the responsibilities and goals as in the full diagram.

Key Support Tasks:
- Review feedback from previous projects
- Pre-application discussions with statutory and regulatory bodies
- Research opportunities for collaboration
- Agree schedule of services, design responsibility matrix and information exchanges and prepare project delivery plan including technology and communication strategies and consideration of common standards to be used

Information Exchange:
- Strategic Brief
- Project Specification
- Initial Project Brief
Objective 1.1 – To implement the project in accordance with the Code of Practice

Why is this objective important?

The Owner/Developer may be an individual or organisation, they will ultimately be responsible for the installation and should therefore take the lead in executing this Code of Practice. They will wish to procure surface water source heat pump system that works effectively, is reliable and cost-effective. The Owner/Developer will need to ensure compliance with all relevant legislation and any conditions imposed by other stakeholder organisations e.g. the local planning authority or the Environment Agency.

Minimum Requirements

1.1.1 The Owner/Developer shall ensure that this Code of Practice is included as a key requirement in briefs and specifications for the delivery of:
- Feasibility studies
- Design services
- Construction contracts
- Commissioning contracts
- Operation and Maintenance contracts

1.1.2 The Owner/Developer or identified representative shall:
- monitor implementation of the Code of Practice on a regular basis and at the end of each stage of the project
- monitor the compliance of the project against the minimum requirements
- obtain evidence that the minimum requirements has been met

1.1.3 The Owner/Developer shall ensure all those working on the project conduct a formal and effective handover process between each stage

1.1.4 The Owner/Developer shall provide feedback to CIBSE on the operation of the Code of Practice to ensure the Code of Practice can be progressively improved

1.1.5 The Owner/Developer shall check that suitably qualified and experienced people are employed on the project appropriate to each stage

1.1.6 The Owner/Developer shall provide designers with clear responsibilities using the guidance in the Building Services Research and Information Association (BSRIA) Design Framework where appropriate
Best Practice

In the future a system of accreditation will be developed for individuals or companies with the capability, systems and expertise. Best practice will be to appoint an independent accredited individual to carry out an audit of the project to check and certify the requirements in the Code of Practice have been met and an audit report produced.
Objective 1.2 – To develop the specification/project brief

Why is this objective important?

A project brief shall be prepared by the owner/developer. The priority will be to determine the steps to assess the viability of the proposed SWSHP scheme. The brief shall be used to focus project planning activity, assess the marketplace and identify suitable specialists required to deliver the project.

Minimum Requirements

1.2.1 A suitable surface water heat source shall be identified. It should be within reasonable distance of the site to minimise extra energy consumed by pumping

1.2.2 Where appropriate, the interactive water source heat map produced by DECC shall be used to identify the specific characteristics of the water body, such as annual temperature and flow rates and if there are any environmental sensitives which may constrain development

1.2.3 The sustainability aspirations for the building shall be identified, confirmed and used to inform the brief

1.2.4 The possibility of collaboration to create a heating/cooling energy loop and/or heat network shall be explored

1.2.5 The projected heat (or cooling) load of the proposed development shall be estimated

1.2.6 The likelihood of further phases or other development nearby which could utilise the same

1.2.7 The calculation shall be in sufficient detail (peak load, hourly annual heat load etc.) to assess the best heat source(s)

1.2.8 The sources of data to be used to calculate the cost and carbon savings of different heating options shall be identified

1.2.9 The eligibility for the Renewable Heat Incentive (RHI), the Enhanced Capital Allowance (ECA) scheme or other government incentives shall be determined
Stage 2: Feasibility

Objectives:

2.1 To accurately estimate peak and seasonal heating and cooling demands and profiles

2.2 To identify and quantify the most suitable surface water sources and the best method for energy exchange

2.3 To determine what permissions are necessary to access the water and what implications this may have.

2.4 To determine the requirement for monovalent or multivalent operation and note influencing or determining factors

2.5 To agree suitable load-side flow and return operating temperatures, flow rates and control strategies

2.6 To determine heat pump location and source-side heat exchanger or inlet and outfall details (including costs estimates)

2.7 To assess environmental impacts and benefits

2.8 To assess operation and maintenance needs and costs

2.9 To conduct a financial analysis in order to comprehensively evaluate the installation options

2.10 To analyse risks and carry out a sensitivity analysis
Key Support Tasks:
- Further pre-application discussions with statutory and regulatory bodies
- Prepare risk assessments
- Undertake third party consultations as required and any research and development aspects
- Develop:
  - Sustainability strategy
  - Maintenance and operational strategy
  - Construction strategy
  - Health and safety strategy

Information Exchange:
- Feasibility Study
  - Concept design including outline structural and building services design
  - associated project strategies
  - preliminary cost information
- Final project brief
- All notes, actions and outcomes
Objective 2.1 – To accurately estimate peak and seasonal heating and cooling profiles and demands

Why is this objective important?

An accurate estimate of both the peak power requirement and annual heating and cooling demand, together with the consumption profile is important to ensure feasibility studies are useful.

For existing buildings the estimates will mainly rely on heat loss calculations based on the fabric and ventilation and take into account thermal mass, internal and solar heat gains as appropriate. These can be further informed by actual fuel use, meters, local meteorological data and any other relevant site specific information.

This data must then be revised to take account of all practical energy efficiency measures and any heat recovery reuse opportunities to develop a strategy which avoids unnecessary investment while still delivering a safe comfortable indoor environment.

For new buildings, a modelling approach will be needed. It is important that this reflects the expected operation of the building as it will be used, in the location where it is to be built. This may differ significantly from modelling needed to show compliance with the Part L of the Building Regulations.

Minimum Requirements

2.1.1 For existing buildings, heat and cooling demands shall be estimated on a monthly basis using actual fuel used from meter readings wherever available and an assessment of existing equipment efficiencies, taking account of any potential for cost-effective investments in energy efficiency, or by use of benchmarks. Peak loads can be established using a heat loss calculation method based on BS EN 12831 and these peak loads can be used to confirm equipment size requirements.

2.1.2 The data shall be analysed to separately estimate the heat demand for space heating, domestic hot water, any other heat demands such as industrial processes and any system losses within the building.

2.1.3 The space heating element shall be adjusted by means of degree days or other method to provide a monthly heat demand profile for an average year using an appropriate baseline temperature for the building concerned (although it is important that in any later analysis the sensitivity of this profile is tested for extremes).
2.1.4 Where possible, an understanding of the daily, weekly and annual occupancy pattern of each building shall be established to inform the design and any need for thermal storage together with any future expected changes which may have an impact.

2.1.5 For existing buildings the peak demands shall be estimated from a combination of a knowledge of the installed heat source capacity and how these heat sources are operated in practice, benchmarks using floor areas and age of the building, or from half hourly gas meter readings if available and supplemented by modelling using CIBSE TM54 (CIBSE, 2013). Benchmarks for peak and annual heat demand estimates based on floor areas which can be used in feasibility studies are given in the following references:

- CIBSE TM46: 2008 Energy benchmarks (for existing buildings)
- CIBSE Guide F: Energy Efficiency in Buildings (for existing buildings)

2.1.6 Future heat demands for building or system extensions shall be estimated in a similar way and where appropriate a sensitivity analysis carried out to show the impact on the design.

2.1.7 Large Commercial facilities shall be modelled by development of a Dynamic Simulation Model (DSM) or other approved software and for use within the SWSHP system design.

2.1.8 The Government’s Standard Assessment Procedure for the Energy Rating of Dwellings (SAP) is a commonly used annual energy assessment tool. However, this does not provide the monthly or peak load information. If SAP is used to provide annual kWh for a simplified system then a further calculation shall be carried out in order to ascertain the peak load for equipment and heat exchanger sizing. SAP can be used to size heat pumps provided that it is adjusted for the local CIBSE external references temperature.

2.1.9 Simplified Building Energy Model (SBEM) is also commonly used to ascertain an annual energy assessment and is able to provide monthly kWh. However, SBEM does not provide peak load data. As such, if SBEM is used for monthly data for a complex system providing the entire heating and cooling load then a further calculation shall be carried out in order to ascertain the peak load for equipment and ground heat exchanger sizing.

**Best Practice**

Best Practice could be to obtain hourly or half-hourly fuel use data from meters throughout the year where this is available or to install monitoring equipment to establish the demands more accurately.
Best Practice could also include the use of operational data from other similar sites to generate a heat demand profile. From this data an annual heat load duration curve can be produced.

Best Practice could be to take account of local climates such as the heat island effect in large cities when assessing space heating demands and the lower demand for hot water that may be seen in summer (due to higher cold water feed temperatures and lower temperatures used for showers).

Best practice could also dynamically model the building using hourly bin data rather than a monthly based static degree day data model and look to take into account potential future building occupancy profiles.

**Cooling** also requires an estimate of demand which for existing older buildings is often hard to establish as cooling was rarely measured directly and electricity use for chillers is also not usually metered separately. For new buildings dynamic simulation modelling can be used to provide the cooling demand profiles.
Objective 2.2 – To identify and quantify the most suitable surface water source and the best method of energy exchange

Why is this objective important?

In the planning and briefing stage the potential for a surface water source heat pump will have been identified. The characteristics of the proposed body of water will inform the practicality of using a SWSHP and the choice between open and closed loop systems.

All projects should start from a good engineering practice perspective and then, where necessary modified to accommodate other determining factors or limiting conditions e.g. flood risk, access, price, noise or security considerations etc.

The diagram below identifies the mechanisms which influence the transfer of heat into and out of a body of surface water. These all need to be evaluated when identifying and quantifying the most suitable surface water sources.

Minimum Requirements

2.2.1 The DECC surface water source heat map shall be used in the feasibility study to research the specific characteristics of the water body, for example, annual temperature profile, flow rates and any environmental sensitives which may need consideration

2.2.2 Any other available maps, plans, satellite imagery and Geographic Information System (GIS) data shall also be used to evaluate the site
2.2.3 The surface water source shall be fully investigated, measured and reported in the feasibility study. Important considerations are:

- is it static or flowing and if flowing, was its origin groundwater or run off
- how deep is it
- what is the turnover rate, for example how frequently is the water replaced
- is it stratified and can this be used to an advantage
- is there any other form of recharge, for example solar gain - is it in full sunlight or shaded or is it downstream of a power-station, factory or sewage works which may modify the temperature profile

2.2.4 The energy potential of the open water source shall be calculated to establish if and how it can best be utilised. Rules of thumb should only be used with great care in the feasibility study and the calculations must be shown

2.2.5 Accurate building heat demand information shall be used to calculate:

- the annual water volume required by an open loop heat pump to satisfy the load
- the size of closed loop heat exchanger required to satisfy the load

2.2.6 An options appraisal for the use of open loop and closed loop shall be carried out on the basis of engineering practicality. This should include: flood risk, likelihood of accidental damage, for example, from passing water craft or vandalism. Short and long term environmental effects, potential visual and thermal impact and pollution risk, for example the risk of escape of thermal transfer fluid shall be taken into account in the options appraisal

2.2.7 An options appraisal for the use of open loop and closed loop shall be carried out on the basis of operational efficiency and whole life costs and reported in the feasibility report

2.2.8 An options appraisal for the heat pump type shall be carried out on the basis of operational requirements, efficiency and compatibility with the identified surface water source and reported in the feasibility report

**Best Practice**

Best practice could be to calculate the energy potential of the source water using computer simulation and this model extended to provide a clear performance comparison between open and closed loop at this location, see appendix I.

Best practice could be to compare open loop and closed loop on the basis of operational efficiency, contributions to CO2 reductions and whole life costs taking account of future trends in energy prices and electricity decarbonisation
Example

Oklahoma State University has developed design tools to accurately size surface water heat exchangers (see appendix I). The SWSHP pond model simulates a pond or lake of any size with submerged hydronic tubes or flat plates through which the heat transfer fluid is circulated. The model considers the effects of stratification as observed in deeper lakes and calculates the ice and snow thickness formed at the pond/lake surface.

The model can be simulated with four different types of heat exchanger coils such as spiral helical coils, flat spiral coils, vertical or horizontal slinky coils and flat plate heat exchangers (SlimJim®). The model also considers the effect of heat transfer due to the ice formation on the heat exchanger coils.
Objective 2.3 - To determine what permissions are necessary to access the water and what implications this may have

Why is this objective important?

When a surface water is proposed as a heat source or sink for a SWSHP system a range of permissions will be required. These can vary from site to site and need to be carefully investigated and noted as an oversight can cause delay and disruption which can be very costly. In England, many are within the remit of the Environment Agency, for example abstraction licence and environmental permit for a water discharge activity, and they should be approached as early in the project as possible (see below for requirements for Wales, Scotland and Northern Ireland)

Minimum Requirements

2.3.1 The Water Source Heat Map produced by DECC shall be used to identify if the proposed location is sensitive to known environmental issues which may constrain the development

2.3.2 For most installations in England, an environmental permit for the discharge activity shall be required from the Environment Agency

2.3.3 For a single domestic property the Environment Agency regulatory position statement GEHO0810BSYD-E-E shall be used to identify if a discharge permit is required. If the SWSHP system complies with the criteria of the position statement, a discharge permit shall not be required. For other small installations which comply with specific criteria, the Environment Agency may issue a Standard Rules discharge permit

2.3.4 To abstract more than 20 cubic metres of water per day a full abstraction licence is required. Pre-application discussions for an abstraction licence and an environmental permit for a water discharge activity shall be held with the Environment Agency

2.3.5 All abstraction licences are given a time limit, a standard licence period is six to 18 years, the renewal period is for 12 years. The licence period may be lengthened to 24 years if further criteria are met set out in the Environment Agency guidance notes on Part B8 New ground source or surface water source heating and cooling scheme. The decision to lengthen the licence period shall be assessed and reported in the feasibility study

2.3.6 Permissions shall be sought from land owners, port authorities and navigation authorities and riparian rights owners to access the water source and can form part of the pre-application discussions with the Environment Agency
2.3.7 Consultation with the Environment Agency and other relevant statutory bodies shall be carried out for works in, over, under or adjacent to rivers to assess the need for permissions in line with the Water Act 2014 (previously the Water Resources Act 1991 and associated byelaws).

2.3.8 The installation of a SWSHP may be considered permitted development and may not need an application for planning permission. Early consultation needs to be undertaken with the local planning authority to establish if planning permission is required, including the requirement of permissions for temporary works for storage of materials and other construction purposes where necessary.

2.3.9 The Town and Country Planning (Environmental Impact Assessment) Regulations 2011 can apply even when the project is considered permitted development. Early consultation with the local planning authority needs to be undertaken to establish requirements.

2.3.10 Nearby interest groups and users of the water body, such as boating clubs, angling and fishing clubs/associations and river trusts, shall be identified and initial discussions shall be held to assess potential concerns about the scheme and any issues which may constrain development.

2.3.11 The costs of permissions shall be determined. There will be application charges for any licences and environmental permits required. There will also be annual subsistence charges for the time the licence and permit are live. There may also be charges for pre-application advice. The details of these fees can be obtained from the Environment Agency and other regulatory bodies.

The approach to abstraction licensing in England is subject to review by the Government under its Abstraction Reform programme and, when implemented, this may affect the rights and conditions granted by existing licences (for more information refer to the Environment Agency website, see appendix C).

**Best Practice**

Best Practice could be to assign an individual as the point of contact for the Environment Agency and other relevant statutory bodies for all stages of the project.
Closed loop systems

Neither an abstraction licence nor a bespoke discharge activity environmental permit are required for a closed loop system. However consultation with the Environment Agency and other relevant statutory bodies shall be carried out to identify what permissions or registration is required, for example in terms of flood risk. If failure of a closed loop system results in the release of potentially harmful chemicals to a water body this may lead to enforcement action against the system operator/owner by the relevant regulatory body.

Permissions required for Wales, Scotland and Northern Ireland (where different from above)
**Objective 2.4 – To determine the requirement for monovalent or multivalent operation and note influencing or determining factors**

**Why is this objective important?**

There are times when it may be appropriate to use more than one heat generator in an installation. This could be for a variety of reasons, for example, thermal capacity of heat source or sink, plant room space, limits to electricity supply, capital costs and operational efficiency objectives. While generally it is important to keep an installation simple the financial and operational advantages of a multivalent system can be considerable and need to be assessed.

**Options:**

With a **monovalent** system, the SWSHP is specified to cover 100% of the thermal energy demand at all times. Carefully sized buffer volumes are required to avoid cycling in part load scenarios and to mitigate against peak loads where the instantaneous power requirements are in excess of the heat pump instantaneous output.

With a **bivalent** system, the heat pump is designed to be undersized and is paired with a second heat/coolth generator to supplement output when demand is high. A valency point, the ambient temperature at which the load on the primary heat generator exceeds its output, is set and when it is reached it triggers either:

- **Parallel operation** when both heat generators operate at the same time, or
- **Alternate operation** when the heat pump is replaced entirely by a second heat/coolth generator capable of delivering 100% of the peak load.

**Parallel operation** is possible where there is only a requirement for additional heating or cooling capacity at load side temperatures that the heat pump is capable of delivering. In this case the heat pump remains in circuit at all times, with the secondary generator brought into operation when the demand side load exceeds the capacity of the heat pump. The sizes of the heat pump and secondary generator can be varied at will – as long as the total capacity of the two systems meets the worst day loads. Careful design, usually employing low loss headers or four or more pipe buffer stores is required to blend the different flow and return temperatures from the different heat sources
Alternate operation is used in situations where, as the ambient temperature moves towards extremes, the heat pump is no longer capable of delivering load side temperatures that will satisfy the required comfort levels in the building. The heat pump is then dropped out of circuit, and the alternate source is brought into operation to cover the total heating or cooling demand, at the required load side temperatures. This method of operation is typically employed in retrofit situations where, under some ambient conditions, the building thermal envelope and/or the heating/cooling emitters require the use of load side temperatures that are outside the range of the heat pump. Alternate operation is also sometimes referred to as series operation.
**Monoenergetic** is the description given to bivalent installations where only one energy source is used for two or more heat generators. For example, a heat pump supplemented by a direct electric resistance heater is a monoenergetic (electric) system (this is commonly found in domestic heat pumps).

With a **multivalent** system two or more heat generators are used, for example, a gas CHP generator, heat pump and electric resistance heater combination.

For larger non-domestic systems, it is not uncommon to find a heat pump installation supplemented with a gas boiler and and/or an air source chiller to provide supplementary peaking capacity.

**Minimum Requirements**

2.4.1 The type of installation shall be determined. The most straightforward technical solution will be monovalent heat pump installation capable of meeting the peak heating and/or cooling loads at the required emitter temperatures.

2.4.2 The decision to employ a bivalent solution shall be assessed in line with a number of factors:

- **Physical limitations:**
  - Physical size of heat pump(s) relative to desired plant room size
  - Size of electrical supply
  - Thermal capacity of the available water source
  - Ability of the selected heat pumps to meet the worst day load side emitter temperatures

- **Other design /cost considerations:**
  - If the heating /cooling load profiles are “peaky”, it may be considered economically attractive to provide supplementary sources to meet the peaking loads. This supplementary source might be an Air Source Heat Pump or some form of combustion technology.
  - If the heat pump system is delivering heating and cooling, then it may be economically attractive to meet the lower of the heating / cooling peak loads with a heat pump, and to supplement the other peak load with an alternative source.
  - Requirements around plant redundancy, standby/back-up requirements for mission critical applications.

2.4.3 For bivalent systems that are capable of meeting the heating/cooling loads using parallel operation, the annual load profiles of the building shall be established and a decision made as to the split of size between the heat pump and the supplementary source(s). The basis for a
decision shall take into account any or all of: capital costs, running costs, plant physical sizes, and carbon emissions

2.4.4 For bivalent systems that need to be run in alternative mode, the heat pump shall be sized to meet the maximum loads that can be achieved at heat pump emitter temperatures. The alternative source(s) shall be sized to meet the worst day design loads.

2.4.5 The physical limitations referred to above, shall be taken into account in determining the size of the heat pump(s) versus supplementary heating/cooling sources.

2.4.6 Suitable attention shall be given to the way that bivalent systems will be controlled.

Best Practice

For larger systems, best practice could be the use of building/plant simulation systems coupled to an appropriate local climate data. These models allow investigation of the optimal split of the bivalent plant based around considerations of capex, running costs and carbon emissions.

Best practice could be to use a Building Energy Management System (BEMS) to accurately control the operation of the system.
Objective 2.5 – To agree suitable load-side flow and return operating temperatures, flow rates and control strategies

Why is this objective important?

Operating temperatures are a key aspect of the design process and will influence both the capital and operating costs as well as the system heat losses. They are key determinants of the impact of the installation on the open water source, the efficiency of the SWSHP and the volume of any thermal storage. Whilst there will be opportunity to refine and optimise the design later, the feasibility study must be based on clearly stated assumptions which comply with any legal or other requirements and are practical and achievable. The same assumptions should be used for all calculations used to produce the cost and performance data at the feasibility stage.

Minimum Requirements

2.5.1 The most suitable operating temperatures for the SWSHP shall be identified, taking account of how efficiencies will vary with operating temperatures and any limits imposed by the owners or other relevant statutory body

2.5.2 For a retrofit project, the temperatures used by the existing heating system shall be obtained and any potential for reducing the return temperature identified. It is important to note that the temperature difference across a modern condensing boiler can be up to 20°c whilst the temperature difference across the condenser in a SWSHP will typically be around 5°c

2.5.3 At the feasibility stage, it can be assumed where improvements have been made to an existing building after the original installation, the heat emitter circuits can be rebalanced to achieve lower return temperatures

2.5.4 The potential to reduce the flow temperature as demand falls (weather compensation) shall be analysed to reduce heat losses under part load conditions. It will take account of pumping energy, impact on return temperatures and heat pump coefficient of performance (CoP)

2.5.5 The temperature difference that occurs at any hydronic separation (i.e. at a heat exchanger) shall be taken into account in defining operating temperatures

2.5.6 Careful consideration shall be given to minimising any health risks from scalding and legionella growth which could occur in the secondary hot water system. Alternative methods of legionella control may be used to permit the use of lower temperatures, see Appendix D for standards and guidance.
Best Practice

Best Practice approach could be to carry out a specific temperature optimisation study taking account of all impacts to derive lifecycle costs and environmental performance for a range of temperatures.

Best Practice could seek to achieve the lowest feasible return temperatures and consider more complex ‘cascade’ systems where the return temperature from a space heating circuit is used to pre-heat cold feed to a centralised Domestic Hot Water Service (DHWS), for example in a building such as a hotel or leisure centre. In some cases lower flow temperatures may be advantageous alongside low input temperature heating devices e.g. Air Handling Units (AHUs), Underfloor Heating (UFH) etc.

Operating Temperatures for Cooling

Cooling systems are more constrained in operating temperatures than heating as they have to operate between a minimum flow temperature close to 0°C and a return temperature below the typical space temperature of 20°C. Recently some high temperature cooling devices have entered the market but until they become common place typical temperatures of 6°C flow and 12°C return will remain the norm. The use of chilled beams is favourable for cooling as a higher return temperature is possible. The possibility of supplying chilled beams from the return from air handling units in a cascade manner would also be beneficial for District Cooling.
Objective 2.6 – To determine heat pump location and water inlet and outfall (or closed loop heat exchanger) details, including cost estimates

Why is this objective important?

The location of the heat pump in relation to the load and surface water source, and the positioning and design of inlet and outfall ports or submerged closed loop heat exchangers, are critical decisions. It is recommended to always start from a good engineering perspective and where necessary, modify this to accommodate other determining factors or limiting conditions, for example flood risk, access, cost, noise or security considerations.

In most cases, a SWSHP will cost more to install but less to maintain and operate than conventional gas or oil systems therefore a whole life cost comparison is essential. Care must be taken to ensure that a specification is agreed in advance to facilitate direct cost comparison. It may or may not be appropriate to take into account issues such as embodied energy, carbon dioxide emission penalties or direct or indirect government support.
Minimum Requirements

2.6.1 The route and distance of any pipelines between the heat pump, the heat load and source shall be measured. The costs shall be estimated and feasibility of transporting the heat shall be established taking into account any parasitic energy consumption, for example pumping.

2.6.2 Where possible the greater distance shall be from the source to the heat pump, either directly or via a heat-exchanger and closed loop, to achieve less heat loss and potentially heat gain. Such an approach will compliment both open and closed loop systems. This will also have lower installation costs due to little or no requirement for insulation.

2.6.3 The feasibility of an open loop system shall be established taking into account all engineering, practical, environmental, space, access and ownership issues.

2.6.4 The most suitable method of abstracting and discharging water shall be identified and the location of the abstraction and discharge ports established, taking into account any limits or other conditions which may be required for environmental permits or licences (see objective 2.3).

2.6.5 The location of abstraction and discharge ports and the level of force of the water discharged shall take into account environmental, navigation and other considerations, such as fish migration routes and spawning areas.

2.6.6 The practicality of the location shall be assessed to ensure safe access for maintenance requirements.

A key element of system design is the difference in temperature between surface water entering the heat exchanger and leaving it ($\Delta T$). For the purpose of feasibility studies a $\Delta T$ of 3K is a reasonable starting point and a number of successful installations have been so based. However the $\Delta T$ permissible in any specific location will vary with the size, temperature and use of the body of water and must be discussed in detail with the Environment Agency or other regulatory body in view of local conditions, protection of sites and species and pressures from other developments.

Best Practice

Best practice could be to model several options to accurately determine the most energy efficient operational arrangement to further inform the decision. Even if the knowledge of daily demand profiles is limited, this type of modelling will be more accurate and is often required to establish how a scheme will operate in practice, particularly where there are a range of heat sources and thermal storage.
Closed loop systems

A closed loop heat exchanger is an assembly which is submerged in the water body. This needs careful design and planning as there are a number of alternatives which will affect both cost and efficiency. The chosen system shall depend on a number of factors including the quality of the water, the nature and use of the water body. Maintenance requirements and the route and protection of the header pipework shall be assessed.
Objective 2.7 – To assess environmental impacts and benefits

Why is this objective important?

The environmental impacts on a global or macro level may need to be assessed for larger projects or if otherwise required. The impact and benefits to the local environment, for example works in, over, under or adjacent to the body of water are set out in Objective 2.3 To determine what permissions are necessary to access the water and what implications this may have.

Minimum Requirements

2.7.1 CO₂ emission calculations shall be based on published emission factors and realistic projected efficiencies. The Department of Energy and Climate Change (DECC) updates projections of energy demand, supply and greenhouse gas (GHG) emissions annually (for more information refer to the DECC website, see Appendix C).

2.7.2 For new build schemes, emission factors used in Part L of the Building Regulations shall be used for consistency with compliance calculations. For existing buildings alternative emission factors may be used where these are more appropriate for example, those published by Defra or those used in the CRC scheme

2.7.3 Heat losses and the carbon intensity of the electricity used to run the heat pump shall be taken into account in the CO₂ emissions calculations

2.7.4 Where appropriate, a Life Cycle Assessment (LCA) shall be carried out in line with ISO 14044 to measure and evaluate the environmental impacts associated with a product, system or activity, by assessing the energy and materials used and released to the environment over the product’s life cycle

Best Practice

Best practice could be to use the Inventory of Carbon and Energy published by BSRIA, CEN TC350 Standards or other relevant tools to calculate the embodied and operational environmental impacts of construction products across the entire lifecycle.

Best practice could be to extend the environmental impact assessment to formally address and record these issues.
Objective 2.8 – To assess operation and maintenance needs and costs

Why is this objective important?

At the feasibility stage, operation and maintenance needs and costs should be assessed and included in the financial model. It is useful to split these into capital, fixed and variable. The main variable operating cost will be for electricity, however estimates need to be made for non-energy operating costs, for example pump maintenance and filter cleaning and replacement. Plant replacement cycles should also be costed and included. The income will from RHI Scheme or equivalent and any heat sold.

Minimum Requirements

2.8.1 An operational model shall be set-up for use in the financial analysis from which operating costs and revenues (if any) can be determined

2.8.2 A long term repair/replacement strategy shall be developed to ensure that the true long term costs are assessed

2.8.3 The cost of parasitic electricity consumption shall be included as well as any estimated overhead and maintenance costs for the SWSHP installation and directly related plant

2.8.4 New Rules of Measurement (NRM) shall be used. NRM provides a standard set of measurement rules and essential guidance for the cost management of construction projects and maintenance works

2.8.5 The operation and maintenance needs shall be assess for the intake screen type and capacity. As outlined in case studies for Kingston and GSK Brentford; there are submersible, self-cleaning screens for a wide range of duties and filtration down to 1.5 mm. These remove the requirement for operational attendance and also reduce required planned preventive maintenance to typically once per three to five years

2.8.6 The operation and maintenance needs shall be assessed for the intake screen location and orientation to ensure all seasonal conditions are taken into account, for example high and low water levels, flows and suspended solids, and easy accessibility for maintenance without the requirement for sub surface (diving) works. Defender structure shall also be considered to prevent damage from navigation etc.

2.8.7 The operation and maintenance needs shall be assessed for the intake pump(s) location and orientation. Ideally the intake pumps shall be located in a plant room above water level, for
ease of access. Typically, pumps for this duty, have a maximum negative suction lift of 5 metres through the intake screen and up to the pump. Where the suction lift is greater than the available pump suction lift submersible pumps may also be appropriate

2.8.8 For operation, maintenance, durability and security, the location of instrumentation and valves, secondary filtration, heat exchangers and secondary circuit pump location shall be assessed with a secured plant room nominally in the vicinity of the intake/water source

Best Practice

Best Practice could be to base costs on data obtained from actual operating schemes where full details of the scheme are available to ensure it is of a similar type.
Objective 2.9 – To conduct a financial analysis in order to comprehensively evaluate the installation options

Why is this objective important?

At the feasibility stage financial analysis is required to research the costs and benefits of the various options. Capital cost, operating cost, whole life cost including disposal costs and internal rate of return on the investment need to be investigated. Care must be taken to ensure that the same parameters are used to ensure the alternatives developed are directly comparable.

Minimum Requirements

2.9.1 The factors to be included in the feasibility study shall be agreed in advance with the Owner/Developer. The parameters and variables chosen shall be sufficiently comprehensive to deliver useful results but be proportionate to the project scale.

2.9.2 All analysis shall be conducted in accordance with accepted accountancy principals and cover an agreed period, typically 50 years for heat pump projects unless the projected life of the building is considerably less. Capital equipment replacement costs estimates and timescales shall be included in any calculation.

2.9.3 The cashflow model shall use a discount rate related to the owners cost of capital. Energy prices shall be obtained either from existing customer’s contract prices, market indices such as Heren, the quarterly prices as published by DECC, or equivalent and projected forward for both cost and carbon content.

2.9.4 The Internal Rate of Return (IRR) and Net Present Value (NPV) shall be calculated initially for a base case assuming current energy prices remain constant for the analysis period in real terms and a sensitivity analysis used to determine a range of outcomes depending on future carbon content and energy price trajectories.

2.9.5 Where there are viable retrofit energy efficiency measures, the cost must be noted and the expected performance improvement included in the analysis.

2.9.6 The costing in the feasibility study shall be based on realistic estimates to ensure sufficient funding is allocated. An appropriate contingency fund shall be allocated and clearly identified to cover unforeseen costs.
2.9.7 To assess the economic benefit of the scheme for retrofit installations, the comparative costs will be determined against the total heating costs (fuel, maintenance and capital replacement) the customer would have incurred over the same period if they had retained the existing equipment. In the case of new developments, the comparison will be between the predominant form of conventional heating used for similar developments at the time of the study (e.g. gas boilers)

**Best Practice**

Best Practice could include the creation of a detailed profit and loss account (P&L) and balance sheet and a simplified indexed P&L and balance sheet for the duration of the scheme.
Objective 2.10 – To analyse risks and carry out a sensitivity analysis

Why is this objective important?

At the feasibility stage it is important to assess the risks of the project. A risk register should be developed and then reviewed and updated throughout the project. A sensitivity analysis should also be carried out to quantify the impact of the identified risks. The risk register and sensitivity analysis will be used to aid the decision to take the project to the next stage. An example risk register can be found in Appendix G.

Minimum Requirements

2.10.1 A risk register shall be developed using the following categories:

- Health and Safety
- Environment
- Construction costs
- Construction delays (including impact of phasing of new developments)
- Performance of plant and equipment
- Broader economic risks, including future energy prices, regulation
- Planning and other permissions.
- Reputational risk

2.10.2 The risk analysis shall examine the likelihood and severity of each risk, who the risk will impact and what mitigating actions are required. The likelihood and severity of each risk shall be re-scored assuming the proposed mitigation measures are in place.

2.10.3 The mitigation measures shall be assigned to the relevant party to take forward.

2.10.4 A sensitivity analysis shall be carried out to show the impact of each major financial risk (both Capex and Opex risks) and test the mitigation approach.

Best Practice

Best Practice could be to carry out a risk analysis workshop to identify and analyse the potential risks to the project. Best Practice could be to carry out more detailed studies of particular risk mitigation measures to ensure the project moves into the next stage with a lower risk profile.
Stage 3: Design

Objectives:

3.1 To design for safety in construction, operation and maintenance
3.2 To accurately determine peak heating and cooling demands and seasonal energy consumption profiles
3.3 To design an efficient load-side hydronic system interface
3.4 To design a reliable installation with a long life and low maintenance requirements
3.5 To design a data collection systems to accurately record performance
3.6 To update and refine risk register and sensitivity analysis
3.7 To prepare a costs statement for the main system elements of the project
3.8 To evaluate environmental impacts and benefits
3.9 To apply for the permissions necessary to access the water
Objective 3.1 – To design for safety in construction, operation and maintenance

Why is this objective important?

Minimum Requirements

Best Practice

Objective 3.2 – To accurately determine peak heating and cooling demands and seasonal energy consumption profiles

Key Support Tasks:

- Update risk assessments
- Undertake third party consultations as required and any research and development aspects
- Review and update:
  - Sustainability strategy
  - Maintenance and operational strategy
  - Construction strategy
  - Health and safety strategy
- Review and update project delivery plan, including change control procedures.
- Prepare and submit building regulations applications, if applicable
- Prepare and submit applications to Environment Agency (once final design has been adopted)

Information exchange

- Developed design, including building services design and updated cost information
Objective 3.1 – To design for safety in construction, operation and maintenance

Why is this objective important?

Reducing health and safety risks is of primary importance to any project. The designer must first carry out a risk assessment and then mitigate these risks by making appropriate design decisions and assess how the proposed design will be constructed, operated and maintained.

As bodies of surface water are generally easily accessible the health and safety of the public must be a priority at all times.

Minimum Requirements

3.1.1 The owner/developer shall recognise their role and obligations under the CDM Regulations and register the project prior to the start of the design process

3.1.2 The principal designer shall carry out the requirements under the CDM Regulations and develop a designer’s risk assessment at an early stage

3.1.3 The requirements of the COSHH and DSEAR Regulations shall be taken into account in developing the design

3.1.4 The designer shall mitigate risks in construction, operation, maintenance and decommissioning as far as possible and provide a risk register for use during construction

3.1.5 The design shall provide sufficient access around plant and equipment in the plant room to enable safe maintenance to be carried out including access/egress and handling of equipment/parts associated with any repair/replacement works

3.1.6 The design shall locate valve chambers and other facilities requiring access (including surveillance system monitoring terminals) in a suitable location so that safe operation and maintenance can be carried out

3.1.7 Trench depths shall be minimised as far as possible to reduce the risks to operatives.

3.1.8 The design shall mitigate the risks of legionella and follow the HSE code of practice *Legionnaires’ disease: The control of legionella bacteria in water systems 2013*

3.1.9 Adequate access and other provisions shall be made to enable safe replacement of plant in the future. A plant replacement strategy report shall be produced during the design stage
**Best Practice**

Best practice could be the appointed design company be certified under ISO 9001: 2008 Quality Management System or operate in accordance with an equivalent quality assurance scheme.

Best practice could be to develop the design so the operator can achieve ISO 14001 and ISO 18001 certification.
Objective 3.2 – To accurately determine peak heating and cooling demands and seasonal energy consumption profiles

Why is this objective important?

At the design stage the values used for peak heat demand will determine the capacity of the SWSHP and any multivalent heating sources, the capacity of the heat emitters and ancillaries and this will therefore determine much of the capital cost. The annual heat consumption and daily demand profiles will determine the energy consumption of the SWSHP and important elements of the operational cost.

For new buildings the heat demand estimates should be produced by the appointed building services designer although the SWSHP designer may have valuable advice to offer based on previous experience. It is vital that a consensus is reached at this stage to avoid the potential for significantly oversizing or undersizing of the SWSHP unit.

For existing non-domestic buildings it will normally be the responsibility of the customer to define the peak heat demand that they wish to contract for and to provide an estimate of their annual heat energy consumption. However this analysis should be with the close involvement of the SWSHP designer/operator who may be able to draw on experience of supplying similar buildings.

It is noted that performing heat loss calculations can be as much about art as it is about science. The designer has to design for worst case scenarios and has to make judgement calls as to whether the fabric is constructed to the U-value as specified in the original design and whether the ventilation rate accurately reflects the buildings in-use reality. The designer can cover this by talking to the builders and end users to evaluate the accuracy of the data. This is particularly important when sizing a heat pump which unlike most combustion boilers, should be neither under or over-sized but rather sized to the buildings requirements. More has been written about this subject by the Zero Carbon Hub through the Performance Gap reports and project (see appendix D).

Minimum Requirements

3.2.1 Peak demands for existing buildings shall be assessed by the customer from a combination of data on fuel use (accounting for system efficiency), existing heat source use, and building simulation modelling or other calculation of heat losses as appropriate. This assessment should be supported by the heat pump system designer who may be able to use data from monitoring demands at similar buildings to assist

3.2.2 For existing non-domestic buildings, space heating consumption in each month shall be estimated by the customer, in conjunction with the heat pump designer, from fuel or heat meter readings together with a degree day analysis to produce heat consumptions for each month for an average year taking account of the location of the building, the required internal space temperature and an appropriate baseline temperature for the building
3.2.3 For existing dwellings, calculations shall be carried out by the building owner/developer (e.g. local authority or housing association) using established calculation methodologies and these calculations shall be agreed with the heat pump system designer. For private dwellings the heat pump system designer shall carry out the calculations.

3.2.4 For new non-domestic buildings heat demands shall be estimated using modelling software and by using the guidance in CIBSE Guide F and TM46, other sources of benchmark data or data obtained from similar operational schemes.

3.2.5 For new dwellings, heat demands shall be estimated using standard design calculation methodologies based on the proposed fabric and ventilation standards. DHW can be sized using BS EN 806 and BS 8558.

3.2.6 For dwellings, the space heating consumption shall be profiled using degree days or IES annual weather files to obtain monthly consumptions and a 24 hour variation in demand created for heating and hot water demand.

**Best Practice**

Best practice could be, if time permits and it is appropriate, to determine peak demands by monitoring the heat currently supplied to the building or its fuel use, under external design conditions using existing or temporary meters and recording data at hourly or half-hourly intervals. It is now more common to find half-hourly gas meters and if available this data should be used to help produce a heat profile for a typical year for use in the operating model and to determine peak demands.

Best practice could be to use a full year’s data and include monitoring of external air temperature so the data can be normalised. The installation of new meters or setting up logging of data using a BMS should be considered at an early stage in the project.

Dynamic modelling using climate data rather than static modelling based on monthly degree day data might also provide useful information to support the best practice design process.
Objective 3.3 – To design an efficient load-side hydronic system interface

Why is this objective important?

An important design choice is whether the building’s heating and/or cooling load are directly or indirectly connected to the heat pump i.e. is a heat exchanger used to provide a physical barrier between circuits. The choice has an impact on efficiency, risk management, operating temperatures and space and cost.

Indirect connection has the following benefits:

- Heat Pump and building distribution fluids are kept separate so there is less scope for contractual disputes if these systems are in different ownership
- The optimum design flow through the condenser of the heat pump is maintained at all times.

Direct connection has the following benefits:

- Less complex, fewer components, so lower maintenance and fewer potential points of failure
- No increase in primary return temperatures across a heat exchanger
- More compact – less plantroom space needed
- No risk to supply from fouling of heat exchanger

Minimum Requirements

3.3.1 The hydronic interface shall be designed, i.e. direct or indirect connection. If a buffer tank or thermal energy store is to be used the size and location shall be determined

3.3.2 Where top-up boilers are being specified for use at times of high (peak) demand the connection design shall ensure boilers are used only when required. Care shall be taken not to exceed any low distribution temperature design parameters especially within the heat pump’s condenser

3.3.3 The heating and cooling loads of the building shall be assessed to a level of accuracy agreed with the client and to comply with all relevant standards (see Appendix D)

3.3.4 Appropriate de-aerators and particulate filters shall be specified to reduce the risk of contamination effecting operation

3.3.5 For indirect systems a variable volume control principle shall be employed. If two port valves are used care shall be taken not to increase net energy consumption

3.3.6 The design of plantrooms shall provide sufficient space for maintenance access and for future replacement of equipment including suitable power supplies for carrying out maintenance, lighting, ventilation, water supply and drainage facilities
3.3.7 Any other boundary conditions or influencing factors shall be noted, action taken and the result reported to all relevant stakeholders

**Best Practice**

Best practice could be to use computer simulation techniques to model the hydronic arrangements and advanced flow analysis and system modelling capabilities to simulate the system in complete detail.
Objective 3.4 – To design a reliable installation with a long life and low maintenance requirements

Why is this objective important?

In the feasibility stage, the location of the heat pump installation and preferred method of abstraction will have been identified. Surface water systems all require regular maintenance on the source side to ensure the installation is reliable and provides optimum performance, so the design must take into account water quality and any other factors which could degrade performance. Open loop systems are susceptible to chemical attack and fouling of the heat exchanger so maintenance frequency depends on the chemical composition of the water, turbidity, sediment in suspension or other pollutant’s.

Minimum Requirements

3.4.1 The location of the installation and method of abstraction shall be determined using the information from the feasibility stage

3.4.2 The abstraction and discharge ports shall be designed taking into account requirements from regulatory bodies, for example, the Environment Agency, and ensuring provision for regular maintenance and problem-free performance

3.4.3 The installation shall be designed to the permitted temperature range and $\Delta T$ agreed with the Environment Agency or other regulatory body in view of local conditions, protection of sites and species and pressures from other developments

3.4.4 The abstraction and discharge ports shall be designed to prevent ingress of wildlife, fish etc.

3.4.5 The intake pump(s) capacity, configuration and location shall be designed taking into account turn down range, redundancy and planned preventive maintenance access from the feasibility stage

3.4.6 The instrumentation, secondary filtration and heat exchanger interface; capacity, configuration and location shall be designed taking into account turn down range, redundancy and planned preventive maintenance access from the feasibility stage

3.4.7 The discharge port shall be designed to ensure water discharged does not cause erosion or disrupt fish migration and habitats

3.4.8 The installation shall be designed to ensure optimum performance throughout the range of heating and/or cooling loads

3.4.9 The location of the heat pump shall take into account security to avoid potential human interference
3.4.10 The installation shall be designed using the best materials, equipment and guidance available within financial parameters to ensure long-life and reliability

**Closed loop systems**

The submerged heat exchangers used by closed loop systems must be protected from physical damage and care taken to ensure that they are securely anchored. The heat exchangers should be inspected from time to time, the frequency depending on the characteristics of the water body. To mitigate against the risk of thermal transfer fluid escaping the pressure in a closed loop must be constantly monitored to immediately expose any leakage.

For closed loop systems, automatic top-up systems must NOT be used/connected to the source side.

**Example: Kingston Heights in London**

The intake and return design for **Kingston Heights** in London was based on the given flow and load requirements for the development and the requirements of the various departments of the Environment Agency. In addition historic Sonic Survey information relating to the depth and distance out from the river bank for optimum consistent temperatures.

**River abstraction intake filter (F1)**

This is mounted on a pre-constructed support frame with bracings and weight bias to ensure the filter remains in the required orientation and with a clearance of greater than 2.0 m from the river water surface. Based on the data obtained in the Sonic Survey F1, it is located 10 to 15m from the outer face of the barge dock wall where the depth of the river is 3.5 to 4.5 m.

The inlet screens have a clean calculated DP of 0.654 psi per screen at full flow of 550 m3/hr. The slot velocity at the max flow with 50% fouling factor is 0.135 m/s. These factors are further reduced in DP and velocity due to two filters in operation.

**Secondary filters (F2 A/B)**

The duplex duty / standby filters are located in the Barge Dock Plant Room in the line from the intake pumps to the heat exchangers array.
Objective 3.5 – To design a data collection systems to accurately record performance

Why is this objective important?

A comprehensive metering and monitoring system is essential to ensure ongoing operational performance. It is essential that the heat recovered, the heat supplied and the energy used can all be measured and reported. The feasibility stage should have established the performance monitoring requirements in line with any permissions necessary, such as abstraction licence and discharge permit (see Objective 2.3). Other requirements, such as metering for the Renewable Heat Incentive (RHI) schemes or the owner/clients own performance records should also be determined (see Appendix D).

Modern BMS can be used to monitor the installed meters/temperatures to allow ongoing performance to be determined and displayed continuously.

Intelligent Building Energy Management Systems (BEMS) are evolving fast. Their purpose is specifically to optimise a buildings energy use especially where a mixture of heat generators are employed or simultaneous heating and cooling is operational. They enhance rather than replace a standard Building Management System (BMS).
Minimum Requirements

3.5.1 The metering and data system shall be designed to ensure ongoing performance can be measured. This shall include the necessary data outputs and reports required for maintenance, environmental permissions and other incentive schemes.

3.5.2 The outputs to the BEMS and any other maintenance and performance systems shall be established and recorded in a SWSHP log book and in the operation and maintenance manuals.

3.5.3 Sensors shall be located to ensure flow and return temperatures and flow rates on both the source and load side are accurately recorded. A range of heat meters are now available to cover most types and sizes of installation and shall be used as appropriate. Thermal energy meters must be sized with appropriate resolution for the peak and the minimum loads.

3.5.4 The appropriate metering system shall be designed to measure and record all electrical input to the SWSHP including any parasitic load.

3.5.5 The performance data by the Building Energy Management System (BEMS) shall be used to monitor and manage in real time the heat pump to ensure it is performing optimally. The monitoring frequencies for reporting purposes shall be every three minutes.
**Best Practice**

Best practice could be to monitor the system continuously and design a display with a full energy balance, Coefficient of Performance (CoP), EER etc. The data could also be presented and compared against expected energy consumption.

Best practice could be the employment of remote data collection to facilitate real time monitoring to detect any performance or maintenance issues.

Best practice could be for reliability, duty standby arrangements to be considered to ensure 100% reliability of the metering systems. This is especially important for flow and temperature sensors.
Objective 3.6 – To update and refine risk register and sensitivity analysis

Why is this objective important?

At the feasibility stage a risk register should have be developed and a sensitivity analysis should have also be carried out to quantify the impact of the identified risks.

During the design stage the financial projections shall be used in conjunction with the risk register to evaluate the effect of uncertainty on objectives and the costs and benefits of mitigating risk. The sensitivity analysis should be carried out using a range of appropriate variables in order to fully stress-test the proposals.

Minimum Requirements

3.6.1 The risk register shall be updated and the mitigation measures reviewed and revised as necessary

3.6.2 A sensitivity analysis shall be conducted to quantify each risk in terms of impact on IRR, NPV and output value. This shall also include assessing the potential benefit from defined risk mitigation measures, for example:

- retaining the risk by informed decision
- avoiding the risk by deciding not to start or continue with the risky activity
- removing the risk source
- changing the likelihood
- changing the consequences

3.6.3 As a minimum the following sensitivities shall be included:

- environmental variables
- weather impacts, especially drought and flooding
- future energy prices
- construction programme over-run
- construction cost over-run
- plant reliability
- operation, maintenance and management costs

3.6.4 A separate analysis shall be carried out to assign monetary value to the CO₂ saved, for example by using the DECC traded carbon values or other relevant tool. This may be used to evaluate the viability of the investment in carbon reduction terms
Best Practice

Best practice could be to follow the principles of ISO3100 to carry out the risk analysis.
Objective 3.7 – To prepare a costs statement for the main system elements of the project

Why is this objective important?

During the design stage the financial projections shall be updated to reflect the most recent version of the planned installation and the current cost targets for the main elements of the system.

The objectives of this process are:

- to describe, together with the outline proposal drawings, the chosen distribution of the resources within the budget to provide a balanced design to meet the client’s needs;
- to set cost targets for the main elements so that, as the design develops, the targets can be checked and adjustments made so that the overall cost of the project is managed within the budget;
- to provide the design team with controls which communicate the costs, quantity, quality and time parameters to be followed; and
- to provide the opportunity for consideration of life-cycle costs (see ISO 15686-5)

This information is used to ensure engineering decisions are financially robust and further the financial model can be used in conjunction with the risk register to evaluate the effect of uncertainty on objectives and the costs and benefits of mitigating risk.

Minimum requirements

3.7.1 The costing team shall be provided with all the information they require to complete the task. This shall include:

- the budget. Where alternative budgets have been proposed, the client should state the preferred alternative;
- confirmation of the programme for design and construction times stated in the budget report;
- acceptance or variation of any other matters within the budget report; and
- confirmation of the brief;
- authority to proceed

and

- outline drawings of the building and site works indicating alternative solutions; and
- an indication of the preferred specification for the main elements.
- outline proposals for installation, indicating any alternative system or structural solutions
- outline proposals for operating duty, capacity and maintenance requirements

3.7.2 The costs calculations and report shall include:

- a statement of cost;
- a broad indication of the specification;
- a statement of equipment duties and capacities;
- a request for decisions on any alternative proposals and/or procurement routes, with advice thereon;
- an updated cash-flow forecast;
- allowances for contingencies and design reserve; and
- an update of inflation projections.

3.7.3 The level of detail of the information provided shall be appropriate to the scale and complexity of the system. Issues to be considered include:

- the measurement of approximate quantities and the application of rates to the quantities generated;
- comparison of the requirements with analyses of previous projects of a similar character;
- use of appropriate cost models; and/or
- a mixture of the above methods.

3.7.4 An evaluation shall be made of key elements of the system which carry major financial implications to assist and inform the decision process.

**Best Practice**

Best practice could be to carry out the sensitivity analysis using a range of appropriate variables in order to fully stress-test the proposals.

In the feasibility stage, it was identified as best practice to produce a profit and lost (P&L) account and balance sheet. If this process has been followed, the P&L account and balance sheet should be updated.
Objective 3.8 – To evaluate environmental impacts and benefits

Why is this objective important?

At the design stage the environmental impacts on a global or macro level may need to be evaluated for larger projects or if otherwise required. The impact and benefits to the local environment, for example works in, over, under or adjacent to the body of water are set out in Objective 2.3.

Minimum Requirements

3.8.1 The CO₂ savings and carbon intensity of the heat supplied shall be calculated for the project. This should include sensitivity analysis taking into account changes in the future as the electricity grid is decarbonised taking into account heat losses and the carbon intensity of the electricity used to run the heat pump

3.8.2 Materials shall be responsibly sourced considering the social, ethical and environmental aspects of a construction product from extraction and use to recycling/reuse and disposal. The BRE standard BES 6001 for Responsible Sourcing is a framework that assesses the responsible sourcing practices throughout the supply chain of construction products and allows manufacturers to prove their products have been responsibly sourced

3.8.3 A Life Cycle Assessment (LCA) shall be carried out in line with ISO 14044 to measure and evaluate the environmental impacts associated with a product, system or activity, by assessing the energy and materials used and released to the environment over the product’s life cycle

3.8.4 F-gas regulations shall be followed in the designing of the heat pump system (see appendix D)

Best Practice

Best practice could be to use the Inventory of Carbon and Energy published by BSRIA, CEN TC350 Standards or other relevant tools to calculate the embodied and operational environmental impacts of construction products across the entire lifecycle.

Best practice could be to consider how the installation could be used to positively impact and benefit the environment, for example, by creating a water feature.
Example: **GlaxoSmithKline** Global Data Suite Cooling, which used the Canalised River Brent in London is an example of using a water feature for the water discharged from a cooling system.
Objective 3.9 – To apply for the permissions necessary to access the water

Why is this objective important?

In the Feasibility Stage the permissions necessary to access the water should have been determined and pre-application discussions held with the Environment Agency and other relevant statutory bodies (see objective 2.3). At the Design Stage, applications need to be submitted and permissions granted before any abstraction and discharge can take place.

Minimum Requirements

3.9.1 For England, if a full abstraction licence and a bespoke discharge activity environmental permit from the Environment Agency are required, the following forms shall be completed (see below for requirements for Wales, Scotland and Northern Ireland):

- Form EPA: Application for an environmental permit – Part A about you
- Form EPB: Application for an environmental permit and full abstraction licence – Part B8 new ground source or surface water source heating and cooling scheme
- Form EPF: Application for an environmental permit – Part F2 charging for discharges

3.9.2 Consultation with the Environment Agency and other relevant statutory bodies shall be carried out for works in, over, under or adjacent to rivers to assess the need for permissions in line with the Water Act 2014 (previously the Water Resources Act 1991 and associated byelaws)

3.9.3 The installation of a SWSHP may be considered permitted development and may not need an application for planning permission. If planning permission is required, applications shall be made to the local planning authority including permission for temporary works for storage of materials and other construction purposes where necessary

3.9.4 The Town and Country Planning (Environmental Impact Assessment) Regulations 2011 can apply even when the project is considered permitted development. If required, an Environmental Statement shall be developed

3.9.5 Nearby interest groups and users of the water body, such as boating clubs, angling and fishing clubs/associations and river trusts, shall be consulted to resolve potential concerns about the scheme and issues which may constrain development

The approach to abstraction licensing in England is subject to review by the Government under its Abstraction Reform programme and, when implemented, this may affect the rights and conditions granted by existing licences (for more information refer to the Environment Agency website, see Appendix C)
**Best Practice**

Best Practice could be to assign an individual as the point of contact for the Environment Agency and other relevant statutory bodies for all stages of the project.

<table>
<thead>
<tr>
<th><strong>Closed loop systems</strong></th>
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<tbody>
<tr>
<td>Neither an abstraction licence nor a bespoke discharge activity environmental permit are required for a closed loop system. However in the Feasibility Stage pre-application discussions should have been held with the Environment Agency and other relevant statutory bodies (see objective 2.3) to identify requirements necessary to access the water. The relevant applications or registration shall be carried out and permissions granted before any construction can take place. If failure of a closed loop system results in the release of potentially harmful chemicals to a water body this may lead to enforcement action against the system operator/owner by the relevant regulatory body.</td>
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| **Permissions required for Wales, Scotland and Northern Ireland (where different from above)** |
Stage 4: Construction and Installation

Objectives:

4.1 To reduce health and safety risks to staff, customers and the general public

4.2 To reduce adverse environmental impacts of construction

4.3 To achieve a high quality installation in accordance with the design and to deliver a reliable long life asset

4.4 To pressure test, flush clean, purge, fill and set to work
Key Support Tasks:

- Review and update sustainability strategy and implement handover strategy, including agreement of information required for commissioning, training, handover, asset management, future monitoring and maintenance and ongoing compilation of ‘As-constructed’ Information
- Update construction and health and safety strategies

Information Exchange:

- ‘As-constructed’ information
Objective 4.1 – To reduce health and safety risks

Why is this objective important?

Reducing health and safety risks is of primary importance in any project. This section is not intended to be comprehensive but will emphasise particular risks associated with the construction of SWSHPs.

Where access cannot be controlled the health and safety of the general public must be carefully assessed and maximum mitigation measures implemented.

Minimum Requirements

4.1.1  The Principal Designer shall be appointed and a site specific health and safety risk register developed. This will also include those risks identified in the design stage

4.1.2  The Health and Safety at Work Act 1974 and the Management of Health and Safety at Work Regulations 1999 must be followed and any regulations in regards to working in or near water (see the HSE website for further information)

4.1.3  It is recommended advice is sought from risk management authorities, such as the Environment Agency and Local Authorities, before any work is undertaken. Other organisations, such as the Canal and River Trust provide advice for works conducted on their sites

4.1.4  For working in or near water it is essential that safe working methods are devised and training provided for all operatives. A safety boat crewed by qualified boatmen with first aid training need to be considered and throw-lines and life-rings should be available at strategic points on the bank. If divers are required the Diving at Work Regulations 1997 must be followed

4.1.5  Close links with the Environment Agency flood warning service and the Met Office should be established and maintained as part of the flood response procedures. In the event of a flood warning the rate of rise and maximum flood level shall be determined. The evacuation procedure to ensure that all maintenance personnel are out of danger must be initiated before conditions become hazardous

4.1.6  Leptospirosis (Weil’s disease) is a health risk and anyone working near water should carry a leptospirosis card and ensure that any medical practitioner treating them for flu-like symptoms is aware of their particular risk

4.1.7  Silt that may have lain undisturbed on a riverbed for decades may contain contaminants that are harmful to human health. The Environment Agency shall be consulted on any site specific issues and on the requirement for the analysis of silt samples
4.1.8 The HSE guidance HSG47 (HSE, 2014) avoiding danger from underground services must be followed to minimise health and safety risks associated with excavation

4.1.9 For staff and public safety, trenches and site compounds shall have fences and warning signs

4.1.10 Trench walls and other excavations shall be properly supported at all times and kept clear of ground water and debris

4.1.11 Tools and equipment shall not be left unattended at any time and shall be stored in secure facilities outside working hours

4.1.12 When welding, suitable screens shall be placed to protect the public

4.1.13 Spoil heaps shall be minimised by removing any surplus at frequent intervals

4.1.14 Detailed design carried out by the contractor shall take account of the future provision of safe working practices for the safe maintenance of plant and equipment
Objective 4.2 – To reduce adverse environmental impacts of construction

Why is this objective important?

Although the ultimate aim of a SWSHP scheme is to provide an environmental benefit there may be negative environmental impacts during construction which need to be identified and minimised.

Minimum Requirements

4.2.1 Materials shall be responsibly sourced considering the social, ethical and environmental aspects of a construction product from extraction and use to recycling/reuse and disposal. The BRE standard BES 6001 for Responsible Sourcing is a framework that assesses the responsible sourcing practices throughout the supply chain of construction products and allows manufacturers to prove their products have been responsibly sourced.

4.2.2 F-gas regulations shall be followed in the installation of the heat pump system (see appendix D).

4.2.3 The Contractor shall follow the requirements of the Considerate Contractor scheme.

4.2.4 The impact on flora and fauna that live in, on or depend on the water body shall be assessed and all risks mitigated with specific attention to issues identified by the Environment Agency and other regulators.

4.2.5 Contamination of the water body with materials or chemicals shall be prevented.

4.2.6 Water use in the construction process shall be minimised and waste water disposed of in accordance with local by-laws. Run-off into the water body shall be prevented.

4.2.7 Dust shall be controlled by using sprays on road surfaces which shall be cleaned regularly.

4.2.8 Fuel use for site vehicles and machinery shall be monitored and minimised and all pollution controls observed especially when refuelling - engines shall be turned off when not in use.

4.2.9 The Contractor shall manage the site to recycle waste and minimise the risk of waste being blown off site into surrounding areas by collecting and storing waste as soon as it is created.

4.2.10 Spoil heaps shall be covered to avoid rain run-off carrying sediment which may block drains.

4.2.11 Noise and other disturbance to residents shall be minimised and agreed site operating hours observed.
4.2.12 Trees and other landscaping shall be protected from damage with qualified arborists or landscape architects consulted as necessary

Best Practice

Best Practice could include the provision of large and easily readable posters fixed to the site hoardings to outline the nature of the works and the proposed carbon benefits.

Best Practice could include the use of the Civil Engineering Environmental Quality System (CEEQUAL) with a target to achieve Very Good or Excellent.

What is CEEQUAL?

CEEQUAL is the international evidence-based sustainability assessment, rating and awards scheme for civil engineering, infrastructure, landscaping and works in public spaces, and celebrates the achievement of high environmental and social performance.

CEEQUAL aims to assist clients, designers and contractors to deliver improved project specification, design and construction of civil engineering works. The scheme rewards project and contract teams who go beyond the legal, environmental and social minima to achieve distinctive environmental and social performance in their work. In addition to its use as a rating system to assess performance, it also provides significant influence to project or contract teams as they develop, design and construct their work as it encourages them to consider the issues at the most appropriate time and strive to secure the CEEQUAL score their work deserves. See www.ceequal.co.uk
Objective 4.3 – To achieve a high quality construction in accordance with the design and to deliver a reliable long life asset

Why is this objective important?

SWSHP systems should be designed to have a long life and be exceptionally reliable. This is only achieved if good construction standards are specified and delivered. The SWSHP system should be installed using the best materials, equipment and guidance available within financial parameters to ensure long-life and reliability. If any issues arise in the construction and installation stage where the design cannot be followed, for example due to unforeseen site conditions, the contractor must refer back to the designer and any modifications carried out transparently and with full agreement of all parties.

Minimum Requirements

4.3.1 The Contractor shall report any requirements for a variation in the design to the designer and other agreed parties, such as the Owner/Developer

4.3.2 The abstraction and discharge ports shall be installed according to the design taking into account requirements from regulatory bodies, for example, the Environment Agency

4.3.3 The abstraction and discharge ports shall be installed according to the design and prevent ingress of wildlife, fish etc. and ensure water discharged does not cause erosion or disrupt fish migration and habitats

4.3.4 The location of the heat pump shall take into account security to avoid accidental damage, flooding and potential human interference

4.3.5 The SWSHP system shall be installed using the best materials, equipment and guidance available within financial parameters to ensure long-life and reliability

4.3.6 All pipework whether steel or polymer, pre or post insulated shall be installed in accordance with all relevant standards and with the manufacturer’s instructions and guidance (see appendix D)

4.3.7 Welding of steel or polymer pipework shall only be carried out under suitable conditions observing all manufacturers conditions and recommendations. The welding area must be protected especially during inclement weather

4.3.8 All fitters employed to install the pipe work shall have received the appropriate training and hold appropriate certificates demonstrating competence for the type of pipe system being used
4.3.9 The Contractor shall carry out quality inspections at each stage of the installation process.

Best Practice

Best practice could be to adopt a system of independent inspection to verify that the above quality checks are being undertaken including written records of sample checks carried out.

Closed loop systems

The submerged heat exchangers used by closed loop systems shall be protected from physical damage and care taken to ensure that they are securely anchored.

The header pipes connecting the heat exchanger to the shore shall be installed invisibly if possible and protected to avoid the risk of any damage.

To avoid the risk of thermal transfer fluid escaping care shall be taken in the installation to mitigate all risks of leaks. Submerged joints should be avoided. If unavoidable compression fittings must not be used. It is especially important to ensure fusion welded joints are competent and have been tested and the test recorded.
Objective 4.4 – To pressure test, flush clean, purge and fill all pipework and plant.

Why is this objective important?

Pipe testing and hygiene are frequently overlooked or poorly performed yet can cause problems which seriously impact the efficient and reliable operation of any system. Fouling can be caused by debris accumulation, oxygen ingress, chemical reactions between materials in the system, dissolved or suspended metals or minerals etc.

Information, such as the use of inhibitors and dealing with water hardness, can be found in the Domestic and Non-Domestic Building Services Compliance Guides (see Appendix B).

Minimum Requirements

4.4.1 The load side shall be considered the same for all load side plant room pipework in accordance with the relevant standards and BSRIA or CISBE guidance (see Appendix D)

4.4.2 Consideration shall be given to the impact of low output temperatures from the heat pump on the system, including the associated health and performance implications, for example microorganism growth and management in hot water distribution circuit

4.4.3 The source side shall require pressure testing to identify leaks and initial flushing and cleaning shall be carried out to remove debris

4.4.4 The air shall be purged out of the system to avoid microbubbles adhering to the pipe wall

4.4.5 The system shall be set to work in accordance with the specification
Stage 5: Commissioning

Objectives:

5.1 To commission the heat pump and immediate supply-side equipment to function as designed

5.2 To commission and calibrate the performance data collection

5.3 To commission the source side of the heat pump installation

5.4 To carry out a formal handover with and provide appropriate and comprehensive information to the operations team
Key Support Tasks:

- Review and update sustainability strategy and implement handover strategy, including agreement of information required for training, handover, asset management, future monitoring and maintenance

Information Exchange:

- Commissioning report
Objective 5.1 – To commission the heat pump and immediate supply-side equipment to function as designed

Why is this objective important?

A heat pump installation will have been specified and designed to deliver energy to a heating and/or cooling load. Site specific operating strategies will have been developed to satisfy this load, for example base load or peak lopping. The flow and temperature parameters will also have been specified.

The unit and its ancillaries, for example isolating heat exchangers must be checked, adjusted and commissioned to fulfil these requirements especially at the times of peak demand.

Minimum Requirements

5.1.1 The Heat Pump shall be commissioned in accordance with the manufacturers and designers settings and procedures

5.1.2 Commissioning operatives shall receive training in commissioning the system to achieve the designed performance

5.1.3 Any flushing loops shall be closed off before commissioning commences

5.1.4 At the point of primary heat supply to the distribution system the maximum flow rate shall be adjusted to the design value, for example by using an adjustable differential pressure control valve and, if necessary, regulating valves or a pressure independent control valve

5.1.5 All measured data and set points on valves etc. shall be recorded on the commissioning record sheet and a copy provided to the customer

5.1.6 The flow rate shall be measured. Where bypass valves are installed the flow rate shall be set up under minimum system flow conditions

Best Practice

Best practice could be to provide an additional check on the maximum flow rate setting, an independent flow measuring device such as a calibrated orifice plate.
Objective 5.2 – To commission and calibrate the performance data collection

Why is this objective important?

During construction, sensors and data recorders will have been installed. The specification will take into account the data collection needs of the owner/developer and the reporting requirements of third parties, for example, the Environment Agency as a condition of granting abstraction permission or Ofgem as the basis for any government incentive payments. These sensors and data recorders must be calibrated and commissioned to ensure the reliability and accuracy of the data.

Minimum Requirements

5.2.1 Prior to commissioning there shall be an initial check that the installation has been carried out in accordance with the designers and meter manufacturer’s instructions, particularly in relation to location, orientation and sensor installation as appropriate for the data recorder

5.2.2 The data recorder shall be calibrated on load to establish that flow rate and temperatures are being recorded accurately. This should include spot checks with temporary measurement equipment to confirm/correct operation

5.2.3 A verification calculation shall be carried out to demonstrate that the conversion to kWh from the flow rate and temperature measurements is correct

5.2.4 A Coefficient Of Performance (CoP) and if cooling an Energy Efficiency Ratio (EER) will be calculated and recorded to be used as the baseline for long term monitoring and Seasonal Performance Factor (SPF) calculation. [The period to establish CoP for commissioning purposes need to be discussed]

5.2.5 An information pack shall be provided to the operations and maintenance teams as to the functioning of the data recording system and the reporting requirements

5.2.6 A commissioning report shall be produced according to CIBSE Commissioning Code M (see Appendix B). This shall include any faults, deficiencies or problems identified in the commissioning process and shall clearly identify the actions taken

5.2.7 The sensors and data loggers shall be integrated into the Building Energy Management System and used to optimise performance in real time

Best Practice

Best practice could be to enable off site monitoring and control and to facilitate rapid response to any faults.
Objective 5.3 – To commission the source side of the heat pump installation

Why is this objective important?

The apparatus for collecting heat from or rejecting heat into the surface water body will have been carefully designed, specified and installed to fulfil specific requirements and to enable the heat pump to perform as intended. This will either involve pumping the water out of and returning it into the water body (open loop) or circulating fluid through an immersed heat exchanger (closed Loop). The commissioning processes differ but the objective is to make sure the source side of the installation supports the planned performance and fulfils all other requirements.

To undertake this commissioning, it will be necessary for the load side of the heat pump(s) to be ready to receive a heating and/or cooling supply as appropriate.

Minimum Requirements

5.3.1 All available design calculations and documentation, equipment data and test sheets, flow diagrams, installation and test records shall be collected and collated

5.3.2 A commissioning schedule and record document detailing all relevant heat pump and ancillary equipment performance parameters, for example evaporator (source side) flow rates, pressure drops, pump heads, ΔT etc., shall be prepared

5.3.3 A commissioning schedule and record document detailing all relevant source water environmental parameters, for example temperature constraints, abstraction limits etc., shall be prepared

5.3.4 Before operating any heat pump compressor, adequate flow rates shall be established in the source and load side circuits. Failure to do this can lead to damage cause by freezing in the heat exchanger

5.3.5 All hardware functions shall be verified as to the design and all pipework shall be checked to ensure correctly installed and protected. The system shall be adjusted as necessary and all results shall be accurately recorded. For closed loop systems care shall be taken to ensure that all entrained air is removed from the source side collector

5.3.6 All environmental and other parameters relating to the water source shall be measured and the results accurately recorded

5.3.7 All information and data collected shall be recorded correctly into the site’s operations and maintenance manual and records
5.3.8  Following initial commissioning, any filters and/or demountable heat exchangers shall be inspected for debris, cleaned if necessary, and re-sealed prior to further operation.

**Best Practice**

Best practice could be local and remote monitoring of the source side data to ensure initial and ongoing performance and to alert any reduction in performance or malfunction. Of principal importance will be source water flow rate, absolute temperature and temperature differential.

**Closed loop systems**

The commissioning process for a closed loop heat exchanger is broadly the same for all variants. As for all closed loop heat pump systems, care shall be taken with pressure testing to ensure there are no leaks in the source side collector.

Some thermal transfer fluids contain harmful or potentially harmful chemicals and great care shall be taken to ensure that an appropriate fluid is selected and used in the correct manner.

The Thermal Transfer Fluid type, pH and concentration shall be measured and recorded. Notices containing this information shall be left in a visible location close to the injection/drain points in the plant room, as well as in the operations and maintenance manual.

The location where the pipework enters the surface water body shall be inspected to ensure it is protected and safe and the heat exchanger array is located correctly and secure.
Objective 5.4 – To carry out a formal handover with and provide appropriate and comprehensive information to the operations team

Why is this objective important?

Handover follows on from project completion which is the point in the construction process when the senior construction team or project manager determines that the installation is complete and ready for the client. Once completion has been certified, the contractor surrenders the site to the client who then assumes full responsibility.

The main parties involved in the handover process will typically be the senior construction team, mechanical and electrical contractors, any nominated sub-contractors, the designer and the client's maintenance personnel or nominated maintenance contractor. Good communication is especially important during the final stages of construction and ideally the maintenance team should be involved early in the handover process. Where a commissioning manager is appointed, he will supervise and confirm satisfactory completion of all the stages of the handover.

Minimum Requirements

5.4.1 A formal handover between the construction, maintenance teams and any other identified key party shall be carried out in line with BSRIA or CISBE guidance (see Appendix D). This is vital to ensure that all aspects of the design are explained and the importance of correct operation and maintenance are understood, including requirements for any abstraction licence and discharge permit.

5.4.2 A comprehensive “snagging” list will be prepared and arrangements made for any remediation required and subsequent re-inspection.

5.4.3 A comprehensive operations and maintenance manual shall be compiled both electronically and in hard copy to include:

- a schedule of planned maintenance
- the use of performance data to identify repair or maintenance requirements
- a list of all components and their suppliers
- a list of specialist training courses (required and desirable)

Best Practice

Best practice could be to use planned maintenance software to ensure full and accurate records are kept to minimise the likelihood of failure.
Best practice could be to contract an independent professional to plan and carry out the stages of the handover.
Stage 6: Operation and Maintenance

Objectives:

6.1 To reduce health and safety risks to staff, customers and the general public

6.2 To deliver a cost-effective efficient maintenance schedule that maximises system efficiency, reliability and asset life

6.3 To provide appropriate monitoring and reporting, including reliability and CO₂ emissions

6.4 To minimise environmental impacts of operation and maintenance
This is an example of how the Plan of Work will be used at the beginning of each stage, it will include the responsibilities and the goals as in the full diagram

Key Support Tasks:

- Conclude activities listed in handover strategy including post-occupancy evaluation, review of project performance, project outcomes and research and development aspects
- Updating of project information, as required, in response to ongoing client feedback until the end of the building’s life

Information Exchange:

- Annual reports and regular performance monitoring reports, as agreed
- All data and feedback to owner/developer including planned and unplanned maintenance reports and costs
Objective 6.1 – To reduce health and safety risks to staff, customers and the general public

Why is this objective important?

Reducing health and safety risks for staff, customers and general public is of primary importance in any scheme. This section is not intended to be comprehensive but will emphasise particular risks associated with the operation and maintenance of SWSHPs.

Minimum Requirements

6.1.1 The COSSH and DSEAR Regulations may apply and shall be followed

6.1.2 The heat pump operator shall be certified under ISO18001, Occupational Health and Safety standard

6.1.3 Plant rooms, vaults and manholes containing heat exchangers, pumps and other equipment shall be kept locked and access controlled

6.1.4 Checks on the water systems shall be carried out and any water treatment recorded in accordance with HSE Guide HSG274 Part 2, 2014 The control of legionella bacteria in hot and cold water systems

6.1.5 Permanent and durable signage to warn of potential suction and flow of the body of water shall be securely attached and readily visible to the public and the operator

6.1.6 Safety barriers shall be fitted and maintained in accordance with current legislation and appropriate life-saving equipment provided where necessary

6.1.7 The operator shall carry out maintenance procedures in accordance with the operation and maintenance manual

6.1.8 When maintaining equipment in or near water, it is essential that safe working methods are devised and relevant health and safety regulations are followed (see the HSE website for further information)

6.1.9 Close links with the Environment Agency flood warning service and the Met Office should be established and maintained as part of the flood response procedures. In the event of a flood warning the rate of rise and maximum flood level shall be determined. The evacuation procedure to ensure that all maintenance personnel are out of danger must be initiated before conditions become hazardous
6.1.10 Leptospirosis (Weil’s Disease) is a health risk and anyone working near water should carry a leptospirosis card and ensure that any medical practitioner treating them for flu-like symptoms is aware of their particular risk

6.1.11 A fire risk assessment shall be carried out and fire alarm, detection systems and any fire suppression systems shall be checked regularly in accordance with regulations

6.1.12 If insulation needs to be removed for maintenance or repair it shall be refitted as soon as possible. If removed for an extended period of time a temporary arrangement should be established and suitable barriers/notices shall be put in place
Objective 6.2 – To deliver a cost-effective efficient maintenance schedule that maximises system efficiency, reliability and asset life

Why is this objective important?

A water source heat pump is a relatively high cost but robust and reliable capital asset. This means that getting a return on the investment may take time but the long term rewards will be substantial. The quality of materials, design and construction of the SWSHP is important but correct operation and timely, proficient maintenance is also essential to ensure the installation is reliable and provides optimum performance.

The load side of a SWSHP is broadly the same whatever the heat source. However on the source side, closed loop and open loop systems will have different requirements. Open loop systems are susceptible to chemical attack and fouling of the heat exchanger so maintenance frequency depends on the chemical composition of the water, turbidity, sediment in suspension or other pollutants; whereas closed loop systems are susceptible to physical damage and fouling by silt, weed or other detritus.

Minimum Requirements

6.2.1 The basis for the planned maintenance regime shall be in accordance with the PAS 55 standard following the Plan-Do-Check-Act cycle of continual improvement

6.2.2 Maintenance on central plant shall be according to manufacturer’s instructions and BSRIA Guide BG3/2008 Maintenance for Building Services and CIBSE Guide M Maintenance Engineering and Management

6.2.3 To minimise the risk of damage, as installed drawings of the installation shall be maintained and provided to all stakeholders

6.2.4 All staff shall receive appropriate training before operating or maintaining any equipment

6.2.5 In addition to regular inspections, a remote monitoring and surveillance system shall be installed and the installation continuously monitored to ensure efficient operation. All alarms shall be investigated and the location of the fault identified and repairs shall be carried out as required. This is particularly important for closed loop systems when any escape of TTF could cause environmental problems

6.2.6 Comprehensive records of test results, water treatment and repairs on the system shall be maintained

6.2.7 Major plant maintenance shall always be scheduled to minimise any interruptions in heat supply and wherever possible there shall be sufficient resilience in the system to prevent supply interruptions
**Best Practice**

Best practice could be to record pressures and temperatures to check all pipework has been operated within the specified design parameters. This is particularly important to ensure plastic pipe integrity and longevity and to identify cycling.

**Closed loop systems**

The thermal transfer fluid (TTF) shall be regularly tested to ensure there is no deterioration.

**Best Practice**

Best practice could be to ensure all water used to fill or top up a closed loop system shall be suitably treated to provide a very high quality from the outset.
Objective 6.3 – To provide appropriate monitoring and reporting, including reliability and CO2 emissions

Why is this objective important?

Monitoring and reporting requirements will have been defined by the Environment Agency and other regulatory bodies in issuing the relevant permissions and by Ofgem for the Renewable Heat Incentive (RHI) or other relevant grant/tariff awarding bodies. Reports and notifications will need to be prepared and sent in the agreed format and at agreed intervals.

It is important to monitor the operation of the installation and to provide regular reports to the owner/developer so that a high standard of performance can be maintained. In larger schemes, the details of the reporting requirements will typically form part of the contract for the operation of the system.

Minimum Requirements

6.3.1 Monitoring Certification Scheme (MCERTS), the framework of standards to monitor the emissions to air, land and water, shall be followed

6.3.2 The continuous monitoring of the inlet and discharge points shall be carried out to alert the operator if specified limits are exceeded and for potential freezing conditions where the heat pump and circulating pumps shall be shut down before freezing can occur in the pipework and/or evaporator

6.3.3 The operator shall send all reports and notifications in line with the relevant permissions to the Environment Agency or other regulatory bodies at an agreed interval and all records shall be kept for at least six years from the date the records were made

6.3.4 The operator shall send all reports to Ofgem for RHI or other relevant grant/tariff awarding body at an agreed interval

6.3.5 The electrical input to the heat pump and the electrical inputs to the source side circulation pumps shall be monitored and reported at an agreed interval

6.3.6 For larger schemes, an operating report shall be produced by the operations and maintenance contractor, at an agreed interval (e.g. monthly, quarterly, annually) to be issued to the owner, which typically contains the following information:

- health and safety incidents
- operating and performance data and related design data and anticipated energy consumption and production
- unplanned downtime, system failures and faults that occurred
- planned downtime and maintenance activities carried out
- planned maintenance events due over the next 30 and 90 days
- electricity consumption and running cost
- indirect CO₂ emissions from electricity use and displaced CO₂ emissions compared to alternative fuel(s)
- results of mandatory FGas inspections

6.3.7 An annual report shall be prepared by the operations and maintenance contractor and shall include the information in 6.5.3 and also information on:
- calculation of average CO₂ emission factor for heat over the year
- Seasonal Performance Factor (SPF)

6.3.8 The annual report shall be made available electronically and issued as hard copy by request

**Best Practice**

More frequent reports, for example issued on a monthly basis, could constitute best practice.

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**Closed loop systems**

The submerged heat exchangers used by closed loop systems shall be protected from physical damage and monitored to ensure they are securely anchored.

To avoid the risk of thermal transfer fluid escaping, the pressure in a closed loop shall be constantly monitored to immediately identify any leakage. The heat pump, and associated source side circulating pump(s) should be shut down in the event of a significant loss of pressure.

The thermal transfer fluid shall be tested for concentration and PH and reported at an agreed interval.
Objective 6.4 – To minimise environmental impacts of operation and maintenance

Why is this objective important?

Although the ultimate aim of a water source heat pump scheme is to provide an environmental benefit there may be negative environmental impacts during operation and maintenance which need to be identified and minimised. The permissions issued by the Environment Agency and other relevant regulatory or statutory bodies will have specified requirements in monitoring and reporting to ensure the scheme operates within the agreed parameters. Other regulations, such as f-gas, also need to be complied with.

Minimum Requirements

6.4.1 The operation of the scheme shall be certified to ISO14001

6.4.2 The temperature of the water discharged shall be monitored continuously to ensure it is within the $\Delta T$ set by the Environment Agency or other regulators

6.4.3 The operator shall maintain records of all monitoring required by the Environment Agency or other regulators including the taking and analysis of samples, instrument measurements (periodic and continual), calibrations, examinations, tests and surveys and any assessment or evaluation made on the basis of such data

6.4.4 The Environment Agency shall be notified without delay following the detection of:
  - any malfunction, breakdown or failure of equipment or techniques, accident or emission of a substance not controlled by an emission limit which has caused, is causing or may cause significant pollution
  - the breach of a limit specified in the permission, for example $\Delta T$
  - any significant adverse environmental effects

6.4.5 The operator shall allow access by the Environment Agency and other regulators if requested to allow inspection of the system in operation

6.4.6 F-gas regulations shall be followed in operating and maintaining the heat pump (see appendix D). Only qualified technicians shall carry out any of the following work on a heat pump system:
  - maintenance
  - leak checking
  - recovering refrigerant gases

6.4.7 Filtration systems shall be regularly monitored and cleaned to prevent fish and other wildlife from entering abstraction and discharge ports
Closed loop systems

Temperature flow and pressure will be monitored continuously to identify deterioration or leaks of the heat transfer fluid
Stage 7: Decommissioning

Objective:

7.1 To decommission the heat pump
7.2 To decommission the source side
This is an example of how the Plan of Work will be used at the beginning of each stage, it will include the responsibilities and the goals as in the full diagram.

**Key Support Tasks:**
- Produce decommissioning plan
- Engage with Environment Agency and other regulatory bodies on processes of decommissioning and the level of requirements for site reinstatement

**Information Exchange:**
- Decommissioning Plan
- Reports in line with f-gas and other regulations
- Reports to Environment Agency and other regulatory bodies as required
Objective 7.1 – To decommission the heat pump

Why is this objective important?

Any end of life heat pump, whether used for heating, cooling or both must be correctly decommissioned to avoid any risk of pollution, minimise waste and maximise the recovery for reuse its constituent parts. The equipment can contain hazardous substances, such as ozone depleting substances (ODS) and fluorinated gases (F-gases) so particular care must be taken to recover for reuse or safe, correct disposal of all refrigerant in accordance with all F-Gas legislation (see appendix D).

Owners and operators have legal obligations under UK and EU F-Gas Regulations to ensure that any company and or person they allow to install, service, maintain, repair, carry out leakage checks and or decommission their refrigeration and/or air conditioning systems holds valid F-Gas qualifications.

Minimum Requirements

7.1.1 Under UK and EU F-Gas Regulations any person carrying out decommissioning of a heat pump that contains fluorinated greenhouse gases shall hold a valid F-Gas qualification

7.1.2 All documentation shall be kept and correctly completed in line with UK and EU F-Gas Regulations

7.1.3 All chemicals, including secondary refrigerants such as ethanol or propylene glycol mixtures, shall be stored in an area where spills will be contained and if contaminated, treated as hazardous/special waste

7.1.4 Solutions containing refrigerant of any type shall not enter watercourses or surface water drains

7.1.5 If contaminated water accidentally enters public sewers, the water and/or sewerage company and other relevant authorities shall be contacted immediately

7.1.6 When effluent is discharged to surface or ground water a discharge consent shall be obtained from the Environment Agency or other relevant regulatory body

7.1.7 When effluent is discharged into public sewers a trade effluent consent or a trade effluent agreement shall be obtained from the water and/or sewerage company and all discharges shall comply with the agreed conditions

7.1.8 All compressors or associated components shall be placed on a drip tray to collect any leaking oil. The drip tray shall be emptied regularly and treated as hazardous/special waste.
7.1.9 All ancillary buildings and equipment shall be dismantled or demolished to an acceptable standard and in accordance with all current legislation and any specific agreements with regulatory and other bodies

**Best Practice**

Best practice could be all traces of the installation shall be removed and the site reinstated such that no visible evidence remains.
Objective 7.2 – To decommission the source-side to reduce health and safety risks and manage environmental impacts

Why is this objective important?

Although the ultimate aim of a water source heat pump scheme is to provide an environmental benefit there may be negative environmental impacts during decommissioning which need to be identified and minimised.

Reducing health and safety risks is of primary importance. This section is not intended to be comprehensive but will emphasise particular risks associated with the decommissioning of SWSHP systems.

Minimum Requirements

7.2.1 The Health and Safety at Work Act 1974 and the Management of Health and Safety at Work Regulations 1999 must be followed and any regulations in regards to working in or near water (see the HSE website for further information)

7.2.2 It is recommended advice is sought from risk management authorities, such as the Environment Agency and Local Authorities, before any work is undertaken. Other organisations, such as the Canal and River Trust provide advice for works conducted on their sites

7.2.3 For working in or near water it is essential that safe working methods are devised and training provided for all operatives. A safety boat crewed by qualified boatmen with first aid training need to be considered and throw-lines and life-rings should be available at strategic points on the bank. If divers are required the Diving at Work Regulations 1997 must be followed

7.2.4 Close links with the Environment Agency flood warning service and the Met Office should be established and maintained as part of the flood response procedures. In the event of a flood warning the rate of rise and maximum flood level shall be determined. The evacuation procedure to ensure that all maintenance personnel are out of danger must be initiated before conditions become hazardous

7.2.5 Leptospirosis (Weil’s disease) is a health risk and anyone working near water should carry a leptospirosis card and ensure that any medical practitioner treating them for flu-like symptoms is aware of their particular risk

7.2.6 The decision shall be made on whether to excavate all pipework. If required the HSE guidance HSG47 (HSE, 2014) avoiding danger from underground services must be followed to minimise health and safety risks associated with excavation
7.2.7 The impact on flora and fauna that live in, on or depend on the water body shall be assessed and all risks mitigated with specific attention to issues identified by the Environment Agency and other regulators.

7.2.8 Notice shall be given to the Environment Agency and the necessary applications forms shall be completed to revoke the abstraction licence and surrender the discharge permit for the system.

7.2.9 Contamination of the water body with materials or chemicals shall be prevented and all fluids shall be disposed of carefully in line with relevant legislation and regulations.

7.2.10 Materials shall be responsibly disposed of considering the social, ethical and environmental aspects of recycling/reuse and disposal of construction products.

**Closed loop systems**

The decision shall be made on whether to remove all fixings in the surface water source. If remaining, obstacles to navigations and impact on flora and fauna shall be assessed and all risks mitigated.

The thermal transfer fluid shall be disposed of carefully in line with relevant legislation and regulations (see Appendix D).
Appendices

Appendix A: Glossary of terms and acronyms
Appendix B: References and other resources
Appendix C: Useful contacts
Appendix D: Standards and guidance
Appendix E: National Heat Map: Water source heat capacity
Appendix F: Navigating the way: A customer journey for potential developers
Appendix G: Example Risk Register
Appendix H: Case studies
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<tr>
<th>Term or acronym</th>
<th>Definition</th>
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<tr>
<td>AHU</td>
<td>Air Handling Units</td>
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<td>ASHP</td>
<td>Air Source Heat Pump</td>
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<td>BEMS</td>
<td>Building Energy Management System</td>
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<td>BMS</td>
<td>Building Management System</td>
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<tr>
<td>Capex</td>
<td>Capital expenditure</td>
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<tr>
<td>CDM</td>
<td>Construction Design Management Regulations</td>
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<tr>
<td>CEEQUAL</td>
<td>Civil Engineering Environmental Quality Assessment and Award Scheme</td>
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<tr>
<td>CoP</td>
<td>Coefficient of Performance (Please note, to prevent confusion this acronym must not be used for Code of Practice)</td>
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<tr>
<td>COSSH</td>
<td>Control of Substances Hazardous to Health</td>
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<tr>
<td>CRC</td>
<td>Carbon Reduction Commitment</td>
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<tr>
<td>DC</td>
<td>Direct current</td>
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<tr>
<td>Delta-T or $\Delta T$</td>
<td>The temperature difference from the water abstracted to the water discharged</td>
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<tr>
<td>DHWS</td>
<td>Domestic Hot Water Service</td>
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<tr>
<td>DP</td>
<td>Differential Pressure</td>
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<tr>
<td>DSEAR</td>
<td>Dangerous Substances and Explosive Atmospheres Regulations</td>
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<tr>
<td>DSM</td>
<td>Dynamic Simulation Model</td>
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<td>EC</td>
<td>Energy centre</td>
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<td>ECA</td>
<td>Enhanced Capital Allowance</td>
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<td>ECO</td>
<td>Energy Company Obligation</td>
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<td>EER</td>
<td>Energy Efficiency Ratio</td>
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<td>ETL</td>
<td>Energy Technology List</td>
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<td>EUETS</td>
<td>EU Emissions Trading System</td>
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<td>GHG</td>
<td>Greenhouse Gas</td>
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<td>GIS</td>
<td>Geographic Information System</td>
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<td>HIU</td>
<td>Hydraulic interface unit</td>
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<tr>
<td>HN</td>
<td>Heat networks</td>
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<tr>
<td>Hybrid</td>
<td>Multivalent systems can also be described as hybrid</td>
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<tr>
<td>IRR</td>
<td>Internal Rate of Return</td>
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<tr>
<td>LCA</td>
<td>Life Cycle Assessment</td>
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<td>Leptospirosis</td>
<td>Weil’s Disease</td>
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<td>Load</td>
<td>Building or other use</td>
</tr>
<tr>
<td>MCERTS</td>
<td>Monitoring Certification Scheme</td>
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<td>MID</td>
<td>Measurement Instruments Directive</td>
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<td>NPV</td>
<td>Net Present Value</td>
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<td>NRM</td>
<td>New Rules of Measurement</td>
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<td>Open water</td>
<td>Open water can also be used to describe surface water</td>
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<td>Opex</td>
<td>Operational expenditure</td>
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<td>P&amp;L</td>
<td>Profit and loss account</td>
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<td>RHI</td>
<td>Renewable Heat Incentive</td>
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<td>SAP</td>
<td>Standard Assessment Procedure</td>
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<tr>
<td>SBEM</td>
<td>Simplified Building Energy Model</td>
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<tr>
<td>Source</td>
<td>Surface water body</td>
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<tr>
<td>Acronym</td>
<td>Description</td>
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<tr>
<td>SPF</td>
<td>Seasonal Performance Factor</td>
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<tr>
<td>SWSHP</td>
<td>Surface water source heat pump</td>
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<tr>
<td>TER</td>
<td>Target Emission Rate</td>
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<tr>
<td>TFEE</td>
<td>Target Fabric Energy Efficiency</td>
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<tr>
<td>TTF</td>
<td>Thermal Transfer Fluid</td>
</tr>
</tbody>
</table>
Appendix B – References and other resources


CIBSE TM46: *2008 Energy benchmarks* (for existing buildings) (London: Chartered Institution of Building Services Engineers)


CIBSE Guide M: *Maintenance Engineering and Management* (London: Chartered Institution of Building Services Engineers)

CIBSE: *Commissioning Code M: Commissioning Management* (London: Chartered Institution of Building Services Engineers)


Environment Agency (August 2010): *Regulatory position statement GEHO0810BSYD-E-E*


HM Government (2013): *Domestic Building Services Compliance Guide (For England)*

HM Government (2013): *Non-Domestic Building Services Compliance Guide (For England)*

Zero Carbon Hub (2014): *Closing the Gap Between Design and As Built Performance*
Appendix C – Useful Contacts

European

**International Energy Agency**
9, rue de la Fédération
75739 Paris Cedex 15
France
 Telephone: +33 1 40 57 65 00
 Fax: +33 1 40 57 65 09
 Email: info@iea.org
 Website: www.iea.org

**European Geothermal Energy Council**
Place du Champ de Mars, 2
5ème étage
1050 Bruxelles
Email: com@egec.org
Website: http://www.egec.org/

**European Heat Pump Association**
Website: http://www.ehpa.org

UK

**Department of Energy and Climate Change**
3 Whitehall Place
London
SW1A 2AW
 Telephone: 0300 060 4000
 Email: correspondence@decc.gsi.gov.uk

**Ground Source Heat Pump Association**
23 York Road, Stony Stratford
Milton Keynes MK11 1BJ
 Telephone: 01908 56 26 00
 Email: info@gshp.org.uk
 Website: www.gshp.org.uk

**Heat Pump Association**
Telephone: 0118 940 3416
 Fax: 0118 940 6258
 Email: info@heatpumps.org.uk
 Website: www.heat-pumps.org

**National Parks UK**
126 Bute Street
Cardiff Bay
Cardiff
CF10 5LE
 Telephone: 029 2049 9966
 Email: info@nationalparks.gov.uk
 Website: www.nationalparks.gov.uk

**The Crown Estate**
16 New Burlington Place
London
W1S 2HX
 Telephone: 020 7851 5000
 Email: enquiries@thecrownestate.co.uk
 Website: www.thecrownestate.co.uk
England

Environment Agency
National Customer Contact Centre
PO Box 544
Rotherham
S60 1BY
Telephone: 03708 506 506
Minicom (for the hard of hearing): 03702 422 549
Email: enquiries@environment-agency.gov.uk
Website: www.gov.uk/government/organisations/environment-agency
Monday to Friday, 8am to 6pm

Marine Management Organisation
Lancaster House
Hampshire Court
Newcastle upon Tyne
NE4 7YH
Telephone: 0300 123 1032
Email: info@marinemanagement.org.uk
Website: www.gov.uk/government/organisations/ marine-management-organisation

Natural England (access, rights of way, protected areas)
Block B, Government Buildings, Whittington Road
Worcester
WR5 2LQ
Telephone: 0300 060 3900
Email: enquiries@naturalengland.org.uk
Website: www.gov.uk/government/organisations/naturalengland

Forestry Commission
620 Bristol Business Park
Coldharbour Lane
Bristol
BS16 1EJ
Telephone: 0300 067 4000
Email: fe.england@forestry.gsi.gov.uk
Website: www.forestry.gov.uk

Canal & River Trust
First Floor North, Station House
500 Elder Gate
Milton Keynes
MK9 1BB
Telephone: 01908-351884
Email: Darren.Leftley@canalrivertrust.org.uk
Website: www.canalrivertrust.org.uk
Scotland

Scottish Environment Protection Agency (SEPA)
Telephone: 03000 99 66 99
Website: www.sepa.org.uk

Forestry Commission Scotland
Silvan House
231 Corstorphine Road
Edinburgh
EH12 7AT
Telephone: 0300 067 6156
Email: fcscotland@forestry.gsi.gov.uk
Website: www.scotland.forestry.gov.uk

Wales

Natural Resources Wales (NRW)
c/o Customer Care Centre
Ty Cambria
29 Newport Rd
Cardiff
CF24 0TP
Telephone: 0300 065 3000 (Mon-Fri, 8am-6pm)
Email: enquiries@naturalresourceswales.gov.uk
Website: www.naturalresourceswales.gov.uk

Canal & River Trust
First Floor North, Station House
500 Elder Gate
Milton Keynes
MK9 1BB
Telephone: 01908-351884
Email: Darren.Leftley@canalrivertrust.org.uk
Website: www.canalrivertrust.org.uk

Northern Ireland

Northern Ireland Environment Agency (NIEA)
Telephone: 0845 302 0008
Email: nieainfo@doeni.gov.uk
Website: www.doeni.gov.uk

Website: www.dardni.gov.uk

Forest Service Headquarters
Dundonald House
Upper Newtownards Road
Ballymiscaw
Belfast
BT4 3SB
Telephone: 02866 343165
Fax: 02866 343144
Email: customer.forestservicedardni.gov.uk
## Appendix D – Standards and guidance

<table>
<thead>
<tr>
<th>Specific Standard</th>
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<tr>
<td>ISO 9001</td>
<td>Certification for quality management</td>
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<td>ISO14001</td>
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<td>ISO 18001</td>
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<td>ISO 14044</td>
<td>Environmental management - Life cycle assessment</td>
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<td>BSI PAS 55</td>
<td>British Standards Institution's (BSI) Publicly Available Specification for the optimized management of physical assets</td>
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<td>CEN TC350</td>
<td>Sustainability of construction works</td>
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<td>BS 5422:2009</td>
<td>Method for specifying thermal insulating materials for pipes, tanks, vessels, ductwork and equipment operating within the temperature range -40°C to +700°C</td>
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<td>BS EN 15632-4:2009</td>
<td>District heating pipes. Pre-insulated flexible pipe systems. Non bonded system with plastic service pipes; requirements and test methods</td>
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<td>BS EN 15698-1:2009</td>
<td>District heating pipes. Preinsulated bonded twin pipe systems for directly buried hot water networks. Twin pipe assembly of steel service pipe, polyurethane thermal insulation and outer casing of polyethylene</td>
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<td>EN 1434:2007</td>
<td>Heat meters. General requirements</td>
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<td>ISO 17025</td>
<td>General requirements for the competence of testing and calibration laboratories</td>
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<td>BS EN 15316-4-7:2008</td>
<td>Heating systems in buildings. Method for calculation of system energy requirements and system efficiencies. Space heating generation systems, biomass combustion systems.</td>
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<td>BS EN 805-2000</td>
<td>Water supply – requirements for systems and components outside buildings</td>
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<td>BS EN 806-3:2006</td>
<td>Specifications for installations inside buildings conveying water for human consumption. Pipe sizing. Simplified method</td>
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<tr>
<td>BS EN 806-4:2010</td>
<td>Specifications for installations inside buildings conveying water for human consumption. Installation</td>
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<td>BS 8558:2011</td>
<td>Guide to the design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages. Complementary guidance to BS EN 806</td>
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<td>BES 6001</td>
<td>BRE standard for Responsible Sourcing</td>
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<td>American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)</td>
<td>Procedures for Commercial Building Energy Audits, 2nd Edition</td>
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<tr>
<td>Building &amp; Engineering Services Association (B&amp;ES)</td>
<td>Domestic Heating - Design Guidance DHG1</td>
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<tr>
<td>Building Research Establishment (BRE)</td>
<td>Design of low-temperature domestic heating systems: A guide for system designers and installers</td>
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<td>BRE</td>
<td>Making the most of renewable energy systems</td>
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<tr>
<td>Building Services Research and Information Association (BSRIA)</td>
<td>Environmental Code of Practice for Buildings and their Services 2nd Ed (COP6/99)</td>
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<td>BSRIA</td>
<td>Heat Pumps – A guidance document for designers (BG7/2009)</td>
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<td>BSRIA</td>
<td>Heating Controls in Large Spaces (TN23/97)</td>
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<td>Illustrated Guide to Renewable Technologies (BG1/2008)</td>
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<td>Inventory of Carbon and Energy (ICE) (BG 10/2011)</td>
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<td>Screeds with Underfloor Heating – Guidance for a defect-free interface (IEP1)</td>
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<td>Sustainable Housing - Options for independent energy, water supply and sewerage (AG26/97)</td>
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<td>Chartered Institution of Building Services Engineers (CIBSE)</td>
<td>AM11 Building Energy and Environmental Modelling</td>
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<td>AM14 Non-Domestic Hot Water Heating Systems</td>
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<td>Domestic Heating - Design Guide 2015 (Domestic Building Services Panel)</td>
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<td>CIBSE</td>
<td>Guide B: Heating, Ventilating, Air Conditioning and Refrigeration</td>
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<td>CIBSE</td>
<td>Guide J: Weather, Solar and Illuminance Data</td>
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<td>CIBSE</td>
<td>Guide L: Sustainability (under revision)</td>
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<td>CIBSE</td>
<td>KS03 Sustainable Low Energy Cooling: An Overview (CIBSE Knowledge Series 3)</td>
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<td>CIBSE</td>
<td>KS08 How to Design a Heating System</td>
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<td>CIBSE</td>
<td>TM22 Energy Assessment and Reporting Methodology (inc CD-ROM) 2nd Edition</td>
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<td>CIBSE</td>
<td>Underfloor Heating: Design &amp; Installation (Domestic Building Services Panel) 2012</td>
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<td>DCLG</td>
<td>Non Domestic Building Services Guide - Part G (Sanitation, Hot Water Safety and Water Efficiency)</td>
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<td>Environment Agency</td>
<td>Environmental good practice guide for ground source heating and cooling (GEHO0311BTPA-E-E)</td>
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<td>Environment Agency</td>
<td>Ground Water Protection: Policy and Practice GP3 2007</td>
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<td>Environment Agency</td>
<td>Living on the Edge: A guide to your rights and responsibilities of riverside ownership</td>
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<td>European Commission</td>
<td>1907/2006 - REACH: Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)</td>
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<td>European Commission</td>
<td>1999/45/EC: classification, packaging and labelling of dangerous preparations</td>
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<td>European Commission</td>
<td>2000/60/EC: establishing a framework for Community action in the field of water policy</td>
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<td>2004/22/EC: Measuring Instruments Directive (MID)</td>
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<td>European Commission</td>
<td>2006/118/EC: on the protection of groundwater against pollution and deterioration</td>
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<td>CLP-Regulation No 1272/2008: Classification, labelling and packaging of substances and mixtures</td>
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<td>80/68/EEC: on the protection of groundwater against pollution caused by certain dangerous substances</td>
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<td>European Heat Pump Association (EHPA)</td>
<td>Heat Pump Implementation Scenarios</td>
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<td>Greater London Authority (GLA)</td>
<td>Sustainable Design and Construction: Supplementary Planning Guidance</td>
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<td>Health and Safety Executive (HSE)</td>
<td>Managing Health and Safety in Construction. Construction (Design and Management) Regulations 2007 Approved Code of Practice</td>
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<td>C. Reporting of Injuries Diseases &amp; Dangerous Occurrence Regulations 1995</td>
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<td>Dangerous Substances &amp; Explosive Atmosphere Regulations 2002 (DSEAR 2002) (ACOP L138)</td>
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<td>Workplace (Health, Safety &amp; Welfare) Regulations 1992 2002 (ACOP L24)</td>
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<td>Non-Domestic RHI Guidance Volume One: Eligibility and How to Apply (Version 4)</td>
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<td>Technical Guidance - Section 6 Energy</td>
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<td>Supporting Guidance (WAT-SG-62) Groundwater Abstractions - Geothermal Energy</td>
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Appendix E – National Heat Map: Water source heat capacity

To be added in the final publication

Appendix F – Navigating the way: A customer journey for potential developers

To be added in the final publication

Appendix G – Example risk register

To be added in final publication

Appendix H – Case studies

To be added in final publication

Appendix I – Computer Modelling

To be added in final publication: The Oklahoma State University – Design Tools for Surface Water Source Heat Pumps