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Cyfoeth Naturiol Cymru
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Llywodraeth Cymru
Welsh Government

Removing or repurposing redundant reservoirs

Information and source document on discontinuing, abandoning or repurposing UK reservoirs

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Caveat

This document does not constitute legal advice. It includes information on the applicable regimes in the devolved administrations, but the Environment Agency is unable to guarantee accuracy. If in any doubt, please refer to the devolved authorities. The Environment Agency takes no responsibility for the legal content and readers should seek their own advice where appropriate.

1 Introduction

This document has been produced to inform readers and provide reference material on the processes required to remove or repurpose redundant reservoirs. It is not guidance as such. It discusses the steps that you should consider if you are evaluating the options to remove or repurpose a reservoir that has become redundant. Chapters in this guide cover legislation, options assessment, planning implications, construction and the long-term management of the asset. These can be used for reference during the decision-making process. To help with decision-making, scoring matrices can be developed and used to rank the options using a comparative method. Devolved administrations are responsible for their respective jurisdictions.

This document is intended to assist reservoir owners, reservoir managers, undertakers and panel engineers, enabling all the applicable options to be considered in removing or repurposing reservoirs. Appropriate legal advice should normally be sought to ensure that decisions are lawful.

There are 2 main reasons to consider removing or repurposing a reservoir:

1) The asset has become redundant and is no longer used for the purpose it was originally constructed for - in addition, with the potential change in legislation post the Toddbrook reservoir independent review report (and pressure to improve safety) many smaller structures may possibly, in the future, be subject to requirements that could require significant investment in remedial works to renovate the structure to ensure compliance.
2) Occasionally, reservoirs can be significantly damaged during a storm event and upon investigation the most cost-effective option is to remove them, as was the case for Boltby Reservoir in North Yorkshire (Walker, 2008)

To ‘remove’ or ‘repurpose’ a redundant reservoir an owner must follow a number of procedures and processes. In doing this, it is possible to achieve a wide range of benefits, including environmental and society-focused improvements.

Planning and designing removal or repurposing works is an increasing relevant subject in the UK as discussed by McCulloch (2008) and Hughes and others (2008). The process may be expensive and difficult, so an owner of a dam may wish to consider other ways of disposing of/repurposing the reservoir. This could include selling the reservoir, modifying it for hydropower production or to provide flood protection.

All the potential repurposing or removal options will have benefits and disbenefits to the wider hydrological, environmental, ecological, geomorphological and societal receptors. Assessing these will be crucial in identifying the preferred option.

All reservoirs are unique and, as such, what is the best option/methodology for one reservoir is not necessarily the best option for the next reservoir. The chosen solution will depend on site-specific factors, economic viability and the temporary or final state of the reservoir required. Discontinuance or abandonment within the meaning of reservoir legislation could also be a temporary or interim measure, and these are discussed in the Legal overview /definitions chapter of this document.

Historically, some reservoirs (especially those constructed for water supply) were built following an Act of Parliament. These Acts have bespoke conditions that may state constraints that define what happens to the site should the reservoir no longer be required. Any applicable legal obligations from these Acts should be reviewed and any implications understood early in the removal or repurposing process.

Planning authorities and other bodies with an amenity, flood alleviation, environmental, heritage or recreational interest could object to removing or repurposing a reservoir. Some water-retaining structures have been designated as listed structures, and it is possible that there may be statutory objections to an attempted removal or repurposing. The reservoir removal or repurposing may also be subject to an Environmental and/or Heritage Impact Assessment process. A screening opinion should be sought at an early stage from the planning authority. This document draws attention to other potentially applicable legislation with a view to being helpful, but it does not claim to be comprehensive or applicable to individual cases. Independent legal advice should be sought wherever appropriate.

Removing or repurposing a large raised reservoir in the UK can be a complex process. The Conclusions chapter of this document includes a summary prompt list of the things to consider during the process.

2 Legal overview and definitions

This section sets out the principal statutory provisions. It is designed to be helpful but please note it is neither comprehensive or an authoritative account, and with time may not be entirely up-to-date, so legal advice should be sought where appropriate.

This chapter covers:

- definitions and principles
- legal drivers
- reservoir legislation
- other legislation to consider

2.1 Definitions/principles

This section explains commonly-used, but not statutory terminology. These terms have no legal status but are explained solely to assist readers.

Types of reservoir

"**Online**" reservoirs create a body of water that lies along an existing watercourse and impounds the water from it. These are, therefore, also referred to as 'impounding reservoirs'. Note that some impounding reservoirs that lie along a watercourse may, in fact, be part or majority filled by pumping or diversion of water from elsewhere, but they still lie on the line of an existing watercourse.

"**Offline**" reservoirs create a body of water that lies off the line of a watercourse, for example, as bankside storage. These waterbodies are filled by diverting water to them or by pumping and are, therefore, non-impounding.

Service reservoirs store potable (drinking) water in a completely closed cell, sometimes referred to as 'tanks'.

Abandonment and discontinuance of reservoirs

These are terms defined within the reservoir safety legislation that formalise the removal of the dam. The implications of each term differ within the reservoir safety legislation applicable to each devolved UK country and these are described in the following chapters.

Removal

This term is normally understood as meaning the physical removal of a large raised reservoir so that it is no longer capable of holding water above the natural ground level.

Repurposing

This term is normally understood as meaning the adaptation of a large raised reservoir for a different use. The capacity of the reservoir may not be altered and the structure may remain under reservoir legislation (subject to the Reservoir Act, 1975). This may involve a change in ownership/undertaker/reservoir manager, for example:

- change of use from a water supply reservoir to an amenity resource (fishing, boating, water sports)
- change of use from a water supply reservoir to a flood retention reservoir
- adaption/development for hydropower electricity production
- adaption/development as licensed waste landfill site

Owner

This is a non-statutory term and does not affect interpretation of the RA 1975. “Owner” is normally taken to mean any person who owns a reservoir (or part of one). This can be a different entity to the undertaker, and care should be taken not to conflate the terms.

Undertaker

Welsh and English term under the Reservoirs Act 1975 (England and Wales) for the owner or operator of the reservoir who has ultimate responsibility for the safety of the reservoir. Can be a different entity to the owner. Refer to Section 1(4) of Reservoir Act.

Reservoir manager

Scottish term under the Reservoir (Scotland) Act 2011 and the Reservoir Act (Northern Ireland) 2015 to define the person who has ultimate responsibility for the safety of the reservoir. Can be a different entity to the owner.

Enforcement authority

Term under all devolved UK reservoir safety legislation to denote the bodies that have a duty to ensure the law is observed and that undertakers/reservoir managers comply with the appropriate Acts.

Qualified civil engineer

Term under all devolved UK reservoir safety legislation to denote a civil engineer appointed to one of the panels (for example, All Reservoirs Panel Engineer) set up by the relevant Secretaries of State.

2.2 Legal drivers

All ‘large raised reservoirs/controlled reservoirs’ (those greater than the prescribed threshold value) in England, Wales, Scotland and Northern Ireland are regulated under reservoir legislation that has evolved from the Reservoir (Safety Provisions) Act 1930 (HMSO, 1930). This was enacted with the sole purpose of "preventing the escape of water from a large raised reservoir to avert potential danger to persons and property from such an escape".

The undertaker/owner/reservoir manager must register these large raised reservoirs with the enforcement authority. After the registration process, the enforcement authority will provide a risk classification for the structure. This risk classification considers the resultant impact from an uncontrolled release of water from the reservoir. Other factors (that include those listed here) are considered in the classification process:

- broader impact of flooding from an uncontrolled release of water
- impact on transport infrastructure, agricultural land, environmentally significant sites, sites of cultural heritage
- potential risk to life of people located downstream of the reservoir
- probability of an uncontrolled release of water

The current reservoir legislation thresholds and risk classifications for the devolved UK countries are:

- England**:**
    - Enforcement authority: Environment Agency
    - Threshold: 25,000m^3
    - Risk classifications: high risk/not high risk
- Northern Ireland:
    - Enforcement authority: Department for Infrastructure (DfI)
    - Threshold: 10,000m^3
    - Risk classifications: high/medium/low consequence
- Scotland:
    - Enforcement authority: Scottish Environment Protection Agency (SEPA)
    - Threshold: 25,000m^3
    - Risk classifications: high/medium/low risk
- Wales:
    - Enforcement authority: Natural Resources Wales (NRW)
    - Threshold: 10,000m^3
    - Risk classifications: high risk /not high risk

In some cases, dam owners decide to reduce the capacity of the reservoir below the threshold, which removes it from being subject to the law (Hughes and others, 2008). This practice could increase the risk associated with the structures by leaving systems without the appropriate monitoring. This situation presents a challenge to the current legislation and offers the opportunity to reconsider the problem based on a risk of failure approach instead of the amount of volume that the structures are capable of holding.

The discontinuance of reservoirs in the UK has historically been driven by a practical approach of reducing the capacity of the reservoirs below the threshold set by the legislation. Other countries, such as the United States, have opted more often for restoring the original riverine systems altogether when considering discontinuing reservoirs. This difference in approach is visible in the vocabulary used. In the UK, 'discontinuance' is generally used to indicate that the volume of a reservoir has been reduced below the applicable threshold value, by partially removing the body of the dam, but without suggesting any restoration to the ecological habitat. 'Decommissioning' is an ambiguous term, which usually indicates a dam ceasing operation.

Agreeing arrangements for land access can be a lengthy process (Dunne and others, 2016), especially if access is across another party's land. Once settled, the requirement and conditions of the environment might change during the lifespan of the reservoir. This was the case with the Boltby Reservoir in North Yorkshire, when the dam was damaged during a major flood in 2005. Discontinuing the dam was shown to be the most cost-effective solution. However, completely removing the dam was ruled out by the original lease of land, which required the retention in perpetuity of a minimum of 'half an acre' of water within the reservoir (Walker, 2008).

During the planning of the final state of the discontinuance of Hameldon Reservoir, the location of the excavated material was constrained by the need to minimise land take, and it required compensation to be paid to the landowner to be able to proceed with the works (Edmonds and others, 2010).

There are many legal requirements that need to be addressed when considering the removal/repurposing or discontinuance of a reservoir. These include the modification of water discharge to the watercourse, temporary relocation of fish and tree removal. Planning permission, flood risk assessment, Environmental Impact Assessments and Water Framework Directive (WFD) assessment, are generally required when considering the change of use of a reservoir. Depending on downstream conditions, there may be a requirement to carry out further assessments, for example a Habitats Regulations assessment.

Reservoir legislation

This chapter provides an overview of legislation applicable to reservoirs, with particular emphasis on removing and repurposing them.

Historically, legislation was enacted to enable the construction of reservoirs in conjunction with their associated infrastructure. The potential implications of this are briefly discussed in the appropriate chapter below.

The current reservoir safety legislation has subtle differences between the devolved UK countries. The following chapters provide an overview of the relevant clauses/sections in relation to discontinuance and abandonment of reservoirs from the Reservoirs Act 1975 (England and Wales), the Reservoirs (Scotland) Act 2011 and the Reservoirs Act (Northern Ireland) 2015. These overviews are provided as a guide to confirm the terms and processes for discontinuance and abandonment in the devolved countries.

Appropriate legal advice should be sought to ensure the legislative impacts of the selected removal or repurposing option are understood and mitigated.

Historic reservoir legislation

Historically, the construction of some reservoirs for providing water supply was permitted under bespoke Acts of Parliament that provided permission to construct the reservoir and stipulated any constraints and/or conditions that were to be met. These conditions could cover factors such as:

- compensation releases
- impoundment restrictions
- abstraction limits
- restrictions on abstraction (for example, time periods, minimum river flows)
- restrictions on use of the site

This historic legislation is most probably still enacted in its original form (unless there is proof it has been amended or repealed) and, as such, it may have implications for the available options and processes that need to be completed during any future removal or repurposing of the reservoir.

There may be a requirement to get the original Acts repealed or amended by a new Act if the proposed future use contravenes the incumbent Act.

3 Reservoirs Act 1975 (England and Wales)

This chapter summarises the main sections from the Reservoirs Act 1975 (England and Wales), (HMSO, 1975). Words in “quotation marks” are direct quotes from the legislation.

3.1 Large raised reservoir (SA1(1))

A large raised reservoir is any of the following structures or areas which is capable of holding 25,000 cubic metres [This may be reduced to 10,000 cubic metres, subject to further provisions of the Minister (Schedule 3 & 4 of Statutory Instrument No.1590 (HMSO, 2013))] or more of water above the natural level of any part of the surrounding land:

a) “A large, raised structure designed or used for collecting and storing water; and,
b) A large, raised lake or other area capable of storing water which was created or enlarged by artificial means.”

Exclusions are permitted under SA1(8) and these are detailed in Schedule 3 of Statutory Instrument No.1896 (HMSO, 2013) and listed below.

Specified things not to be treated as large raised reservoirs:

1. “For the purposes of section A1(8) of the Reservoir Act 1975 the following are not to be treated as a large raised reservoir;
    a. A mine lagoon which is tip within the meaning of Part 1 of the Mines and Quarries (tips) Act 1969;
    b. A quarry lagoon which is:
        i. a tip within the meaning of the Quarries Regulations 1999; or,
        ii. a disused tip within the meaning of Part II of the Mines and Quarries (Tips) Act 1969.
    c. a canal or other inland navigation;
    d. a road or railway embankment except where:
        i. the drain or drains through it are artificially blocked for the purposes of using areas upstream to store water; or,
        ii. the drains or drains through it are constructed so that water is stored above natural ground level.
2. Paragraph 1)c) does not include a reservoir which forms part of a canal or other inland navigation.”

3.2 Discontinuance (S13)

Discontinuance of a large raised reservoir requires the undertaker to alter the large raised reservoir in such a way as to ensure that it is no longer capable of holding more than the minimum volume (threshold) of water set out in law. This is a permanent reduction of capacity, with no possibility that the reservoir could fill to more than the reduced capacity.

It should be noted that if the regulatory regime is extended so that it also applies to reservoirs with a capacity of between 10,000m^3 and 25,000m^3, then a currently discontinued reservoir with a capacity of over 10,000m^3 would, in due course, come back under the legislation.

Discontinuance, therefore, covers 2 cases:

1) altering a large raised reservoir to be a raised structure or area; that still stores water above the lowest level of the natural ground. However, the stored capacity is below the threshold capacity defined in law
2) the removal of the entire large raised reservoir by partially or totally removing the impounding structure

No large raised reservoir shall be altered to reduce its capacity to be below the threshold unless a qualified civil engineer is employed to design or approve and to supervise the alterations (S13(1)).

Certificates relating to discontinuance

Interim certificate under Section 13(1A) on discontinuance

The interim certificate must stipulate any (lowered) water level that must not be exceeded during the discontinuance process. The purpose of this certificate is to provide for greater control over the process of reducing the capacity of a reservoir, ensuring that a safe reservoir water level is not exceeded during the execution of the works to reduce the reservoir capacity. The interim certificate for discontinuance can be updated with amendments to the water level as works progress, or the water level can be reduced to zero from the outset.

Schedule 4 of Statutory Instrument 2013 No.1677 (HMSO, 2013) provides details of the wording and inclusions required in the certificate and this is reproduced below for reference.

Example certificate wording

Reservoir Act 1975

Interim certificate under Section 13(1A) on discontinuance:

I (a) of (b), being a member of the (c), appointed by (d) to [design][approve] and to supervise the alteration of the reservoir known as € situated at (f), so as to render it incapable of holding more than (t) cubic metres of water above the natural level of any part of the land adjoining it, consider that the level of the water in the reservoir should be reduced up to a level of (g) by (u) [subject to the following conditions (j)]

Signature of Engineer:

Date of Certificate:

Where: (a) name of engineer; (b) address of engineer; (c) name of panel to which engineer is appointed; (d) name of undertakers; (e) name of reservoir; (f) situation of reservoir; (t) volume of water; (g) level above ordnance datum to which water may be filled; (u) the time by which the water must be reduced; (j) conditions subject to which the reservoir may be filled with water or water may be stored up to the level specified.

Certificate under Section 13(2) on discontinuance

The final discontinuance certificate is issued by the qualified civil engineer (QCE) under the Reservoirs Act 1975 to confirm the alterations have been efficiently executed. Once the enforcement authority receives a copy of the final certificate associated with discontinuance, it is required to remove the reservoir from the register of large raised reservoirs.

Without the issue of a final certificate associated with discontinuance signed by the appointed QCE, the reservoir is not considered to be discontinued and remains within the definition of a large raised reservoir and under the ambit of the Act.

Schedule 4 of Statutory Instrument 2013 No.1677 (HMSO, 2013) provides details of the wording and inclusions required in the certificate and this is reproduced below for reference.

Example certificate wording

Reservoir Act 1975

Certificate under Section 13(2) on discontinuance:

I (a) of (b), being a member of the (c), appointed by (d) to [design][approve] and to supervise the alteration of the reservoir known as € situated at (f), so as to render it incapable of holding more than (t) cubic metres of water above the natural level of any part of the surrounding land, am satisfied that the alteration has been completed and has been efficiently executed.

Signature of Engineer:

Date of Certificate:

Where: (a) name of engineer; (b) address of engineer; (c) name of panel to which engineer is appointed; (d) name of undertakers; (e) name of reservoir; (f) situation of reservoir; (t) volume of water.

Implications

In all circumstances if an existing large raised reservoir is discontinued:

- it is no longer recorded as a large raised reservoir under the Reservoirs Act 1975

- the reservoir will still have an undertaker who is responsible for its safety and has liability under common law if it retains water, but it will no longer be subject to the requirements of the Reservoir Act 1975

3.3 Abandonment (S14)

Abandonment of a large raised reservoir involves emptying the reservoir of water and undertaking remedial works to ensure the reservoir is incapable of filling accidentally or naturally, or is only capable of filling to an extent that does not constitute a risk. The reservoir will still be physically capable of holding in excess of 25,000 cubic metres of water. It is not normally feasible to abandon an impounding reservoir.

Abandonment, therefore, covers:

- the reservoir normally remaining structurally intact, but incapable of filling. An example is a service reservoir which is isolated on the inlet and outlet from the distribution system.

Certificates relating to abandonment

Certificate under Section 14(3) on abandonment

The certificate is issued by the qualified civil engineer (QCE) under the Reservoirs Act 1975 along with his report and states whether the report does or does not recommend any measures to be taken in the interests of safety.

Schedule 4 of Statutory Instrument 2013 No.1677 (HMSO, 2013) provides details of the wording and inclusions required in the certificate and this is reproduced below for reference.

Example certificate wording

Reservoir Act 1975

Certificate under Section 14(3) on abandonment:

I (a) of (b), being a member of the (c), appointed by (d) to give a report as to the measures (if any) that ought to be taken in the interests of safety to secure that the reservoir known as € situated at (f), is incapable of filling accidently or naturally with water above the natural level of any part of the land adjoining the reservoir or is only capable of doing so to an extent that does not constitute a risk, have today given a report under Section 14(1) of the Act which [does not include][includes] recommendations for measures to be taken in the interests of safety.

Signature of Engineer:

Date of Certificate:

Where: (a) name of engineer; (b) address of engineer; (c) name of panel to which engineer is appointed; (d) name of undertakers; (e) name of reservoir; (f) situation of reservoir.

Certificate under Section 14 as to the carrying out of safety recommendations

On completion of any safety measures this certificate is issued by the qualified civil engineer (QCE) under the Reservoirs Act 1975, stating that the measures in the interest of safety have been completed.

There is currently no prescribed wording for this certificate available. It is suggested (ICE, 2014) that the wording of the Section 10(6) certificate in Schedule 4 of SI 2013 No.1677 (HMSO, 2013), be used with the title modified to be 'Certificate under Section 14' and a footnote be added with wording to the effect that the certificate does not accord with any current regulation. An example has been produced from the available wording and is reproduced below for reference.

It is considered preferable that a certificate is prepared and issued to the undertaker and copied to the enforcement authority.

Example certificate wording

Reservoir Act 1975

Certificate under Section 14[1] as to the carrying out of safety recommendations:

I (a) of (b), being a member of the (c), appointed by (d) to supervise the carrying into effect at the reservoir known as € situated at (f), of measures taken in the interests of safety recommended in a report made on (n) by (o), am satisfied that those measures have been carried into effect.

Signature of Engineer:

Date of Certificate:

[1]The certificate does not accord with any current legislation

Where: (a) name of engineer; (b) address of engineer; (c) name of panel to which engineer is appointed; (d) name of undertakers; (e) name of reservoir; (f) situation of reservoir; (n) date of inspecting engineer's report; (o) name of inspecting engineer.

Implications

In all circumstances if an existing large raised reservoir is abandoned:

- it still remains registered as a large raised reservoir and is subject to the provisions of the Reservoir Act 1975
- if the reservoir is designated high risk, it will require that the appropriate supervision and periodic inspections continue to:

    - ensure the measures put in place to prevent the reservoir from filling and posing a risk are performing as expected
    - periodically review the suitability and adequacy of the measures
- if a periodic inspection report identities works required as measures in the interest of safety, the undertaker receiving the report shall, within the period specified in the report, carry the recommendations into effect; and if the recommendation involves any alteration of the reservoir, Section 13 shall apply accordingly

However, the benefits are that:

- any risk posed by the full reservoir is reduced
- the construction cost of abandonment may be less than the cost of discontinuance
- the reservoir can be returned to use if required (subject to compliance with Section 9 of the Reservoir Act 1975)

4 Reservoirs (Scotland) Act 2011

This chapter summarises the main sections from the Reservoirs (Scotland) Act 2011, (TSO, 2011). To note: words in “quotation marks” are direct quotes from the legislation.

4.1 Controlled reservoir (S1 (2))

“A controlled reservoir is any of the following structures or areas which is capable of holding 10,000” [25,000 - only reservoirs in Scotland with a capacity of 25,000 or more cubic metres are currently regulated by SEPA. At some point the regime will be extended so that it also applies to reservoirs with a capacity of between 10,000 and 25,000 cubic metres] “cubic metres or more of water above the natural level of any part of the surrounding land:

a) a structure designed or used for collecting and storing water
b) an artificial (or partly artificial) loch or other artificial (or partly artificial) area”

4.2 Controlled reservoirs: supplementary (S2)

Subsection (1) provides further details of what is classified as a controlled reservoir, while subsection (2) lists structures or areas that are not classified as controlled structures and these are reproduced below for reference.

a) “ponds within extractive waste sites or waste facilities
b) canals or other inland waterways
c) weirs
d) structures or areas of water designed to protect land from the sea
e) sewage sludge lagoons
f) road and railway embankments
g) embanked watercourses”

General requirements for undertaking relevant works on controlled reservoirs

When undertaking relevant works (defined in S32 *(7)(e)* “as any works carried out for the purpose of the construction or alteration of a controlled reservoir”), there is a requirement to appoint a construction engineer (S33 (3)).

The construction engineer is appointed to supervise the works until the final certificate is issued. The construction engineer is also required to issue a preliminary certificate (to define the maximum water level in the reservoir during the relevant works) and the construction certificate (formal confirmation that the relevant works have been executed to the satisfaction of the construction engineer) in addition to the appropriate final certificate.

Preliminary certificates (S37)

A preliminary certificate must stipulate any (lowered) water level that must not be exceeded during the discontinuance or abandonment process. The purpose of this certificate is to provide for greater control over the process of reducing the capacity of a reservoir, ensuring that a safe reservoir water level is not exceeded during the execution of the works to reduce the reservoir capacity. The preliminary certificate issued during the relevant works to discontinue or abandon a reservoir can be updated with amendments to the water level as works progress, or the water level can be reduced to zero from the outset.

Schedule 8 of Scottish Statutory Instrument 2016 No.43 Part 1 (TSO, 2016) provides details of the wording and inclusions required in the certificate and this is reproduced below for reference.

Example certificate

PRELIMINARY CERTIFICATE BY CONSTRUCTION ENGINEER

UNDER SECTION 37(1) OF THE RESERVOIRS (SCOTLAND) ACT 2011

Reservoir registration number: [insert reservoir registration number as specified in the

controlled reservoirs register]

I [insert name of engineer] of [insert address of engineer] being a member of [insert name of panel to which engineer is appointed], appointed to supervise the relevant works for the purpose of [the construction (including restoration to use)][the alteration (not amounting to the discontinuance or the abandonment)][the abandonment][the discontinuance] (delete as appropriate) of a controlled reservoir [known as [insert name of reservoir]] (delete if the reservoir has no name) located at [insert location of reservoir, with sufficient detail to identify it (including the national grid reference for the approximate centre of the reservoir)], am satisfied that [the reservoir may be safely filled (wholly or partially) with water.] [the level of water in the reservoir should be reduced.] (delete as appropriate)

The level of water held in the reservoir must not exceed [insert the level (above ordnance datum) that the water in the reservoir must not exceed] (the "specified level"). The reservoir manager must ensure that the level of water in the reservoir does not exceed the specified level.

[The following requirements are imposed as to the manner in which the level of water in the reservoir may be increased or decreased:

[insert requirements that the engineer considers appropriate as to the manner in which the level of water in the reservoir may be increased or decreased].] (delete if no requirements imposed)

This certificate:

replaces any previous preliminary certificate applicable to the reservoir in respect of the relevant works; and

ceases to have effect on the issue of the final certificate applicable to the reservoir in respect of those works.

Signature of engineer

Date signed

Construction certificate (S38)

The purpose of the construction certificate is to formally acknowledge that the relevant works have been executed to the satisfaction of the construction engineer. The construction certificate must be issued no later than the final certificate in relation to the relevant works and must include an annex containing detailed drawings and descriptions giving full information of the completed relevant works.

Schedule 9 of Scottish Statutory Instrument 2016 No.43 Part 1 (TSO, 2016) provides details of the wording and inclusions required in the certificate and this is reproduced below for reference.

Example certificate

CONSTRUCTION CERTIFICATE BY CONSTRUCTION ENGINEER

UNDER SECTION 38(1) OF THE RESERVOIRS (SCOTLAND) ACT 2011 Reservoir registration number: [insert reservoir registration number as specified in the controlled reservoirs register]

I [insert name of engineer] of [insert address of engineer] being a member of [insert name of panel to which engineer is appointed], appointed to supervise relevant works for the purpose of [the construction (including restoration to use)][the alteration (not amounting to the discontinuance or the abandonment)] [the abandonment][the discontinuance] (delete as appropriate) of a controlled reservoir [known as [insert name of reservoir]] (delete if the reservoir has no name) located at [insert location of reservoir, with sufficient detail to identify it (including the national grid reference for the approximate centre the reservoir)] [for which a preliminary certificate was given on [insert date of certificate]] (delete if no preliminary certificate given), being satisfied that the relevant works have been completed to a satisfactory standard, certify that the construction or, as the case may be, the alteration has been executed effectively in accordance with the detailed drawings and descriptions (see Note) in the annex to this certificate.

Signature of engineer

Date signed

Note

In accordance with Section 38(3)(b) of the Reservoirs (Scotland) Act 2011, the drawings and descriptions must give full information about the works for the construction or, as the case may be, the alteration including the dimensions, water levels and details of geological strata or deposits encountered in trial holes or excavations made in connection with the works.

4.3 Discontinuance (S32 (5))

"Alteration of a controlled reservoir amounts to discontinuance of a controlled reservoir where the alteration is for the purpose of making the reservoir incapable of holding 10,000 [25,000] cubic metres of water above the natural level of any part of the surrounding land (but still capable of holding water above the natural level of any part of that land)."

In accordance with S33(2), a construction engineer (as defined by Section 33(3) of the Reservoirs (Scotland) Act 2011) should be appointed to supervise the relevant works until a final certificate is issued.

Final certificate for discontinuance (S39 (3))

The construction engineer issues the final certificate of discontinuance to confirm the alterations have been efficiently executed. Once the enforcement authority receives a copy of the final certificate associated with discontinuance, it is required to remove the reservoir from the Controlled Reservoirs Register.

Without the final certificate of discontinuance, the reservoir is not considered to be discontinued and remains on the Controlled Reservoirs Register and under the ambit of the Reservoirs (Scotland) Act.

Schedule 10 of Scottish Statutory Instrument 2016 No.43 Part 2 (TSO, 2016) provides details of the wording and inclusions required in the certificate and this is reproduced below for reference.

Example certificate

FINAL CERTIFICATE BY CONSTRUCTION ENGINEER

UNDER SECTION 39(3) OF THE RESERVOIRS (SCOTLAND) ACT 2011

Reservoir registration number: [insert reservoir registration number as specified in the controlled reservoirs register] I [insert name of engineer] of [insert address of engineer] being a member of [insert name of panel to which engineer is appointed], appointed to supervise relevant works for the purpose of the discontinuance of a controlled reservoir [known as [insert name of reservoir]] (delete if the reservoir has no name) located at [insert location of reservoir, with sufficient detail to identify it (including the national grid reference for the approximate centre of the reservoir)], am satisfied:

that the discontinuance has been safely completed, that the resulting structure is incapable of holding [insert relevant figure) (see Note (1)) cubic metres of water above the natural level of any part of the surrounding land, and

that the resulting structure or area is sound and satisfactory and may safely be used for the collection and storage of water.

The level of water held in the reservoir must not exceed [insert the level (above ordnance datum) that the water in the reservoir must not exceed] ("the specified level"). The reservoir manager must ensure that the level of water in the reservoir does not exceed the specified level. [The following requirements are imposed as to the manner in which the level of the water in the reservoir may be increased or decreased: -[insert requirements that the engineer considers appropriate as to the manner in which the level of water in the reservoir may be increased or decreased).] (delete if there are no such requirements) A copy of the construction certificate issued in respect of the construction or (as the case may be) alteration on [insert date on which the construction certificate was issued] is attached to this final certificate (see Note (2)).

Signature of engineer

Date signed

Notes

(1) By virtue of Article 3(1) ("the article") of the Reservoirs (Scotland) Act 2011 (Commencement No. 5 and Transitional Provision) Order 2016, the relevant figure is "25,000 until the day on which Section 12 of the Reservoirs (Scotland) Act 2011 ("the 2011 Act") is commenced for all purposes. From that day onwards, the modifications made by the article to Section 39(3)(b) of the 2011 Act will no longer apply and, in consequence, the relevant figure will be "10,000". (2) in accordance with Section 39(8) of the 2011 Act, a copy of the construction certificate must be attached.

Implications

In all circumstances if an existing controlled reservoir is discontinued, it:

- is no longer regulated under the Reservoirs (Scotland) Act 2011
- is not required to be supervised or inspected
- is removed from the Controlled Reservoirs Register
- no longer falls under SEPA’s Reservoir Charging Scheme

4.4 Abandonment (S32 (6))

“Alteration of a controlled reservoir amounts to abandonment of a controlled reservoir where the alteration is for the purpose of making the reservoir incapable of filling with water above the natural level of any part of the surrounding land.”

In accordance with S33(2), a construction engineer (as defined by Section 33(3) of the Reservoirs (Scotland) Act 2011) should be appointed to supervise the relevant works until a final certificate is issued.

Final certificate for abandonment (S39 (5))

The construction engineer issues the final certificate of abandonment to confirm the alterations have been efficiently executed. Once the enforcement authority receives a copy of the final certificate associated with abandonment, it may or may not (depending on the type of structure abandoned) remove the reservoir from the Controlled Reservoirs Register.

Without the final certificate of abandonment, the reservoir is not considered to be abandoned.

Schedule 10 of Scottish Statutory Instrument 2016 No.43 Part 3 (TSO, 2016) provides details of the wording and inclusions required in the certificate and this is reproduced below for reference.

Example certificate

FINAL CERTIFICATE BY CONSTRUCTION ENGINEER

UNDER SECTION 39(5) OF THE RESERVOIRS (SCOTLAND) ACT 2011

Reservoir registration number: [insert reservoir registration number as specified in the controlled reservoirs register] I [insert name of engineer] of [insert address of engineer] being a member of [insert name of panel to which engineer is appointed], appointed to supervise relevant works for the purpose of the abandonment of a controlled reservoir [known as [insert name of reservoir]] (delete if the reservoir has no name) located at [insert location of reservoir, with sufficient detail to identify it (including the national grid reference for the approximate centre of the reservoir)], am satisfied:

- that the abandonment has been safely completed
- that the resulting structure is incapable of filling with water above the natural level of any part of the surrounding land

A copy of the construction certificate issued in respect of the construction or (as the case may be) alteration on [insert date on which the construction certificate was issued] is attached (see Note).

Signature of engineer

Date signed

Note

In accordance with Section 39(8) of the Reservoirs (Scotland) Act 2011, a copy of the construction certificate must be attached.

Implications

For controlled reservoirs that are abandoned the situation is different in that they may or may not remain regulated under the Reservoirs (Scotland) Act 2011 and this depends on the nature of the ‘abandonment’ as discussed below:

Example 1: Controlled reservoir is altered to totally remove the dam structure so it is incapable of holding any water.

This site would be ‘abandoned’ and the construction engineer would issue a final certificate under Section 39 (5). The reservoir no longer meets the definition of a controlled reservoir and it will be removed from the Controlled Reservoirs Register and no longer falls under the remit of the Reservoirs (Scotland) Act 2011.

Example 2: A service (offline) reservoir is isolated from the inlet pipework (by removal/cutting), with the result that no water can enter the reservoir. The dam structure remains intact and is capable of holding 25,000m^3 of water above natural ground level. The outlet pipework has been modified, so that any water entering the reservoir will drain, preventing the reservoir from holding water at the present time.

The site would be ‘abandoned’ and the construction engineer would issue a final certificate under Section 39 (5). The reservoir remains intact and has the potential to hold 25,000m^3 of water above the natural level of any part of the surrounding land should the outlet pipework block or the pipes collapse. The site still meets the definition of a controlled reservoir and will remain under the ambit of the Reservoirs (Scotland) Act 2011.

Example 3: An impounding reservoir is altered by removing its outlet draw-off and scour valves, or fixing them in an open position, but there are no other changes made to the structure.

As water will still enter the reservoir, the construction engineer would need to carefully consider whether or not the reservoir could be classed as ‘abandoned’. Unless the construction engineer can be convinced that there is minimal inflow to the reservoir basin and there is no likelihood of the outlets blocking in some way, it is unlikely to be appropriate to issue a certificate of abandonment in this case.

However, if, for example, there is a by-wash channel with a design capacity capable of diverting the design and safety check flood flows around the reservoir such that inflow to the reservoir from the direct catchment is minimal, the construction engineer may consider the reservoir to be ‘abandoned’. In these circumstances, it should only be considered as abandonment if the construction engineer is satisfied that the reservoir is incapable of filling and holding any water above the natural level of any part of the surrounding land. In this case, as the reservoir no longer meets the definition of a controlled reservoir, it would be removed from the Controlled Reservoirs Register and no longer be under the ambit of the Reservoirs (Scotland) Act 2011.

5 Reservoirs Act (Northern Ireland) 2015

This chapter summarises the main sections from the Reservoirs Act (Northern Ireland) 2015, (TSO, 2015). (words in "quotation marks" are direct quotes from the legislation).

5.1 Controlled reservoirs (S1)

"A controlled reservoir is any of the following structures or areas which is capable of holding 10,000 cubic metres or more of water above the natural level of any part of the surrounding land:

a) a structure designed or used for collecting and storing water;
b) a lake or other area created or enlarged by artificial means, the artificial creation or enlargement having been designed, or the lake or other area so created or enlarged being used, for collecting and storing water."

5.2 Controlled reservoirs: supplementary (S5)

Subsection (1) provides further details of what is classified as a controlled reservoir, while subsection (2) lists structures or areas that are not classified as controlled structures and these are reproduced below for reference:

a) "a canal or other inland waterway;
b) an embanked watercourse;
c) a road or railway embankment which is not integral to the functioning or operation of a controlled reservoir;
d) a weir which does not serve a functional or operational purpose as regards a controlled reservoir;
e) a structure or area of water which protects land from the sea;
f) a pond within an extractive waste site or other waste facility;
g) a sewage sludge lagoon or other waste water treatment lagoon;
h) an ash, silt or sludge lagoon used for the purpose of a mine or power generation;
i) a lagoon for the storage of chemical materials or their waste products;
j) a slurry tank."

General requirements for undertaking relevant works on controlled reservoirs

When undertaking relevant works (defined in S42 as any works carried out for the purpose of the construction or alteration of a controlled reservoir), there is a requirement to appoint a construction engineer (S43 (3)).

The construction engineer is appointed to supervise the works until the final certificate is issued. The construction engineer may issue a preliminary certificate (to define the maximum water level in the reservoir during the relevant works) and is required to issue a construction certificate (formal confirmation that the relevant works have been executed to the satisfaction of the construction engineer) in addition to the final certificates of discontinuance or abandonment.

Preliminary certificate (S47)

The construction engineer may issue a preliminary certificate to provide greater control over the process of reducing the capacity of the reservoir, ensuring that a safe reservoir water level is not exceeded during the execution of the works to reduce the reservoir capacity.

A preliminary certificate must stipulate any (lowered) water level that must not be exceeded during the discontinuance or abandonment process. The preliminary certificate issued during the relevant works to discontinue or abandon a reservoir can be updated with amendments to the water level as works progress, or the water level can be reduced to zero from the outset.

The prescribed wording for the preliminary certificate is provided in S47(2) and this has been used to produce the example certificate below for reference.

Example certificate

RESERVOIRS ACT (NORTHERN IRELAND) 2015

PRELIMINARY CERTIFICATE SECTION 47(1)

I [insert name of engineer] of [insert address of engineer] being a member of [insert name of panel to which engineer is appointed], appointed to supervise the relevant works for the purpose of [the construction (including restoration to use)] [the alteration (not amounting to the discontinuance or the abandonment)] [the abandonment][the discontinuance] (delete as appropriate) of a controlled reservoir [known as [insert name of reservoir]] (delete if the reservoir has no name) located at [insert location of reservoir, with sufficient detail to identify it (including the national grid reference for the approximate centre of the reservoir)], am satisfied that [the reservoir may be safely filled (wholly or partially) with water.] [the level of water in the reservoir should be reduced.] (delete as appropriate).

The level of water held in the reservoir must not exceed [insert the level (above ordnance datum) that the water in the reservoir must not exceed] (the "specified level"). The reservoir manager must ensure that the level of water in the reservoir does not exceed the specified level.

[The following requirements are imposed as to the manner in which the level of water in the reservoir may be increased or decreased:

-[insert requirements that the engineer considers appropriate as to the manner in which the level of water in the reservoir may be increased or decreased].] (delete if no requirements imposed)

This certificate:

- replaces any previous preliminary certificate applicable to the reservoir in respect of the relevant works; and
- ceases to have effect on the issue of the final certificate applicable to the reservoir in respect of those works

Signature of Engineer.

Date of Certificate.

Construction certificate (S48)

The purpose of the construction certificate is to formally acknowledge that the relevant works have been executed to the satisfaction of the construction engineer. The construction certificate must be issued no later than the final certificate in relation to the relevant works and must include an annex containing detailed drawings and descriptions giving full information of the completed relevant works.

The prescribed wording for the preliminary certificate is provided in S48(3) and this been used to produce the example certificate below for reference.

Example certificate

RESERVOIRS ACT (NORTHERN IRELAND) 2015

CONSTRUCTION CERTIFICATE SECTION 48(1)

I [insert name of engineer] of [insert address of engineer] being a member of [insert name of panel to which engineer is appointed], appointed to supervise relevant works for the purpose of [the construction (including restoration to use)][the alteration (not amounting to the discontinuance or the abandonment)][the abandonment][the discontinuance) (delete as appropriate) of a controlled reservoir [known as [insert name of reservoir]] (delete if the reservoir has no name) located at [insert location of reservoir, with sufficient detail to identify it (including the national grid reference for the approximate centre the reservoir)] [for which a preliminary certificate was given on [insert date of certificate)] (delete if no preliminary certificate given), being satisfied that the relevant works have been completed to a satisfactory standard, certify that the construction or, as the case may be, the alteration has been executed effectively in accordance with the detailed drawings and descriptions in the annex to this certificate.

Signature of Engineer

Date of Certificate

Discontinuance (partial decommissioning) (S41 (5))

“Alteration of a controlled reservoir amounts to discontinuance of a controlled reservoir where the alteration is for the purpose of making the reservoir incapable of holding 10,000 cubic metres of water above the natural level of any part of the surrounding land (but still capable of holding water above the natural level of any part of that land).”

This may involve lowering a dam spillway, or breaching an embankment. Such works must be supervised and certified by a construction engineer.

Final certificate for discontinuance (S49 (3))

The construction engineer issues the final certificate of discontinuance to confirm the alterations have been efficiently executed. Once the enforcement authority receives a copy of the final certificate associated with discontinuance, it is required to remove the reservoir from the Controlled Reservoirs Register.

Without the final certificate of discontinuance, the reservoir is not considered to be discontinued and remains on the Controlled Reservoirs Register and under the ambit of the Reservoirs Act (Northern Ireland) 2015.

The prescribed wording for the preliminary certificate is provided in S49(3) and this has been used to produce the example certificate below for reference.

Example certificate

RESERVOIRS ACT (NORTHERN IRELAND) 2015

FINAL CERTIFICATE SECTION 49(3)

I [insert name of engineer] of [insert address of engineer] being a member of [insert name of panel to which engineer is appointed], appointed to supervise relevant works for the purpose of the discontinuance of a controlled reservoir [known as [insert name of reservoir]] (delete if the reservoir has no name) located at [insert location of reservoir, with sufficient detail to identify it (including the national grid reference for the approximate centre of the reservoir)], am satisfied:

- that the discontinuance has been safely completed,
- that the resulting structure is incapable of holding [insert relevant figure) cubic metres of water above the natural level of any part of the surrounding land, and
- that the resulting structure or area is sound and satisfactory and may safely be used for the collection and storage of water

The level of water held in the reservoir must not exceed [insert the level (above ordnance datum) that the water in the reservoir must not exceed] ("the specified level"). The reservoir manager must ensure that the level of water in the reservoir does not exceed the specified level.

[The following requirements are imposed as to the manner in which the level of the water in the reservoir may be increased or decreased: -

[insert requirements that the engineer considers appropriate as to the manner in which the level of water in the reservoir may be increased or decreased].] (delete if there are no such requirements).

A copy of the construction certificate issued in respect of the construction or (as the case may be) alteration on [insert date on which the construction certificate was issued] is attached to this final certificate.

Signature of Engineer

Date of Certificate

Implications

In all circumstances if the controlled reservoir is discontinued:

- it is no longer regulated under the Reservoirs Act (Northern Ireland) 2015
- the structure can be returned to Controlled Reservoir status subject to compliance with Section 41(3) of the Reservoirs Act (Northern Ireland) 2015

5.3 Abandonment (full decommissioning) (S41 (6))

"Alteration of a controlled reservoir amounts to abandonment of a controlled reservoir where the alteration is for the purpose of making the reservoir incapable of filling with water above the natural level of any part of the surrounding land."

This may include removing an embankment. Such works must be supervised and certified by a construction engineer.

Final certificate for abandonment (S49 (5))

The construction engineer issues the final certificate of abandonment to confirm the alterations have been efficiently executed. Once the enforcement authority receives a copy of the final certificate associated with abandonment, it is required to remove the reservoir from the Controlled Reservoirs Register.

Without the final certificate of abandonment, the reservoir is not considered to be abandoned.

The prescribed wording for the preliminary certificate is provided in S49(3) and this has been used to produce the example certificate below for reference.

Example certificate

RESERVOIRS ACT (NORTHERN IRELAND) 2015

FINAL CERTIFICATE SECTION 49(5)

I [insert name of engineer] of [insert address of engineer] being a member of [insert name of panel to which engineer is appointed], appointed to supervise relevant works for the purpose of the abandonment of a controlled reservoir [known as [insert name of reservoir]] (delete if the reservoir has no name) located at [insert location of reservoir, with sufficient detail to identify it (including the national grid reference for the approximate centre of the reservoir)], am satisfied:

- that the abandonment has been safely completed; and
- that the resulting structure is incapable of filling with water above the natural level of any part of the surrounding land.

A copy of the construction certificate issued in respect of the construction or (as the case may be) alteration on [insert date on which the construction certificate was issued] is attached.

Signature of Engineer

Date of Certificate

Implications

In all circumstances if the controlled reservoir is abandoned:

- it is no longer regulated under the Reservoirs Act (Northern Ireland) 2015
- the structure can be returned to Controlled Reservoir status subject to compliance with Section 41(3) of the Reservoirs Act (Northern Ireland) 2015

5.4 Current reservoir legislation summary

As illustrated in the above chapters there are subtle differences between the reservoir safety legislation of the devolved countries. These differences in relation to discontinuance and abandonment have been tabulated and included in Appendix A – Comparison of legal terms.

6 Other legislation to consider

The legal considerations that commonly apply to discontinuance or repurposing are summarised below. This list is not comprehensive; other statutory instruments/legislation may apply, and you should seek specialist advice if in doubt. Information and guidance on consents/permits and health and safety is given in the Planning, procedures and permissions and Remedial works chapters. Following the departure of the UK from the EU, the UK retained some of the legislation and directives that were developed by the EU.

A 2014 legal challenge (Hampstead Heath Society v City of London) was brought to question the validity of the remedial works prescribed as statutory measure under Section 10 of the Reservoir Act 1975 (Hughes, A.K., 2016). During this challenge, the residing Judge (Lord Justice Lang) reviewed the meaning of the Reservoirs Act and its necessity in the legal framework. He concluded that: 52. “In my judgment, the Defendant was correct to submit that the purpose of the RA 1975 is to prevent the escape of water from large raised reservoirs to avert the potential danger to persons and property from such an escape. Its purpose is not to mitigate the effects of an escape, by flood warning and evacuation strategies.” (EWHC 3868 (Admin), 2014).

73. “Neither the RA 1975, nor the ICE guidance, provides for the inspecting engineer to balance considerations of safety against competing factors such as preservation of the landscape, protection of the environment, or heritage assets. In my view, it would have been evident to Government and Parliament when the 1975 Act was passed that reservoirs and dams are situated in a wide variety of locations, including areas of outstanding beauty, and in the case of ornamental lakes, in historic settings close to heritage assets. This knowledge would also be available to the authors of the ICE guidance. So it is significant that the only legislative consideration is public safety.” (EWHC 3868 (Admin), 2014)

6.1 Health and safety

In the UK, health and safety legislation is always applicable and enshrines statutory obligations on the owners/undertakers/reservoir managers in the operation and use of the reservoir. The legislation is in place to protect any person who may be on the site whether lawfully or unlawfully. Health and safety legislation is discussed further in the Planning, procedures and permissions and Remedial works chapters. The legislations concerned are:

EU Health and Safety Directive (EEC,1989) and delegated legislation (including CDM Regulations 2015) - Aims to protect people from health and safety risks arising from construction work. Places duties on clients, designers and contractors during design and construction projects. Note that although this legislation originates from the EU, this has been retained in UK law following the exit of the UK from the EU.

Health and Safety at Work etc. Act 1974 (HMSO, 1974) – Aims to secure the health, safety and welfare of people at work, and to protect others from health or safety risks connected with the activities of people at work. Places duties on both employers and employees.

Occupiers' Liability Act 1957 (HMSO, 1957) and 1984 (HMSO, 1984) – Defines occupiers' liability to people or things that are present on land or property (whether lawfully or unlawfully), for injury or damage resulting from actions or omissions.

Corporate Manslaughter and Corporate Homicide Act 2007 (HMSO, 2007) – Defines corporate manslaughter, a criminal offence. Organisations may be found guilty when serious management failings result in a gross breach of duty of care leading to fatality.

6.2 Environmental

Removal of or change to a reservoir may have both in-construction and longer term effects on the environment, which are covered by legislation listed below.

Given that reservoir construction can be a major disturbance to the environment, removing a reservoir or a reduction in reservoir capacity might be thought of as reinstating an environment to something more like its natural state. However, benefits cannot be presumed. This general principle is likely to be complicated in a largely man-made landscape. The process of discontinuance may cause disruption in the short term and, even in the long term, the environment may not necessarily revert back towards its pre-impounded state. Nor may this be desirable. For example, reservoirs may shelter rare species or present a barrier to invasive species. Reservoirs may also be designated as Sites of Special Scientific Interest because their construction has been of benefit to species warranting protection. Abberton Reservoir in Essex, for example, is designated as of international importance as a haven for wild ducks, swans and other water birds. The River Derwent at Hathersage is designated as a geological Site of Special Scientific Interest due to the response of the river to upstream impoundment.

In England, undertakers need to liaise with the Environment Agency (and Natural England if protected sites are involved). In Wales, Natural Resources Wales (NRW) should be consulted; in Scotland, the Scottish Environmental Protection Agency (SEPA) and in Northern Ireland, the Department for Infrastructure. Note that although much environmental legislation originates from the EU, a lot of this has been retained in UK law following the exit of the UK from the EU. These are:

Environment Act 2021 – Sets clear statutory targets in 4 priority areas: air quality, biodiversity, water and waste, to drive the recovery of the natural world. Includes a target to reverse the decline in species abundance by 2030 and provides new legislative tools that Natural England and others can use to achieve the targets.

Environment Act 1995 – Aims to address a wide range of environmental issues. Establishes and places duties on the Environment Agency, Natural Resources Wales

(NRW) and Scottish Environment Protection Agency (SEPA) to protect or enhance the environment (including buildings, sites and objects of archaeological, architectural, engineering or historic interest) and to contribute towards sustainable development (subject to and in line with other legal provisions and taking into account costs).

Town and Country Planning (Environmental Impact Assessment) Regulations 2017 – Provides protection to the environment, by offering a procedure for identifying, assessing, consulting and coming to a decision on those projects that have a significant effect on the environment and, therefore, should be subject to an Environmental Impact Assessment.

Countryside and Rights of Way (CROW) Act 2000 - Provides public access to open country and registered common land. Places duties on relevant authorities to conserve and enhance the natural beauty in Areas of Outstanding Natural Beauty in exercising or performing their functions.

Natural Environment and Rural Communities (NERC) Act 2009 - Aims to conserve, enhance and manage the natural environment for the benefit of present and future generations. Places duties on Natural England and public bodies to conserve and enhance biodiversity where consistent with their functions.

Environmental Damage Regulations 2009 - Aims to protect natural habitat and resources. Places duties on operators to take practicable steps to prevent environmental damage to protected species, habitats, water bodies or land (for example, by causing pollution).

EU Habitats Directive and delegated legislation - Aims to conserve rare or threatened flora and fauna, and natural habitats, including Special Areas of Conservation (SACs), Special Protection Areas (SPAs) and Ramsar sites. Places duties on nature conservation bodies and public authorities. Note that because of the need to conserve endangered species, designated sites require a high degree of certainty that reservoir decommissioning would not impact on species within, upstream or downstream of a reservoir prior to decommissioning.

EU Birds Directive and delegated legislation (See also Wildlife and Countryside Act 1981) - Aims to protect all wild bird species and to preserve, maintain or re-establish sufficient diversity and area of habitat. Resulted in the designation of Special Areas of Conservation (SACs) and Special Protection Areas (SPAs). Note that because of the need to conserve endangered species, designated sites require a high degree of certainty that reservoir decommissioning would not impact on species within, upstream or downstream of a reservoir prior to decommissioning.

Wildlife and Countryside Act 1981 (as amended) - Aims to protect wild birds, animals, plants and habitats, and to prevent the establishment of invasive non-native species. Makes it an offence to capture, kill, disturb or trade in birds, eggs or their nests, or to intentionally kill, injure or take wild animals. Places duties on landowners and conservation bodies to protect nature conservation sites such as Sites of Special Scientific Interest

(SSSI). The Wildlife and Countryside Act 1981 was enacted as the primary legislation to protect native animals, birds, flora and fauna, especially those at threat. It also defines as an offence releasing or allowing the escape of any non-native specifies to the wild.

Infrastructure Act 2015 - Aims to control invasive non-native species. Environmental authorities may compel landowners to take action or enter land to take action on invasive non-native species.

Salmon and Freshwater Act 1975 - Aims to protect fish. Makes it an offence to cause direct mortality or habitat degradation, obstruct or impede migration, or allow harmful matter to enter watercourses.

European Eel Regulations - Aims to recover eel stocks. Makes it an offence to cause mortality or obstruct eel passage. Anyone impounding water or constructing, altering or maintaining a structure in or near water, must provide for free passage of eels.

6.3 Heritage

The Planning (Listed Buildings and Conservation Areas) Act 1990 - Historic Environment (Wales) Act 2016, Historic Environment Scotland Act 2014 and the Planning Act (Northern Ireland) 2011 all seek to protect buildings and areas of special architectural or historic interest. This legislation prescribes a consent process for modifications to working or redundant built reservoir structures which have been listed for their individual or group heritage value, or where the reservoir lies within a conservation area. Occasionally, listing includes the full extent of the reservoir. Works, modifications or change of use to a reservoir requiring planning consent may also impact on other designated heritage assets (including registered parks and gardens) and undesignated heritage, such as archaeological features, or on the setting of adjacent heritage assets, and therefore require a Heritage Statement to inform consideration by the local planning authority.

The Ancient Monuments and Archaeological Areas Act 1979 - Historic Environment (Wales) Act 2016, Historic Environment Scotland Act 2014 and the Historic Monuments and Archaeological Objects (Northern Ireland) Order 1995 protect monuments of national interest and their settings. There are several examples of reservoirs that lie in the setting of scheduled monuments, especially those in upland landscapes with a high concentration of prehistoric archaeological features. Scheduled reservoir dams are less common, predominantly of earlier origin, such as castle moats, mine workings or canal water supply. Scheduled monument consent would be required from Historic England, Cadw, Historic Scotland or the Department of Communities in Northern Ireland if a reservoir incorporating a scheduled monument was to be discontinued.

Historic Buildings and Ancient Monuments Act 1953 – makes provision for the compilation of the Register of Parks and Gardens of Special Historic Interest in England by Historic England and provides non-statutory protection of historic designed landscapes through the planning process. Many great designed landscapes, gardens and public parks include large ornamental waterbodies either purposely created as features or adapted from former water supply reservoirs (particularly in urban areas). The discontinuance of these reservoirs could have a major detrimental impact on the historic design and character of a registered park or garden. Where planning applications affect a Grade I or II* registered site, applicants are required to consult Historic England. The local Gardens Trust is the consultee for any registered site, regardless of grade, and the national importance of these landscapes is a material consideration in the planning process. Similar arrangements apply for Wales, Scotland and Northern Island where the registers are maintained by Cadw (Register of Parks and Gardens of Special Historic Interest in Wales), Historic Scotland (Inventory of Gardens and Designed Landscapes in Scotland) and the Northern Ireland Environment Agency (Register of Parks, Gardens and Demesnes of Special Historic Interest).

UNESCO Convention Concerning the Protection of the World Cultural and National Heritage 1972 – makes provision for the World Heritage List and the protection of cultural or natural heritage sites of Outstanding Universal Value. Designation brings no additional statutory controls, but it is a material consideration in the planning process. World Heritage Sites also usually contain listed buildings or scheduled monuments reflecting the Outstanding Universal Value.

National Parks and Areas of Outstanding Natural Beauty – will generally have robust policies to conserve historic waterscapes, whether or not otherwise designated, which are likely to affect proposals for discontinuance.

Proposals for abandonment, severing water supplies without substantial discontinuance works – may also fall under planning legislation where this results in a change of use (for example, from water supply to amenity use).

6.4 Waste

Waste Framework Directive and delegated legislation - Aims to ensure waste is managed without harming human health or the environment, or causing nuisance. Encourages re-use and defines waste management hierarchy (prevent, reuse, recycle, recover, dispose). Places duties on those who produce or manage waste and environmental permitting authorities.

Landfill Directive and delegated legislation - Aims to reduce impacts on the environment by introducing stringent requirements for waste and landfills. Places duties on those sending waste to landfill and landfill operators.

6.5 Water

Water Act 2003 – consent is required from the Environment Agency (or the relevant authority) if it is intended to abstract water from a watercourse, impound water on a watercourse, or to alter or remove existing impoundments.

Water Environment (Controlled Activities) (Scotland) Regulations 2011 – A regulatory framework to control activities that may have an adverse effect on Scotland's water environment, including abstraction, impoundments, engineering, dredging, surface water drainage and pollution.

EU Water Framework Directive (WFD) and delegated legislation – Aims to protect and improve the water environment, promote sustainable water use, reduce pollution and mitigate the effects of floods and droughts. For the purposes of the WFD, the network of rivers, lakes and estuaries is split into waterbodies. The WFD sets targets for good chemical and ecological status (or potential) of each of these, and imposes a duty to assess whether activities impact on a waterbody and to support the targets defined in a River Basin Management Plan (RBMP). Note that larger reservoirs may be designated as their own waterbodies and are typically designated as artificial (if there was no waterbody present before reservoir construction) or heavily modified (if there was). The effects of impoundment on the downstream flow regime may also cause river waterbodies downstream of impounding reservoirs to be designated as heavily modified. Ordinary river or lake waterbodies are assessed using water quality and ecological data to determine status. Artificial and heavily modified waterbodies are assessed against their potential, which depends on the presence or absence of mitigation measures. Waterbodies must achieve good status or potential by 2027 and should also not deteriorate in status or potential. Note that although the WFD originates from the EU, this has been retained in UK law following the exit of the UK from the EU.

Undertakers need to liaise with the Environment Agency (or the relevant authority) where they intend to vary releases from reservoirs. However, the impacts of the proposed changes should be fully understood as any modifications to/creation of abstraction infrastructure may require the submission of a new abstraction licence application. Case study 4, Appendix C, included the construction of a new intake structure on the Stepback Brook as part of the discontinuance project, but the abstraction licence was originally issued for the discontinued reservoir and did not cover this new intake structure.

Discussions with the Environment Agency (or the relevant authority) should be held when carrying out any works on a reservoir that may result in changes in the quality, quantity or location of discharge, as part of the planning of those works. Specifically, under the Water Environment (Water Framework Directive) (England and Wales) Regulations 2003 (HMSO, 2003). If a project is determined as resulting in an adverse effect on a waterbody, causing potential deterioration in status, or if it prevents the actions that are required to raise the status of the waterbody, a preliminary assessment must be carried out with mitigation proposals as specified in Regulation 19 of the Water Framework Directive.

7 Optioneering

This chapter covers:

- definitions/principles
- optioneering process
- considerations
- options

7.1 Definitions/principles

Optioneering is a decision-making tool that uses cost-benefit analysis to identify the most beneficial option. The process ensures non-monetary costs and benefits are identified and used together with the implementation and operating costs during the decision-making process. Carter (2022) discusses the intricacies of reservoir discontinuance and concludes that cost and risk are often secondary to the consideration of social and environmental issues.

This chapter contains a non-exhaustive list of considerations that should be included as a minimum within the optioneering process. Other site-specific constraints can be added to the list as required.

There are a finite number of options that can be followed to remove the societal, corporate and monetary obligations of a reservoir that is in a poor state of repair or is an asset with no further useful purpose for the existing owner (undertaker).

The potential options will be defined by the unique characteristics of the reservoir and the influences on/from the upstream catchment and downstream watercourse.

The initial assessment is relatively straightforward and is to confirm whether the reservoir is required for its original design need. This assessment is the gateway to the optioneering process. If the reservoir is required for its original design need, there is no requirement to pursue the discontinuance or repurposing options further.

If the reservoir is no longer required for its original purpose, understanding the most beneficial option for the final state of the reservoir is crucial to reducing the risk and liabilities posed by the reservoir to the owner/undertaker.

The flow chart in Figure 1 illustrates a decision-making method with further details on the optioneering process. The first question is whether the reservoir is required for water resource or flood attenuation (original design need). If yes, it then asks, ‘are the outstanding measures in the interest of safety?’ If yes, appoint a qualified civil engineer and follow procedure to design and obtain certification of the works, then the reservoir remains in use. If no, the reservoir remains in use. If the answer to the first question (whether the reservoir is required for water resource or flood attenuation) is no, then undertake optioneering process to identify the best recourse that depends upon the reservoir situation and associated impacts. For instance this could be: abandon, discontinue, improve reservoir, sell, repurpose.

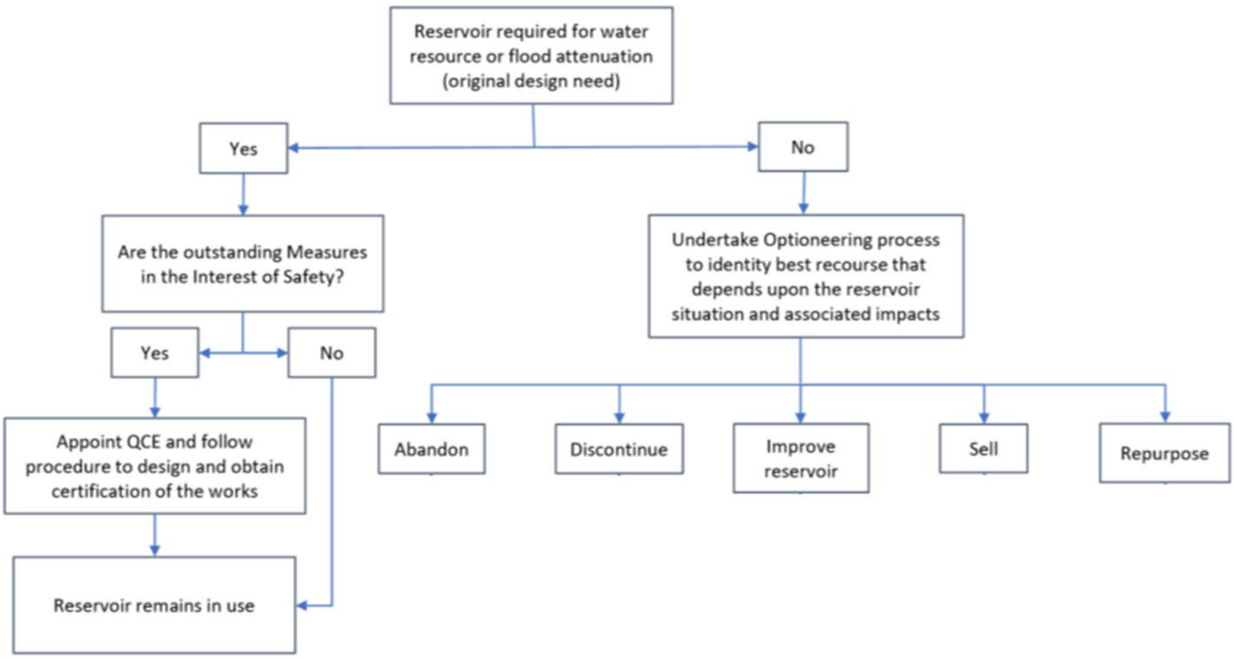

Figure 1: Decision flow chart illustrating a decision-making method to aid identification of the options available with regard to the future use of the reservoir.

7.2 Optioneering process

This chapter provides an overview of the optioneering process and presents one method of assessing the merits and deficiency of a proposal. The process involves:

1) identifying all:
    a) potential options
    b) monetary impacts[1] (remedial works and ongoing operation) – can be a qualitative assessment, low/medium/high
    c) considerations
2) optioneering:
    a) prepare list of all potential final state options for the study site
    b) develop a scoring matrix to appraise all options, resulting in a ranked list of the final state options

[1] Capital expenditure (CAPEX) and Operating expenditure (OPEX) costs used in certain businesses - we have generalised these terms to ensure the guide is applicable to all reservoir owners/undertakers/reservoir managers

The scoring matrix should include all factors affected by the changes to the reservoir. Here is the minimum that should be considered:

- costs:
    - remedial works expenditure (all costs associated with carrying out the proposed work for each option)
    - operational expenses (all costs associated with operating and maintaining each option)
    - future liability (including statutory)
- impacts on current reservoir users:
    - flood detention
    - third party rights (for example, water supply, fisheries, access across dam)
    - amenity and recreation
    - cultural heritage
- impacts on wider stakeholders:
    - energy supply
    - effects on the environment
    - habitat ecology (construction phase)
    - habitat ecology (long-term impact)
    - pollution control
    - transport infrastructure (impact of vehicle movements during remedial works and final state)
- legislative/policy compliance

The assessed factors should be weighted according to the site-specific and local/downstream influences; this individual weighting will vary for each reservoir.

Once the weighted list has been finalised, the scoring of each factor for the identified options can be completed. This will result in a ranked list that identifies the most beneficial option for the final state.

The scoring is best carried out in a qualitative comparator fashion, where the worst impact is scored the lowest, with the remainder being scored comparatively, and the least impact is scored the highest.

An online optioneering tool has been developed as part of this project.

To ensure the optioneering process is robust and not based on an individual bias, it is recommended that an option scoring workshop (or similar) be held. This workshop will enable collective scoring of the options to be undertaken, resulting in a robust assessment process.

Carter (2022) identified the following points that were instrumental in successfully completing the optioneering process:

- understand the main drivers
- establish main driver priorities
- engage a broad range of stakeholders
- agree a clear process for assessing value

It is worth considering that planning authorities and other bodies with an amenity, flood alleviation, environmental, heritage or recreational interest could object to removing or repurposing a reservoir. Some water-retaining structures have been designated as listed structures, and it is possible that there may be statutory objections to an attempt to remove or repurpose them. The reservoir removal or repurposing may also be subject to an Environmental Impact Assessment process, and a screening opinion should be sought at an early stage from the planning authority.

Case study 1, Appendix C, enforces that involving the appropriate expertise for all subjects at an early stage in the optioneering process can be crucial to successfully completing the project, while meeting all stakeholder requirements.

7.3 Considerations

Hydrological issues

There are 2 main ways of discontinuing a reservoir. The first is to totally remove the dam structure, potentially allowing the river system to return to its naturalised state (although this is not a guaranteed outcome and is only applicable to impounding reservoirs). The next is to reduce the capacity of the reservoir, so that the size of the impoundment is much smaller, but there is still a structure present at the site. In both cases, there are consequences for the local hydrology, so they shall be considered separately.

Change in flood risk

One of the principal risks of removing dams is that the downstream flood risk can increase due to removing storage. While in Europe only ⅓ of dams are actually in place for flood risk mitigation, the rest, although built for other reasons, may provide flood protection benefits. Removing a dam that is in a bad state of repair will eliminate the downstream flood risk from the dam failing. Conversely, the drawdown of the water level upstream of the dam's location will reduce flood risk in this area.

Effect on third party water users

The effects of changing the flow regime may also affect other downstream water users. Dams must release a 'compensation flow', which is intended to compensate the river for water stored in the reservoir. However, typically this provides a maintained flow that is lower than inflows for most of the year, but is more reliable than natural flows during a dry summer. This maintained flow may support third party abstraction, hydro-electric power (HEP) generation or dilution of effluent discharges that must be considered in any reservoir discontinuance scheme.

Cultural heritage considerations

The historic significance of reservoirs

Large artificial lakes became fashionable additions to great landscape parks during the ‘English Landscape Movement’ of the eighteenth century, with many of them still surviving today and exceeding the legislative threshold capacities.

During the Industrial Revolution, there was a need to store water for industry, water power, mine working, and water supply to the expanding canal network. The need for water storage was not just confined to industry, fresh water was also required for the expanding towns and cities. Victorian engineers rose to the challenge, designing dams and water supply systems to meet this demand for fresh water.

The important aesthetic and functional roles played by designed lakes and reservoirs has resulted in many of them being recognised for their historic significance by becoming listed structures.

The built heritage of the reservoir can be identified by its listed status. However, the waterbodies themselves may be recognised as historically significant by being included within a registered park and garden, a conservation area or a World Heritage Site.

Conservation designations should identify the most important heritage associated with a reservoir, but the potential for undesignated heritage assets that could be impacted should be considered. These undesignated heritage assets are normally recorded on a County Historic Environment Record maintained by the local authority.

A more, in detailed discussion on cultural heritage is included in Appendix B – Historic significance of reservoirs for information.

Historic England has produced a protocol (Historic England, 2017) that sets out the government’s commitment to setting a good example in the care of historic estates. The protocol provides details of a consistent, coordinated approach to protecting all heritage assets through government departments' procurement, estate management and disposal procedures. Although the protocol is only mandatory for government departments and agencies, it is recommended as best practice for other public bodies (including local authorities).

The potential effects of discontinuance on the historic significance of a reservoir

Totally removing a dam or reducing the capacity of the reservoir by modifying and reducing the impoundment structure may have an impact on the significance of associated heritage assets. In Conservation Principles, Policies and Guidance (2008) Historic

England categorises the aspects that make a place or structure significant into 4 heritage values: evidential value, historical value, aesthetic value and communal value. When determining a planning application, the local authority will assess whether it will cause harm to these heritage values and, therefore, reduce the significance of a heritage asset and its setting. The National Planning Policy Framework subdivides harm into substantial and less than substantial. Substantial harm to a Grade II listed building or registered park and garden should be exceptional, and wholly exceptional for scheduled monuments, Grade I and II* listed buildings and registered parks and gardens, and World Heritage Sites. To determine whether discontinuance would impact on designated assets (such as listed sluice structures, or a lake in a registered park), or only on the setting of designated heritage features, a planning application would need to be accompanied by a Heritage Statement, or by a full heritage impact assessment as part of a more comprehensive Environmental Impact Assessment, where required following screening by the planning authority. The following describes how discontinuance might have an impact on the heritage values of a reservoir.

1) Effect on evidential value

Evidential value is defined as the potential of a place or structure to yield evidence about past human activity, and is most commonly associated with physical remains. The discontinuance of a reservoir could involve the loss of archaeological remains or built fabric related to the reservoir itself or surviving from the pre-reservoir landscape. Historic workings or redundant reservoir structures can provide evidence of their original construction, operation and maintenance, as well as contribute to their aesthetic appearance. Discontinuance could also alter the context of a structure, affecting its interpretation, or threaten the long-term conservation of historic structures through obsolescence or neglect. By contrast, a comprehensive discontinuance might enable the restoration of the wider natural landscape, or even the improved conservation and interpretation of previously flooded archaeology.

2) Effect on historical value

Historical value is closely tied with evidential value, but applies to less tangible aspects of a place that illustrate and help interpret the past. The value of a heritage asset might also be increased when it is associated with a notable person, event or movement. A reservoir might illustrate the design principles of an eighteenth-century landscape gardener, feature in a nationally important painting or influenced other art forms, have contributed to the industrialisation of Britain, provided a supply of water to thousands and shaped the development of a city, or played a role in the defence of the nation during the Second World War. The loss or reduction of that waterbody may, therefore, undermine its contribution to our understanding and appreciation of aspects of local, national or international history.

3) Effect on aesthetic value

Lakes and reservoirs are often appreciated for their scenic beauty in the landscape and valued for their sensory stimulation. This is particularly the case where they were intended to form a feature in a designed landscape, but also applies to water supply reservoirs which have become integrated into a natural landscape. The discontinuance of a reservoir may need to consider the impact on the aesthetic value of the waterbody, the role that value plays in the appearance and character of its surrounding landscape, and any impact on the significance of surrounding heritage assets. There may, for example, be designated heritage assets that have been located alongside reservoirs on account of their aesthetic value. Silent Valley Reservoir, County Down, (1923-33), and its associated buildings are listed partly due to the considerable thought given to the finish and overall symmetry of this dam in relation to its mountain setting.

4) Effect on communal value

Communal value refers to the importance of a place in the collective experience or memory of people. The scenic and recreational value of reservoirs, especially those located in public parks or within rural areas close to urban areas, will almost certainly have become significant for a local community. Similarly, the purpose or use of a reservoir over its history may have meaning for people who have benefitted from its role.

Reversibility and adaptation

In some cases, the discontinuance of a reservoir could have a negative impact on the historic cultural significance but a beneficial impact on, for example, ecological significance. An artificial lake at Arlington, Devon was created for aesthetic value, but has since nearly silted up to become a Site of Special Scientific Interest for the lichens growing on the naturally regenerated marsh and wet woodland. The site managers are now fully assessing both the ecological and heritage significance alongside climate change impacts to help make a balanced and informed decision about what is the best future management option for the reservoir. Where the aim is discontinuance (or abandonment in the case of some water service reservoirs) due to the cost of essential maintenance or reservoir safety modifications in the medium term, and the reservoir has identified cultural heritage significance, reversing the discontinuance should be considered. Changes in the development context, ownership or external funding are sometimes all that is needed to generate the necessary reinvestment, enabling significant historic waterscapes to be reinstated and brought up to modern reservoir design standards.

Case study: Llyn Mawr, Llanarthne: temporary discontinuance

Llyn Mawr at the National Botanic Garden of Wales was drawn down and the dam deliberately breached in 2000 due to concerns about safety. As well as being the site of the National Botanic Garden, the property is also a registered park and garden, centred around a chain of late eighteenth century designed lakes, and a National Nature Reserve. Two decades later, Llyn Mawr was repaired and reinstated as part of a major project to restore the Regency landscape, and bring the reservoir dams up to modern standards. This restoration won the 2021 Institution of Civil Engineers People’s Choice Award.

Ecological impacts

Discontinuance of reservoirs may have effects on both the terrestrial and aquatic environment. Discontinuance of service reservoirs may chiefly have effects on the terrestrial environment, and disturbance to habitats must be considered during and after construction.

Effects on groundwater may also be relevant. Few reservoirs achieve a seal without some seepage and this may have a marked effect on the local water table, resulting in an artificial ground water table rise and lowering of the infiltration potential of the soil. This may, in turn, make the land in the vicinity of the reservoir more prone to run-off and localised flooding, create a saturated zone which supports wetter habitats, and potentially more habitat diversity than prior to reservoir construction. Discontinuance – whether by removing the dam or permanently lowering the maximum water level for the reservoir – presents an opportunity to reduce or even remove these effects. However, depending on the age of the impoundment, habitats are likely to have adjusted to the presence of the reservoir or be in the process of adjustment. These new habitats, although artificially supported, may be valuable, and an appraisal of impacts should, therefore, be made. Note also that recovery of natural systems is not linear and removal of the original cause does not always mean a reversal to the pre-construction state.

Discontinuance of reservoirs must also consider the effects on the body of open water during construction and after the reservoir has been reduced or removed. For off-line reservoirs, this should include considering the effects of reduction or cessation of the abstraction into the reservoir and changes to water level, which may vary with water use, rather than according to a natural pattern.

Impounding (online) reservoirs have the widest range of potential effects on the aquatic environment. As with a non-impounding (offline) reservoir, a body of static water is enlarged or created in the impounded reach, the level of which varies with water use, rather than according to a natural pattern. However, in addition to this:

- upstream of the reservoir there is likely to be a zone where the river is adjusting (hydraulically and geomorphologically) to a new water level downstream - for example:
    - there may be seasonal backwater effects at tributary inputs that vary as the reservoir level rises and falls, changing river habitat and potentially also creating wetlands in the adjoining riparian environment
    - discontinuance activities that lower the water level may affect these habitats and may also create a nick-point (or sudden break in profile), which may migrate upstream over time
    - effects on wetlands in particular need carefully considering as they have declined in number over several decades and there are many high value designated wetland habitats well established on historic reservoirs, such as at Arlington, Devon, and Bosherston Ponds, Pembrokeshire.

- downstream of the reservoir, the river environment is often profoundly affected by impoundment through the:
    - creation of a barrier to movement of mobile species (fish, eels)
    - changes to the pattern of flows (the flow regime) in the downstream watercourse
    - creation of a barrier to sediment transmission downstream
    - changes to water quality

Reservoir discontinuance may cause a reversal or partial reversal of these changes, and a reduction in water storage capacity (other things being equal) will increase spills. Removing the reservoir entirely would allow inflows to pass unaffected as outflows (although outflows would only be natural if inflows were.) Removal generally also negates any effects on fish passage, and opportunities to improve fish passage should also be explored with any partial removals or reductions.

Water quality effects (primarily on temperature and potentially also on dissolved oxygen saturation and possibly on the solubility of some metals) are likely to diminish with reduction in storage depth, although these may only be important in deeper reservoirs (APEM, 2015).

Spills will also increase with reduced storage capacity and depending on when these occur, these may create more migration flows for migratory salmonids (upstream and downstream migrations), eels and other species – if such species use or could use the habitat downstream of the reservoir. More generally, increasing spills also allows more frequent flushing of fine sediment, a less stable environment and potentially, more frequent inundation of the floodplain, increasing the connectivity of the river and riparian environment and nutrient exchange between the rivers and floodplains. Such changes (described further in SNIFFER, 2012) can be important from an ecological perspective, as they may help support greater biodiversity.

These changes back towards a more natural flow and water quality regime may result in a reinstatement of more natural habitat. The Dam Removal Europe[2] project noted that in the cases where the flow was re-naturalised by dam removal, river habitat reverted towards a pre-impoundment state and recovered their wildlife surprisingly quickly. However, this cannot be assumed. Because natural systems do not behave in a linear way, and given the context of historical and present changes to the environment, discontinuance may not lead to recovery towards a prior state without other interventions and may, in fact, lead to evolution towards an entirely different state.

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[2] https://damremoval.eu/

In particular, if reservoirs are disused but remain in place, inflows may be passed over the spillway (with some attenuation) most of the time, but unless a compensation flow is additionally released, during lower inflow periods spills may cease and flow downstream will be reduced.

Importantly, if a reservoir is reduced in size but an impounding wall remains, water can be passed in greater volume and with greater frequency, but the dam may still prove a highly efficient sediment trap, particularly for the coarser bed sediment (gravels) that create spawning habitat for salmonids, lampreys and other fish species. Increased flows downstream arising from discontinuance measures may, therefore, accelerate the loss of such sediment from the reaches downstream without reinstating sediment supply from upstream, resulting in a coarsening of the bed (bed armouring) and a loss in useable habitat for spawning and other ecological functions. This often, precarious balance of flow change and change to upstream sediment supply means that there can be wide-ranging effects of impoundment (and by extension discontinuance) on the morphology of the downstream watercourse and the nature of the habitat it affords. These effects are described in further detail in Petts (1980):

“Increased flows downstream arising from discontinuance measures may, therefore, accelerate the loss of coarser bed sediment (gravels) from the reaches downstream without reinstating sediment supply from upstream, resulting in a coarsening of the bed (bed armouring) and a loss in useable habitat for spawning and other ecological functions.”

On the contrary, sediment release can become a problem where an impounding structure is breached or removed. This exposes formerly submerged sediment. Often, this is fine sediment, which (depending on upstream land use) can be an important store of nutrients (for example, phosphates) that have accumulated from excessive application of fertiliser upstream. Even in upstream and remote reservoir locations contaminants cannot be discounted. The peat deposits of the Southern Pennines have, for example, accumulated aerially-borne heavy metals released during the Industrial Revolution. These have become extensively degraded over the last few decades, often being eroded from the upland catchments and accumulating in deposited sediments. Additionally, poor land management in the upstream catchment can also result in erodible sediment being washed into the reservoir during storm events. While any such sediment stores will eventually be reduced and removed over time, unless they are stabilised, there can be a prolonged period during which the former reservoir bed becomes a source of fine, possibly nutrient enriched sediment to the river downstream.

8 Options

There are 5 options to remove or repurpose redundant reservoirs. Depending on the type of reservoir, its flood category and the bespoke environments at the site, not all options will be applicable for every reservoir. Through the option selections process there will, however, be a need to consider the final state of the options and the resultant corporate and social responsibility they will entail. The potential options are presented and discussed here.

Each reservoir is unique and as such what is the best option/methodology for one is not necessarily the best option for the next. The chosen solution will depend on many factors, including:

- site-specific factors
- required final state of the reservoir
- third party views
- planning permissions
- ecological requirements and/or direction
- hydrogeological requirements and/or directions
- community and heritage
- economic viability

The options appraisal needs to be documented as part of the Environmental Impact Assessment process if an Environmental Statement is required.

8.1 Abandonment

The definition of and processes involved with abandonment are bespoke to each of the devolved country's reservoir safety legislation. Guidance should be sought from the applicable legislation and associated supporting documents during the optioneering phase to ensure an informed decision is achieved.

Process for abandonment

The abandonment process applicable to England and Wales (Reservoirs Act 1975) is included here as an example.

Reservoirs Act Section 14 – Abandonment process

Step 1 – Appoint a qualified civil engineer (QCE) under the Reservoirs Act 1975 to make a report on the reservoir and any measures to be taken in the interest of safety.

Step 2 – Design works for measures in the interest of safety.

Step 3 – Obtain approvals (planning permissions, landowners' permissions, undertake habitat surveys).

Step 4 – Tender and capital works – Project delivery.

Step 5 – Certificate issued by QCE.

Step 6 – Notify the enforcement authority.

Step 7 – Supervising engineer appointment continues.

Discontinuance

The definition of and processes involved with discontinuance are bespoke to each of the devolved country's reservoir safety legislation. Guidance should be sought from the applicable legislation and associated supporting documents during the optioneering phase to ensure an informed decision is achieved.

One option to discontinue a reservoir requiring significant remedial investment is to infill it (if the location is suitable) with inert waste material, such that the volume of water contained is below the applicable threshold value. Any waste material used as infill must have an engineered specification and be suitably certified, and follow a monitored and regulated process.

Once the infilling works have been completed, the reservoir will be refilled with water and the original vistas will remain.

This option can be economically beneficial to the reservoir owner, but can be subject to an extensive planning application process, where traffic management plans (including traffic movement details), ecological reports, highways reports and an Environmental Impact Assessment to name a few are required. The extended planning permitting process can leave the reservoir owner in a difficult situation should there be a statutory deadline to the reservoir safety works.

Process for discontinuance

The discontinuance process applicable to England and Wales (Reservoirs Act 1975) is included here as an example.

Reservoirs Act Section 13 – Discontinuance process

Step 1 – Employ a qualified civil engineer (QCE) under the Reservoirs Act 1975 to design, supervise or approve alterations.

Step 2 – Issue interim certificate (if required).

Step 3 – Design works to reduce capacity.

Step 4 – Obtain approvals (planning permissions, landowners’ permissions, undertake habitat surveys).

Step 5 – Tender and capital works – Project delivery.

Step 6 – Final certificate issued by QCE.

Step 7 – Enforcement authority remove reservoir from register of large raised reservoirs, no supervising engineer required.

8.2 Improve the reservoir (for sale or retention)

The definition of and processes involved with improving a reservoir are bespoke to each of the devolved country's reservoir safety legislation. Guidance should be sought from the applicable legislation and associated supporting documents during the optioneering phase to ensure an informed decision is achieved.

Subject to other strategic and monetary factors, improvement of the reservoir could be an option. However, there will inevitably be the requirement (potentially as statutory measures under the applicable reservoir safety legislation) to carry out interventions to ensure the structural integrity of the reservoir. These interventions could include studies and modelling (hydrology, structural analysis) that could result in the requirement for significant remedial/maintenance works.

Process to improve the reservoir

The reservoir improvement process applicable to England and Wales (Reservoirs Act 1975) is included here as an example.

Reservoirs Act Section 10 – Improvement process

Step 1 – Review latest periodic inspection report to obtain a list of the measures prescribed in the interest of safety.

Step 2 – Appoint qualified civil engineer (QCE) under the Reservoirs Act 1975 to supervise studies, design and construction to mitigate prescribed measures.

Step 3 – Undertake studies/design works – determine improvements.

Step 4 – If required, obtain approvals (planning permissions, landowners’ permissions, undertake habitat surveys).

Step 5 – Tender and capital works – Project delivery.

Step 6 – Final certificate issued by QCE.

Step 7 – Enforcement authority notified of improvement works.

8.3 Sell the reservoir

One option that will potentially remove the legislative and monetary burden of a redundant asset from the current owner/undertaker is to sell the reservoir. However, this is not as straightforward as it first appears. Due to the legislative framework that reservoirs are bound by in respect of their management and environmental releases, the transference of responsibilities and statutory requirements requires specialist legal advice. Divided ownership of some reservoirs (separating out the wider landscape setting, waterbody, dam crest and even spillway structures) has occurred in some places, and is likely to make maintenance, repairs, enhancement or discontinuance a major challenge.

One of the main considerations in relation to selling the reservoir is its condition at the time of the sale and whether there are outstanding statutory safety and/or maintenance works. Many large reservoir owners' (water companies') processes prevent the sale of a reservoir unless there are no outstanding measures in the interest of safety.

From precedents to date, the sale of large raised reservoirs has generally only taken place when all statutory measures in the interest of safety have been completed and discharged. Transferring statutory measures to a subsequent owner/undertaker, while feasible, may not be prudent. This could potentially involve complicated legal procedures and require additional warranties and/or covenants, while the sale price of the reservoir would also be compromised due the transference of risk to the new owner/undertaker. Conversely, the completion of the statutory and/or maintenance works could place a monetary burden on the existing owners that is not recouped during the sale of the reservoir, although the sale process should be simpler and there will potentially be less onerous warranties and/or covenants required.

It is recommended that specialist legal advice is obtained during the optioneering process if selling the reservoir is a desired and valid option, so that the full legal implications of the sale to **all** parties is established.

Owning and operating a reservoir places financial and societal obligations on the new owner(s), therefore, potential purchasers should be screened to ensure they are suitable and have the financial resources to not only purchase, but adequately maintain the reservoir in the future.

Process to sell a reservoir

Selling the reservoir to dispose of the asset from your portfolio involves:

Step 1 – undertaking a review of all incumbent legal obligations.

Step 2 – preparing an information pack (to include all reservoir related information, for example, a copy of the reservoir records and statutory inspection reports and certificates).

Step 3 – appointing a selling agent.

Step 4 – accepting the price offered by the purchaser (individual, company or club/group).

Step 5 – undertaking a due diligence review of the potential purchaser to ensure they are aware of the legal, financial and societal obligations that large raised reservoir ownership entails.

Step 6 – subject to achieving satisfaction in the Step 5 review, completing the sale of the reservoir.

Step 7 – ensuring the new owner has the information pack.

Step 8 – advising the enforcement authority on the details of the new owner/undertaker.

Case study: Knockbracken Reservoir

Knockbracken Reservoir in County Down was originally constructed as an offline water supply reservoir in 1901, with a capacity of 454,000m^3. The reservoir became disused following the completion of the Aquarius pipeline in 2005. Northern Ireland Water sold the reservoir to a businessman who developed the site into a water sports park.

8.4 Repurpose the reservoir

Repurposing a reservoir potentially involves the reservoir being adapted from its current form to enable it to be used for an alternative function. Due to the legislation covering reservoirs and the repurposing option selected, there may be a need to repurpose a reservoir together with works to abandon, discontinue or improve the reservoir. Repurposing a reservoir includes the following options:

- change of use from a water supply reservoir to an amenity resource (fishing, boating, nature reserve, water sports)
- change of use from a water supply reservoir to a flood retention reservoir
- adaptation/development for hydropower electricity production or storage
- adaptation/development for solar farm
- adaptation/development as licensed waste landfill site

The available repurposing options will be constrained by various site-specific factors. These will range from the available hydraulic head (if considering hydropower) to communities downstream (if considering a flood management option), and to access/traffic movements (if considering a licensed waste landfill site).

Depending on the repurposing option chosen, the reservoir may remain under the ambit of the Reservoirs Act 1975, and/or other legislation depending on its final state.

Should the repurposing option result in the reservoir remaining under reservoir safety legislation, those undertaking the statutory roles (for example, undertaker, reservoir manager, supervising engineer) should be identified and confirmed.

Process to repurpose the reservoir

Repurposing the reservoir can be done to change the use of the reservoir from that originally envisaged, so that it has a continued use to society, such as hydroelectric, leisure, flood defence. The process involves:

Step 1 – carrying out the studies and modelling required to ensure the final state is viable.

Step 2 – carrying out a review of all incumbent legal obligations.

Step 3 – completing the required work to comply with the Reservoir Act (either discontinue or retain and improve the reservoir).

Step 4 – completing the works to enable the final state to be realised.

Case study: Chard Reservoir

Chard Reservoir was originally constructed as an onstream canal supply reservoir in 1842, with a capacity of 800,000m^3. It was repurposed firstly for sporting uses when the railway arrived at Chard; and secondly in 1990 when it was given to South Somerset District Council as a public amenity and local nature reserve, with an additional flood storage role managed by the Environment Agency.

9 Planning, procedures and permissions

This chapter covers:

- definitions/principles
- statutory planning authority requirements
- stakeholders
- research opportunities
- health and safety

9.1 Definitions/principles

One of the main tasks in the planning phase is knowing what end result is proposed for the site. Is the long-term normalisation strategy of the site: wetland/woodland/patchwork of different natural zones/developed for public access? Knowing the proposed final state of the site will enable not only the planning, but the permitting, construction and reinstatement processes to be aligned to the required outcome.

9.2 Statutory planning authority requirements

Where planning permission or listed building consent is required (some works may be covered by permitted development) in order to carry into effect measures in the interest of safety, this permission or consent **must** be given by the relevant authority/body. Measures in the interest of safety (MIoS) have the force of law, and while this is generally understood by council officers, elected councillors can struggle to appreciate that they cannot refuse planning permission, but may require certain conditions to be met as part of that permission in order to address any concerns that the planning committee may have. This can often lead to tensions and delays which must be mitigated as far as possible.

As part of the planning process, the following may need to be completed:

- flood risk assessment
- Environmental Impact Assessment
- traffic study
- heritage statement
- biodiversity net gain (BSI, 2021)

Approvals may be needed for:

- listed building consents (can apply if the reservoir/dam structure is within the curtilage of a listed building)
- discharge of water to a watercourse
- fish removal

- tree removal
- protected species licences and mitigation (examples include):
    - relocating badgers, dormice and/or great crested newts
    - working near bat roosts/feeding grounds
- working on an ordinary watercourse

A list of consents that may be required for discontinuing or repurposing reservoirs is provided here. The list is not comprehensive and other consents or permits may be required. The law is changing all the time and readers should seek independent advice. CIRIA Report C786 (Benn and others (2019)) (Section 6.10) summarises the main legal, policy and consents/permits applying to flood risk, drainage, the environment, heritage and health and safety in England, Wales, Scotland and Northern Ireland.

Consent prompt list

The list below is generalised where possible. Requirements applicable to the devolved country that the subject reservoir is located within, should also be considered.

Type of work – Work in or near watercourses

Requirements:

Ordinary watercourse consent – works to erect, alter or repair a structure or obstruction on an ordinary watercourse. Internal drainage board (IDB) byelaws apply to work in an IDB area.

IDBs are geographically concentrated in Cambridgeshire, Kent, Lincolnshire, Norfolk, Nottinghamshire, Somerset and Yorkshire. The Association of Drainage Authorities (https://www.ada.org.uk) can advise on the individual authority areas.

Permit to carry out work on/or adjacent to a main river – Permanent or temporary works in, on, over, under or near a main river, in its floodplain or affecting a flood defence on a main river, or on or near a sea defence. For example:

- flood risk activity environmental permit issued by the Environment Agency
- controlled activity regulations issued by the Scottish Environment Protection Agency
- environmental permits for flood risk activities issued by Natural Resources Wales
- Schedule 6 applications issued by the Department for Infrastructure (Northern Ireland)

Water Framework Directive (WFD) assessment – required to demonstrate how the adverse impact of any works that affect the hydromorphology, ecology or water quality of a classified waterbody will be mitigated, and, where possible, the waterbody is improved to achieve the required ‘good status’ targets.

Impoundment, abstraction or discharge licence – works to impound in a watercourse or to remove water from, or discharge to, a watercourse or groundwater.

Type of work – Permanent and temporary works

Requirements:

Planning permission – required for development and pre-construction activities, for example, construction of something new, major changes to a building, changes of use or demolition. Supported by additional documents, which can include a flood risk assessment, Environmental Impact Assessment, heritage statement, tree protection plan.

Type of work – Earthworks or dredging

Requirements:

Waste exemption for use of waste – waste (for example, silt, dredgings) spread to benefit land or reused in construction.

Waste exemption for disposal of waste – waste (for example, silt, dredgings) deposited along a watercourse.

Waste environmental permit – waste disposed of to landfill. Waste may need to be treated first (for example, contaminated silt may be de-watered to reduce volume).

Type of work – Tree works

Requirements:

Permission to carry out works to trees (including roots) – applies to trees protected by a tree preservation order (TPO), trees sited in a conservation area or a designated nature conservation site. Would also need to consider 'works affecting protected species' downstream of the reservoir. A felling licence might also be required if the works are not covered by a planning consent.

Type of work – Afforestation

Requirements:

Notification or consent to create new woodland – afforestation that is of certain scale and/or proposed in sensitive areas. Afforestation includes planting saplings and young trees, direct seeding or natural regeneration processes, planting Christmas trees or planting short rotation coppice to create new areas of woodland. Tree planting over 0.5ha may also be subject to Environmental Impact Assessment procedures.

Type of work – Works affecting designated ecological sites, protected species or their habitat

Requirements:

Site of Special Scientific interest (SSSI) assent – work affecting a designated Site of Special Scientific Interest (whether on site or nearby).

Habitats Regulations assessment (HRA) – an assessment to be carried out by 2 competent authorities to determine whether the proposed works are likely to have significant effects on a European designated site of nature conservation interest (whether on site or nearby). European designated sites include Special Protection Areas (SPAs) or Special Areas of Conservation (SACs).

Protected species and wildlife licences – works that may involve disturbing protected species or removing or changing the habitat they use for breeding, feeding and other purposes.

Type of work – Works affecting designated heritage assets

Requirements:

Scheduled monument consent – Work or activities that physically affect a scheduled monument.

Listed building consent – Work or activities that physically affect a listed or curtilage listed structure.

Planning permission – Works, activities or change of use affecting a registered park and garden, the setting of listed structures or scheduled monuments, or other heritage assets, also need to be addressed as 'material considerations' in any planning applications.

9.3 Stakeholders

The definition of a stakeholder is an individual, group or organisation of any kind who is (or could become) involved in, or affected by the outcome of the project. The stakeholders for each project will include some statutory and non-statutory consultees.

Effective management of stakeholders

Knowing who your stakeholders are, their opinions and concerns allows you to create joint resources that provide a clear and consistent message. Timely communication of the messages is very important to ensure that all stakeholders are aware of the correct message at the appropriate time. A well-designed public relations campaign can be most beneficial in sharing information and addressing stakeholder concerns. Case study 4, Appendix C, illustrates the need for stakeholder engagement to allay their concerns and to ensure their desire is considered as part of the final state.

The first step in all stakeholder engagement and subsequent analysis is to identify all the appropriate stakeholders. The list of typical stakeholders below is a starting point, but as each reservoir is unique, the appropriate stakeholders will differ and will need defining early in the project.

Stakeholder analysis is a practical method to identify and improve the understanding of the stakeholders who will be involved or affected by the project. The main points are included here, together with a link to a guidance document produced by the Environment Agency.

Stage 1 – categorise all stakeholders – in terms of the project, their interest/involvement and what each one can bring to the project.

Stage 2 – refining stakeholder list – this is in terms of how they are engaged with and their role in the project.

Stage 3 – Capturing information on stakeholders – getting to know more about your stakeholders.

Stage 4 – Identifying knowledge gaps.

Further details on the stakeholder analysis and engagement can be found in Environment Agency 'Working with others – stakeholder analysis' publication 2019. Available here: Catchment based approach.

Typical stakeholders involved in a reservoir project

Environment Agency

Undertakers in England need to liaise with the Environment Agency where they intend to vary releases from reservoirs.

Under provisions of the Water Act 2003 (HMSO, 2003), consent is required from the Environment Agency if it is intended to impound water on a watercourse, or to alter or remove existing impounding.

Discussions with the Environment Agency should be held when carrying out any works on a reservoir that may result in changes in the quality, quantity or location of discharge, as part of the planning of those works. Specifically, under the Water Environment (Water Framework Directive) (England and Wales) Regulations 2003 (HMSO, 2003). If a project is determined as resulting in an adverse effect on a waterbody, causing potential deterioration in status, or if it prevents the actions that are required to raise the status of the waterbody, a preliminary assessment must be carried out with mitigation proposals as specified in Regulation 19 of the Water Framework Directive.

Scottish Environment Protection Agency (SEPA)

Reservoir managers in Scotland need to liaise with the Scottish Environment Protection Agency where they intend to vary releases from reservoirs.

Consent is required from the Scottish Environment Protection Agency where it is intended to impound water on a watercourse or, to modify or remove an existing impoundment.

Refer to the following practical guide for further information: The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended) (SEPA, 2021).

Natural Resources Wales (NRW)

Undertakers in Wales need to liaise with Natural Resources Wales where they intend to vary releases from reservoirs.

Consent is required from Natural Resources Wales where it is intended to construct, alter, repair or remove an impoundment structure.

Further information can be found on the Natural Resources Wales website.

Department for Infrastructure (DfI)

Reservoir managers in Northern Ireland should liaise with the Department for Infrastructure where they intend to vary releases from reservoirs.

Consent is required from the Department for Infrastructure where it is intended to construct, alter, repair or remove an impoundment structure.

Further information can be found on the Department for Infrastructure website.

Natural England

Natural England is the English government's advisor in relation to protecting, conserving and enhancing the natural environment for the benefit of present and future generations.

Further information can be found on Natural England’s website.

Historic England, Historic Scotland, Cadw, and the Northern Ireland Department for Communities Historic Environment Division

These organisations administer scheduled monuments consents and are the statutory consultees for listed building consents and planning applications affecting Grade I and Grade II* listed buildings, registered parks and gardens and historic battlefields.

Local communities

It is important to engage with local communities to make clear the scale of the impact discontinuing or repurposing a reservoir could have on the catchment. A well-designed public relations campaign can be very effective in gathering support from local communities and other stakeholders.

Local communities can sometimes be the driving force behind a project, often becoming engaged after being severely impacted by a large flood event and motivated to prevent similar flooding happening again.

Other local communities may need to be engaged with and educated about/convinced of the benefits of discontinuing or repurposing a reservoir.

Landowners and tenants

Landowners are crucial stakeholders as they often provide the land the measures will be implemented on.

As with communities, some landowners may need educating about/convincing of the benefits of discontinuing or repurposing a reservoir to gain their buy-in to the scheme.

Local authorities and local planning authorities (LPAs)

The planning systems used by the local authorities are not generally set up to consider reservoir safety, removal or repurposing works, and, as such, there can be difficulties encountered during the planning process.

LPAs are integral to the development of flood risk management plans (FRMPs) and also need to be consulted on any necessary permissions or consents. They are responsible for administering listed building consents, Environmental Impact Assessment regulations, and flood defence consents for non-main river watercourses. The LPA archaeologist is also the curatorial archaeologist and planning consultee for archaeological sites that are not scheduled monuments.

Environmental non-governmental organisations (eNGOs), for example, Rivers Trust, Wildlife Trust, charities (including National Trust, Woodland Trust, County Gardens Trusts)

These are not-for-profit bodies that promote, restore and protect the natural environment. They can play a crucial role in helping to plug gaps by conducting research to facilitate policy development, building institutional capacity, and facilitating independent dialogue with civil society to help people live more sustainable lifestyles. In England, the County Gardens Trusts are the formal consultees for planning applications affecting Grade 2 registered parks and gardens.

National park authorities

Public bodies that protect and manage the UK National Parks for all to enjoy. They have certain obligations enshrined in law (these differ in each devolved country) to conserve and enhance the natural beauty, wildlife and cultural heritage, and to promote sustainable use of the natural resources and sustainable economic and social development of the areas' communities.

National Farmers' Union (NFU)/Country Land and Business Association (CLA)

These are industry bodies for the farmers and landowners that work to protect the rural economy, environment and way of life. There are other smaller associations and unions that also support farmers and landowners and the rural economy.

National Flood Forum (NFF)

A national charity to help, support and represent people at risk of flooding.

Land agents

Companies/persons responsible for the negotiation and acquisition of land, valuing farm and estate assets, giving clients advice on legal and tax issues, and planning and developing land use.

Forestry Commission (FC)

A non-ministerial department supported by 2 agencies and public bodies (Forestry Research and Forestry England). The Forestry Commission aims to increase the value of woodlands to society and the environment, and is the statutory forestry authority, issuing felling licences.

9.4 Research opportunities

By careful excavation during the proposed works, we have the opportunity to gather information about the structure that was otherwise unknown, being hidden within the form of the structure. We can learn how the dam was constructed, what materials were used, the extents of a clay core (if applicable) and potentially identify any amendments/modifications that have been completed during the operational life of the asset. This information gathering may seem excessive, however, the chance to see inside a dam structure and obtain visual records and data of the hidden construction is an invaluable opportunity that can be beneficial to both the asset owner and the wider reservoir industry.

There are also wider research opportunities to study environmental and river morphology changes that occur during and after the reservoir removal or repurposing works.

Below is a non-exhaustive list of the potential research options. However, depending on the reservoir, its location and the ultimate state required for the site, there may be other research opportunities too.

To help complete the research opportunities that reservoir removal and repurposing works may provide, there may be a requirement to collaborate with a university or respected industry research organisation that may also be able to co-fund such work. This is particularly relevant where the research could extend over many years and not just the construction phase.

Dam construction

Suggested areas for research activities during reservoir removal projects, related to dam construction include:

- construction details of dam (for example, dimensions of clay core/homogenous sections/shoulders/zoning/masonry/concrete) (Photograph 1 and Photograph 2)
- materials used in dam construction (sources/geotechnical properties/configuration)

- embankment breaching experimental data to help inform predictive numerical breach models
- construction details of associated infrastructure (outlet towers/draw off tunnel/spillways/scour provisions)
- scour pipe or outlet pipe installation detail and seepage control measures used
- attrition of pipe material due to debris flow within it
- drainage provisions within dam body.
- hidden defects discovered in dam and associated infrastructure. What were they caused by? why were there no observable signs externally? what would happen if they had propagated further?
- indications of remedial work/modifications completed over the history of the structure
- do the construction/record drawings match what was built
- monitoring of dam fill material to assess impact of drying and potential desiccation
- consolidation of reservoir basin in short/medium/long term

Photograph 1: Cut section through a discontinued dam showing vertical peat core (source: Dr Andrew Hughes, Dams and Reservoirs Ltd)

Photograph 2: Cut section through a discontinued dam showing peat core (source: Dr Andrew Hughes, Dams and Reservoirs Ltd)

Environmental

Reservoir discontinuance has not been widely studied in the UK. This presents an opportunity to observe the recovery of natural systems in response to removing an often-substantial intervention (a reservoir). Making the most of such opportunities will inform future decommissioning works and build a robust scientific evidence base. Many decommissioning schemes may need to be monitored.

Monitoring may cover the following elements:

- flow and water quality effects
- habitat establishment in short/medium/long term (mammalian/amphibian/aquatic/avian/vegetation repopulation)
- river/stream morphology and the aquatic and sub aquatic rehabilitation
- re-establishment of terrestrial or aquatic flora and fauna in response to habitat changes

Monitoring typically takes place within a before-after-control-impact (BACI) framework that allows post-discontinuance monitoring results to be compared both with pre-discontinuance surveys at the same locations, and with monitoring from 'control' sites that are not affected by the discontinuance proposals. The 'before' element of the monitoring establishes a baseline for recovery and, as such, benefits from forward planning to ensure that sufficient data is captured before decommissioning. Likewise, some post decommissioning changes may occur over very long timescales (geomorphological changes occur over decades). These may not sit well with project funding and delivery cycles, and, therefore, benefit from long-term commitment of resources.

Sedimentation and silt

If there is small amount of sediment (silt) in a reservoir, which is likely to be the case for many UK reservoirs, it may not be acceptable to release it downstream (Hughes and others, 2008). Release downstream does reinstate the natural downstream transmission of sediment and is likely to be cheaper than removal or on-site disposal. However, the exposure of sediment is likely to cause a rapidly accelerated rate of transmission that may (temporarily) exceed the capacity of the downstream channel to absorb it without harming downstream river wildlife. Sediment management plans (SMPs) will, therefore, have to be developed to ensure the silt is either removed from the reservoir or remains stable under various possible future hydrological conditions, as well as during the drawdown period. Off-site disposal under waste management protocols may be particularly necessary where sediment is contaminated.

The research that underpins decision-making for the case when sediment is to remain stable is related to designing measures (for example, vegetation, partitioning through buried retaining structures) and correctly determining their critical flow conditions (for example, flow velocity, bed shear stress). Monitoring the implemented measures may also provide valuable practical information to feed into numerical models of reservoir scour and sedimentation processes such as RESSASS (Petkovsek & Roca 2014) and for adaptive management decisions, as well as to the design of measures for other removed or repurposed reservoirs.

If sediment mobilisation cannot be prevented, downstream impacts will have to be mitigated and to some level accepted. Ecological and geomorphological investigations of the effects of dam removal are in their infancy (McCulloch 2008), and discontinuance, therefore, represents an opportunity to increase our understanding of this. What happens with the previously deposited sediment in the reservoir during floods after the dam has been removed is in some way similar to what happens during a sediment flushing operation with full drawdown. These operations have been practised in many reservoirs around the world for many decades. Therefore, there are lessons to be learned from the flushing experience that are relevant to dam removal sediment management, and vice versa. Nevertheless, there is also an important difference: once the dam is removed, there is no control over outflows from the reservoir. This makes understanding the process of sediment release and its downstream impact even more critical.

Specific research opportunities include:

- exposed sediment in the reservoir presents some research opportunities to study sediment deposition processes, including historical rates, compaction, sorting, and interactions with biochemical processes - this can help improve numerical models of reservoir sedimentation processes

- methods for identifying sources of pollution, past and present, in order to estimate the level and type of contamination of sediment
- sediment erosion (of non-cohesive and cohesive sediment at different compaction rates and biochemical environments) and transport, especially at steep slopes and high velocity and sediment concentrations
- scouring channel evolution in sediment deposited in the reservoir
- impacts of sediment releases on aquatic life both during floods (increased sediment concentrations because of eroded sediment) and afterwards (impacts on habitats due to sediment deposition over bed and morphological changes)
- designing and studying remedial measures for protecting aquatic life during increased sediment concentration periods, for example, evacuation paths into tributaries
- impacts of sediment releases on downstream channel morphology and coastline

In order to plan sediment management for removing or repurposing dams, it is important to know the quantity and properties, including quality, of the sediment deposited in the reservoir, as well as the transport characteristics of the downstream watercourse and likely ecomorphological impacts if it is allowed to be flushed downstream during the flood events. These will determine whether the excavated sediment can be allowed to move downstream, be reused or require disposal (either at or away from site).

To determine the amount of sediment deposited in the reservoir, a bathymetric survey is carried out. These are typically conducted by a boat using an echosounder to measure depths and a global positioning system (GPS) for horizontal positioning. The present bathymetry is then compared to the pre-impoundment bathymetry (if available) or the ‘hard bed’ profile that can be obtained by using sub-bottom profiling techniques during the bathymetric survey. There are specialist companies that can be employed to carry out bathymetric surveys and data analysis to provide a digital terrain model of the ‘soft bed’ (silt) and ‘hard bed’ (original ground) profiles. These can be by traditional manned vessel or, increasingly, by remotely controlled vehicle (Photograph 3).

Photograph 3: Remote controlled boat used for bathymetric surveys (source: HR Wallingford, 2022)

Photograph 3 shows a remote controlled vehicle (ARC boat brand) specifically designed to undertake bathymetric and other water based scientific surveys.

To determine the properties of sediment, such as bulk density, particle size distribution as well as biochemical properties, samples of deposited sediment are taken. The most accurate, undisturbed samples are obtained by 'coring'. While the reservoir is still impounded, gravity coring may be used, where a core barrel is dropped from a winch system and penetrates into the deposited sediments, after which the core is recovered. This method only works if water depth is sufficient, the sediment is fine (soft) and there are no obstructions. Otherwise, cores can be drilled into the sediment, which is easier to achieve when the silt is exposed above the water surface during periods of reduced water levels within the reservoir. In either case, coring requires careful operation to achieve high quality samples. Alternative to coring, grab samples can be taken from the surface of sediment. However, this will not result in undisturbed samples and certain properties, such as bulk density, cannot be obtained with this method.

9.5 Health and safety

Health and safety law applies to the design, construction, monitoring and maintenance of reservoirs during removal or repurposing.

The person who owns or has control over a reservoir has a duty of care to safeguard the public and those working on the asset. Employers have a duty of care to ensure the safety, health and welfare of workers, including volunteers who may not always appreciate hazards. This chapter covers operational and public safety, including hazards, risk assessment and the mitigation hierarchy. Risk is the product of the probability and consequence of harm, and risk assessment is the process of identifying the hazards (a feature, event or action with the potential to cause harm) associated with an asset, the people who may be harmed, and the probability and consequences of them coming to harm. A risk assessment should be carried out:

- before any works commence on site
- to check that legal requirements are being met, including health and safety
- to assess safety performance
- following an accident or near miss
- when an asset approaches the end of its design life
- following a change in flood flows, debris load, catchment or watercourse characteristics or asset management regime

Risk assessments should consider the main groups at risk and may include:

- operational risk assessment - for monitoring and maintenance personnel (this may include landowners, land managers and volunteers)
- public safety risk assessment - for people using the area around the asset

The Health and Safety Executive (HSE) 5 steps to risk assessment are summarised below.

Step 1. Identify the hazards.

Step 2. Determine who may be harmed and how.

Step 3. Evaluate the risks and select mitigation measures.

Step 4. Record the findings and proposed actions, and implement these.

Step 5. Review the assessment and update if necessary.

Further guidance on risk assessment is given in Godfrey (2012) which identifies and assesses risks to activities, health and safety, and the environment, and highlights the hidden (uninsured) costs of accidents at work. Gotch and others (2009) give guidance on public safety risk assessment, including a list of generic hazards derived from BS 8800:2004 and measures to protect the public that do not affect operational access. Information on safety for volunteers is available in British Trust of Ornithology (2016) and NERC (2007).

Mitigation measures to manage the identified hazard or risk should follow the ‘eliminate, reduce, isolate, control’ (ERIC) risk reduction hierarchy. This is defined as:

- eliminate – remove the hazard at source or substitute an alternative
- reduce – reduce the likelihood or consequence of the hazard
- isolate – separate the hazard from those likely to be affected
- control – manage the impacts of the residual risks

Measures to eliminate or reduce risk are preferable to isolating or controlling residual risks, as they are passive and protect all user groups, including members of the public who don't always appreciate the risk associated with an asset. Risks are most easily reduced in the early stages of design. The residual risk should be 'as low as reasonably practicable' (ALARP). This implies a proportionate approach – it does not require risks to be mitigated regardless of cost, time or effort.

Further information on health and safety can be found here:

- Health and Safety Executive
- HSG 151 Protecting the Public
- Royal Society for the Prevention of Accidents (ROSPA) Managing safety at inland waterways
- Countryside and Rights of Way Act 2000

10 Remedial works

This chapter covers:

- construction (design and management) regulations
- programming
- supervision of works
- access
- dam removal methods
- contractor selection
- construction plant
- management of water and flows during construction
- impounding reservoirs
- non-impounding reservoirs
- run-off from works
- management of watercourse flow post dam removal works
- materials management and sustainability
- pollution control
- final state and reinstatement

10.1 Construction (design and management) (CDM) regulations

Construction (Design and Management) (CDM) Regulations 2015 (HMSO, 2015) aim to improve the health and safety for all construction projects by ensuring:

- the work is sensibly planned and the risks are identified and managed from the start of the project to the finish
- the right people are available for the right jobs at the right time
- cooperation and coordination between all involved in the project
- the right information about the risks and how they are being managed is available
- the risk information is effectively communicated to all those who need to know
- consultation and engagement with workers about the risks and how they are being managed is carried out

Demolition is regarded as a construction project for the purposes of CDM and it is likely that reservoir removals (as well as partial removals such as reductions in capacity) would be subject to the CDM Regulations. There may be a requirement to submit an F10 form to notify the Health and Safety Executive of the works.

The regulations assign CDM duty holders who have specified roles in identifying and mitigating the risk through the project lifecycle.

The assigned duty holders are:

- client
- designers
- principal designer
- principal contractor
- contractors
- workers

Each of these have defined roles under the CDM Regulations. Further details can be found on the construction (design and management) regulations 2015 page on the HSE website.

10.2 Programming

Planning and programming the different work tasks/activities (both desk based and site based) to ensure they are completed in a logical sequence is crucial to successfully carrying out the relevant works.

Due to the nature of the works, there may be seasonal requirements to complete studies and/or preparatory works, which may result in long delays if one season is missed.

To successfully carry out the relevant works, it is recommended that a programme (works schedule) be developed early in the project lifecycle. The main tasks/activities should be identified and listed along with an estimate of how long they will take. Once this list has been completed it can be developed into a programme with a completion hierarchy and an overall project duration. There will always be a critical path (the longest sequence of tasks that must be completed to complete the project) that will define the project duration. However, by sequencing works and completing tasks/activities in parallel (where possible), the critical path may be shortened.

During the development of the programme, any seasonal restrictions or network constraints (if the reservoir is part of a water supply system, as illustrated in case study 4, Appendix C) should be considered and works scheduled accordingly. As an example, the construction activities should, as far as possible, be programmed to:

a. protect the local environment from excessive run-off
b. protect/enhance existing habitats and comply with habitats-related legislation (like avoiding bird nesting or fish breeding seasons)
c. promote rapid vegetation regrowth at the end of works to minimise visual impact

Programme delays should be included (project float), and appropriately assessed based on the site-specific characteristics/idiosyncrasies of the reservoir. If the reservoir is located in an upland area, the site conditions may deviate from seasonal patterns of lowland areas and result in unexpected delays as found during the remedial works in case study 4.

10.3 Supervision of works

Supervision of works is likely to be necessary from both an engineering and environmental standpoint. Engineering supervision is provided by a client's representative (for example, Engineering Clerk of Works or Supervisor under NEC4 ECC) who are suitably qualified engineers with appropriate experience to ensure the works are carried out in compliance with the scope and specifications.

Environmental supervision is provided by an Ecological Clerk of Works (ECoW). ECoWs are suitably qualified ecologists or environmental specialists with appropriate accreditation/certifications, They either possess specific knowledge of the types of works carried out and the environment in which they are carried out, or they have access to this specific knowledge. For example, in case study 3, Appendix C, a Fisheries Officer was required to carry out a fish rescue during the drain down stage of the project. Much as the Engineering Clerk of Works ensures engineering compliance with planning and design requirements, so the ECoW ensures compliance with environmental permits and provisions of planning permissions, and may bring a halt to the works in the event of compliance failures or unforeseen circumstances. For larger works, the presence of an ECoW is likely to be a stipulation of permissions.

Following the completion of the heritage statement and/or the heritage impact assessment (if required), there may be a need for further archaeological mitigation to take place. This work is carried out by a suitably qualified archaeological contractor, typically working to the standards of the Chartered Institute for Archaeologists. The archaeological contractor is appointed by the project team and carries out work to a specification agreed with the local authority archaeologist or similar. This can include archaeological work in advance of and during the engineering works on site. Their role is to create a record of any remains of archaeological significance affected by the project as it progresses and to make that information publicly accessible. Sufficient time and resources should be allowed for any agreed archaeological mitigation to take place. A detailed explanation of archaeology in engineering projects can be found in the 2021 CIRIA Publication ‘Archaeology and construction: good practice guidance (C799)’ (Nixon and others (2021)).

10.4 Access

Construction work for removing or repurposing reservoirs will involve access to land during the construction phase and sometimes lead to long-term land use change. Therefore, it is important to understand both the short-term and long-term impacts on land use of removing or repurposing reservoirs.

The short-term and long-term access provisions to the site should be discussed and agreed with any third party landowners or tenants during the planning and design phase.

Any agreements required with third parties in relation to access should be formalised in a contract.

A lot of reservoirs are situated in areas where access for heavy plant can be problematic due to minor roads and/or other infrastructure. Accessing the reservoir both during and after construction could potentially require detailed planning, stakeholder engagement and the construction of access tracks.

In particular, it is important to consider:

- general site management and security to prevent unauthorised access to working area(s) (there can be vandalism issues during the works by those who oppose the scheme)
- location of nearest public highway
- category of nearest public highway (A, B, unclassified)
- road restrictions - are there any width and/or weight and/or height restrictions that impact choice of plant and material transport lorries?
- site access for construction traffic – is a temporary road required?
- haul roads required to move excavated material around the site
- location of site compound (considering fuel storage areas/pollution prevention)
- are there services available to supply the site compound (which is very unlikely if the dam is remote)

10.5 Dam removal methods

The chosen removal methods will ultimately depend on the dam type, construction material and resultant landscaped form.

The removal methods and final dam configuration will require approval and sign-off by a qualified civil engineer (QCE) under the appropriate reservoir safety legislation.

Dam removal is in essence covered by the following 2 main points: It is obviously more involved than these points, but in general terms no matter what the reservoir/dam construction, the points are valid.

1. Excavate to remove a section of/entire earth embankment (Photograph 4):
    a. excavated material left on site: used on site for:
        i. landscaping
        ii. filling spillway
    b. excavated material removed from site:
        i. processed on site and exported for use as inert fill
        ii. exported from site for offsite processing
2. Use rock crusher/hydraulic breaker on excavator to remove concrete/masonry dam structure(s):
    a. recovered material used on site for landscaping

b. recovered material processed on site and exported as recycled crushed aggregate

Photograph 4: Excavating through an embankment dam (source: Dr Andrew Hughes, Dams and Reservoirs Ltd)

Before the site works begin the most important tasks should be identified and any high risk[3] tasks highlighted. The identified tasks will be used to create a works schedule/programme to identify the order in which the tasks should be completed. This programme should have the highest risk items easily identifiable, allowing mitigation measures to be developed and implemented at the appropriate time during the site works. Due to the risk posed when completing significant construction works on a reservoir it is preferential to:

- plan the works – carry out all the studies and site investigations required ahead of the site phase

[3] High risk relates to activities that pose a risk to the structural safety of the dam, or periods when the works and dam are at risk of damage due to flood inundation.

- carry out the works during periods of best weather (dry with little rain)
- be organised so that once you start the site works you finish them as soon as possible with no delays

The excavation and placement of earth over the winter (wet) period is fraught with difficulties (as discussed in case study 4, Appendix C). Generally, bulk excavations stop over the winter period – carrying out significant works to reservoirs over this period should be avoided if at all possible.

If there is a planning/regulatory need to split the works over 2 ‘summer working periods’ (mitigate and avoid if possible due to the risk it may pose to the structural integrity of the dam), then suitable temporary site closure measures will be required to ensure the structural safety of the reservoir over the closed winter period.

As discussed in case study 3 , Appendix C, even after all the investigations, surveys and designs have been completed, once you start cutting ground on site you may uncover the unexpected that require adaptations to the design.

10.6 Contractor selection

Due to the specialist nature of works required to remove or repurpose redundant reservoirs, it is recommended that selecting contractors is not based on economic factors alone. The contractor selection process should ideally include an assessment of the experience/track record the contractor has in the successful completion of similar works to other reservoirs.

As discussed in case study 4, Appendix C, while all contractors may be able to carry out the work, those who have experience of such projects should be better placed than those who are new to this type of work, in order to proactively manage any unforeseen issues.

10.7 Construction plant

The choice of plant will depend partly on the type and quantity of material to be moved, the distance it is to be moved, and the end use of the material. It is very likely that there will be a requirement to have different types and sizes of plant on site to suit the tasks required. Typically, the following plant could be considered:

- tracked 360 degree excavator with appropriate attachments (bucket, rock crusher, hydraulic breaker)
- tracked bulldozer
- pulled or motor scraper box
- articulated dump truck
- tracked dump truck with rotating body (Photograph 5)
- soil compacting roller (smooth/sheep’s foot/pneumatic)

- mobile rock crusher (if processing masonry/concrete on site)
- mobile screening unit (if material to be graded/separated on site)
- dust suppression equipment (tractor and water bowser)
- pumps

The actual plant list will be dictated by the appointed contractor and will depend on the dam construction material and the works to be completed. The overall aim is to select the most appropriate plant for the task to be completed.

Photograph 5: Tracked dump truck with rotating body (source: Dr Andrew Hughes, Dams and Reservoirs Ltd)

10.8 Management of water and flows during construction

Fine sediment in the water column causes high turbidity and lower light penetration, which has biological effects (among others) of reducing macrophyte (plant) growth and clogging fish gills. When deposited, fine sediment can also smother riverbed sediments, reducing the flow of oxygen and nutrients through gravel beds and thereby impacting fish eggs and macroinvertebrates that dwell within them. Sediments can also contain nutrients and contaminants. Silt/sediment/pollution control measures are, therefore, likely to be required to protect the receiving environment during the drain down phase, remedial works phase and in the ultimate removed dam scenario.

To begin the removal/repurposing works, there is a need to dewater the reservoir.

If the reservoir has a suitably sized functioning bottom outlet/scour, this can be used to lower the reservoir water level at a controlled rate (to prevent downstream flooding and/or pollution) and to maintain the reservoir in a dewatered state. Should no adequately sized or functioning bottom outlet/scour provision be available, then the water level will have to be lowered by other means (such as pumping, syphons) and then maintained in this lowered state using these other means. Note that using the scour valves will need permissions and supporting environmental and other risk assessments (Environment Agency Guidance on Reservoir discharges: consents, permits and risk assessments.

Once the reservoir has been dewatered by the appropriate means, it will be necessary to ensure there is sufficient water outflow capacity to prevent the reservoir from partially refilling during a storm event. As discussed in case study 2, Appendix C, managing water flows (especially on space/access constrained sites) can be challenging and require a combination of proactive and reactive measures to ensure the safety of the dam is maintained during the construction phase. The method of maintaining the reservoir in a dewatered state may be:

- bypass facilities (if available) as used in case study 1, Appendix C
- bottom outlet/scour
- pumps
- siphon
- combination of all three

The reservoir will be at its most vulnerable during the dam removal/lowering stages of the work and measures will be required to mitigate the risks as far as possible. These mitigation measures could be, for example, stopping the works and capping the exposed dam area if heavy rain is forecast in the catchment, and/or providing additional water flow capacity to ensure the water level will not flood the working area and exposed dam structure.

10.9 Impounding reservoirs

During the discontinuance works there will be a requirement to divert the watercourse (if possible) to enable the works to be completed.

If there is an existing reservoir inlet control structure and reservoir bypass infrastructure, this can be used to limit the amount of water flowing through the drained reservoir.

To estimate the peak flood flow for a suitable return period rainfall event (for example, 1 in 100yr, 1 in 150yr, 1 in 200yr) the required rainfall event should be agreed with the qualified civil engineer who is supervising and signing off the reservoir modification works.

If there is no reservoir inlet control, either/or a combination of these measures will be required:

1. Temporary barrier designed and installed, at a suitable location, in the watercourse to stop the flow of water through the working area, sufficient pipe capacity will be required to convey the water flow (rate of agreed storm return period) safely past the work location.
2. If piping the natural water flow through the working area is not practicable, the works will have to be completed adjacent to the water flow. This will entail increased planning and management requirements, together with posing an increased health and safety risk. There will also be a requirement to monitor the weather forecast and have a staged water level management strategy that will provide details of actions to be taken to protect the working area/dam and personnel.

10.10 Non-impounding reservoirs

By virtue of the fact that these reservoirs are not built to impound a watercourse, they generally have a means of controlling the water flow into and out of the structure and, therefore, can be maintained in a dewatered state more easily than impounding reservoirs. There is still a requirement to assess the risk of water inundation of the working area and to manage the reservoir in a drained state. With a non-impounding reservoir one of the early tasks would ideally be the permanent isolation of the reservoir from the water supply, or temporary isolation if a water flow is required through the discontinued reservoir site in the final landscape solution.

10.11 Run-off from the works

During the works there will inevitably be run-off water generated from the working area and any unvegetated areas of the reservoir basin. This run-off water is likely to carry sediment collected from the exposed/disturbed soil and is probably going to require some sort of treatment before it leaves the site. This treatment could be via the creation of constructed settlement ponds or proprietary hired bespoke systems that may include modular lamella clarifiers and chemical dosing units to maximise sediment/contaminant removal.

Using least disturbance practices and protecting any cut slopes with appropriate erosion protection matting at the earliest opportunity will reduce the potential for erosion from these faces and the subsequent sediment transportation.

10.12 Management of the watercourse flow post dam removal works

Once the dam has been removed from an impounding reservoir there will be the natural catchment flow that is required to be conveyed safely through the site. Depending on the location of the reservoir and the conditions imposed during the works permitting process there may be a requirement to use the retained structure for flood retention purposes to a predetermined return period, or the watercourse may be returned to its naturalised normal and spate flow regime. Whichever is applicable, there will be a need to ensure the channel/structures through the reservoir basin and breached dam are capable of conveying the flows safely without damaging remaining structures, and any sediment suspension within the water is maintained below the discharge thresholds permitted.

10.13 Materials management and sustainability

The removed dam and bank materials would ideally be reused on the reservoir site for landscaping (case study 1, Appendix C), or if this is not possible, transferred for use on local construction/development sites. The adoption of the voluntary guidance in relation to reuse of excavated soils (natural topsoil and sub soil) should be considered, where applicable, to limit the amount of excavated material being classified as waste. The guidance applicable to the devolved countries are:

- England and Wales – CL:AIRE Code of Practice (CL:AIRE, 2011)
- Scotland – Regulatory Guidance: Promoting the sustainable reuse of greenfield soils in construction (Natural Scotland, 2010)
- Northern Ireland – Regulatory Position Statement – Regulation of Greenfield Excavated Material (NIEA, 2016)

The guidance requirements differ in each devolved country and an appropriately experienced professional should be consulted. The development of a materials management plan is considered best practice and would ideally be developed early in the project to identify and classify the site material, ensuring the appropriate reuse or disposal method has been identified.

During the discontinuance of Boltby Reservoir, part of the dam was removed and the excavated material was used to create a small barrier that impounds 500m^3 of water and promotes flora and fauna, while also reducing the siltation in the main reservoir (Walker, 2008). The excavated materials may also be used for improvement works on other nearby dams, for landscaping, or improvements to river cross section.

Construction works can encompass excavation and reuse of sediment from the reservoir. It may be difficult to find a suitable site for disposal of sediment from the reservoir, and the costs associated with this approach to sediment management may be high. However, on the positive side, the long-term risks are low compared to other management options. There are, however, short-term risks during the excavation itself, and appropriate pollution prevention measures must be implemented. When planning sediment excavation, the main criteria for selecting the appropriate method is based on the particles size of the material and whether it is going to be removed under wet or dry conditions. The type of sediment removal will have different costs associated (USSD, 2015). Potential applications for the extracted material depend on the sediment size. For example, gravel sized material could be suitable for selling on the construction market. Sediment may also have to be removed from the reservoir if it poses a significant risk to the downstream environment and cannot be stabilised. This is most likely the case for contaminated and/or fine sediment.

Although it is recognised that in the UK the number of high dams that are likely to removed or repurposed are small, the following has been included for completeness.

In the case of high dams, dam removal should be planned in stages to control the release of sediment from reservoirs. Two dams on the Elwha River in the USA were removed gradually over a period of more than 2 years (Ritchie and others, 2019). Lowering the water level in smaller increments also allows exposed sediment to dry, compact and become more stable, if stabilisation is the preferred long-term sediment management option.

There is a move in all sectors to transition towards sustainable practices. Two factors that could be considered for the UK are:

Get It Right Initiative

The Get It Right Initiative is a group of UK construction industry experts, organisations and businesses actively improving productivity, quality, sustainability and safety in the construction sector by eliminating error.

Sustainable construction

Sustainability in construction aims to eliminate or reduce negative environmental effects on the design, construction and operation phase by using renewable and recyclable resources and materials, and promoting reduction in waste production and energy consumption, alongside protection of the natural environment around the site.

10.14 Pollution control

During any construction works there is a requirement to follow best practice to minimise the risk of pollution as far as possible to the adjacent receptors and downstream watercourse. Best practice requires that the risk of pollution is assessed and management systems (that incorporate pollution incident response plans) are implemented, reviewed and updated as required.

Dam removal or repurposing works generally have short pathways leading to the environmental receptors and attention must be paid to ensure that pollutants are not released into these, either from reservoir deposits, the dam itself or the construction works.

The sediment deposited in the reservoir should be considered during the reservoir draining exercise. If the quantity of sediment is considerable, some sediment may mobilise during the drawdown period, irrespective of water inflow. Pollution prevention measures and the rate of drawdown should, therefore, be carefully considered for the draining of the reservoir.

The enabling works, construction site compound and any required temporary haul roads are often overlooked, but can be the cause of pollution incidents that result from surface run-off or media degradation due to the wrong choice of construction media as discussed in case study 3 , Appendix C.

If there are fish migration or other ecologically important seasons, it may be recommended to avoid these all together or pause construction.

During the construction works at Loch Mhuilinn reservoir a silt fence was installed as a downstream pollution prevention measure (King, 2013). In addition to the traditional strawbale silt traps, an improved silt trap, consisting of wooden pallets wrapped in geotextile (Pickles and Rebollo, 2014) works both as a filter for suspended sediment, as well as creating a settling area behind due to backwater effects produced by the obstruction.

Silt traps and pollution prevention measures can take many forms, from barriers across a watercourse (Photograph 6) to proprietary lamella plates systems.

Photograph 6: Example of a silt trap barrier across a watercourse (source: Dr Andrew Hughes, Dams and Reservoirs Ltd)

The performance of the sediment/silt management systems used should be continually monitored and their efficacy reviewed. If site conditions change, are found not to be as expected, or the systems are not performing as required, it may be necessary to modify/change the system/method used to manage sediment/silt as discussed in case study 2 , Appendix C.

During the construction phase, turbidity monitoring can be implemented in the downstream channel, with threshold levels defined so that warnings/alarms are raised if the predetermined turbidity level is exceeded.

During the discontinuance of the Loch Mhuilin reservoir, the Scottish Environment Protection Agency (SEPA) advised leaving a step in the watercourse to promote the natural deposition of sediments behind the dam. This technique prevents the sudden release of large volumes of silts during flood events (King, 2013). Alternatively, sediment traps (essentially a deepened flow section) can be used to encourage settlement of larger sediments. These will require maintenance in the form of removing the accumulated sediments once they become full.

10.15 Final state and reinstatement

The resultant landscape and river profile provided will depend on the final state required for the site. If works have been carried out to modify/remove the soft and hard structures, then to provide a sustainable and safe legacy, it is highly probable that the surface profiles and the surface finishes should be considered during the final reinstatement.

Regardless of whether the reservoir has been repurposed or removed, the final state and the resultant legacy that will prevail should be considered.

Cut faces: should be cut to low angles and protected in the short term by proprietary erosion protection matting (Photograph 7) and in the longer term by promoting the establishment of vegetation.

Photograph 7: View of cut slope protected with erosion protection matting (source: Dr Andrew Hughes, Dams and Reservoirs Ltd)

River channel bed and banks: returned to naturalised state or stone riprap or other protection systems used.

Public access needs to be assumed to occur even on sites not formally open to the public so that appropriate hazard mitigation is carried out. This will ensure the final state of the site is safe to any person (authorised or unauthorised) who may visit the site.

11 Long-term management

This chapter covers:

- definitions and principles
- public access
- ecological
- latent function of the site
- sediment management
- flood management
- sustainability

11.1 Definitions and principles

To manage the site for the longer term, a maturity strategy should be developed. The strategy is ideally produced during the planning stage of the works and will reflect the ultimate landscape design. It will provide details of the short and long-term maintenance and management requirements to enhance the socio-environmental, sustainable and environmental aspects of the site, while achieving the ultimate landscape and habitat goals. The following areas, some of which are discussed further in the following paragraphs, are an indication of items to consider when developing a long-term site management strategy:

- proposed/existing site access
- proposed/existing leisure/recreation facilities
- development of habitat enhancement areas/nature reserves
- presence of invasive/non-native species
- latent function of the site (flood detention/pass forward flow control)
- presence of contaminated/polluted areas
- requirement for silt/sediment management
- surface erosion control
- funding opportunities to promote enhancement and development of the environment in the forms of:
    - grants
    - matched funding
- stewardship schemes

The management strategy will potentially be divided into short-term and long-term maintenance items.

The short-term (annual) maintenance requirements are likely to include:

- routine grass cutting
- invasive species control (where required)
- general footpath repairs
- general maintenance (vegetation clearance, channel desilting) associated with any installed structures for flow control or silt/pollution management
- general maintenance associated with any boundaries and leisure facilities

The long-term (biennially, 5 yearly, 10 yearly) maintenance requirements are likely to include:

- specialist maintenance of vegetation (for example, tree management, area clearance and replanting, habitat enhancement/creation)
- significant remedial works to/replacement of:
    a. flow control or silt/pollution management structures
    b. boundary demarcations
    c. leisure facilities

11.2 Public access

The decision to deny or provide access to the site for the general public has a significant impact on the management of the site and the maintenance requirements imposed in the short and longer terms.

Numerous decisions need to be made at the planning stage with respect to the final landscaping layout and the access permitted to the site for the general public/naturalist groups/for angling or other water based leisure activities (if the ultimate state includes a waterbody). The level of planned access to the site will impact on the management strategy for the required infrastructure. Here is a list of things to consider in relation to providing access to the site:

1. Consideration of accessibility for all as per Equality Act 2010 (HMSO, 2010).
2. Location of proposed nature reserves/restricted areas.
3. Is access required/permitted to all areas of the site?
4. Routes of any footpaths.
5. Type of footpaths provided (unmade, wooden board walks, macadam, gravel), wheelchair access?
6. Is a car park required?
7. Are there any recreation facilities to be provided (for example, WCs, café, playground, nature trails, fishing facilities, fishing platforms, kayak/canoe/small boat launching sites)?
8. How do you control access to the site/areas of the site?
9. What plant access is required and at what locations to enable completion of general maintenance and/or replacement of any installed infrastructure.
10. Is access required to any location for research or monitoring purposes?

11.3 Ecological

Habitat enhancement/nature areas

Wherever possible, restoration of habitats should work with natural processes and require as little long-term management as possible – the aim being to generate a self-sustaining ecosystem. Even so, it is accepted that some measures may require some inputs; for example, sediment traps or wetlands intended to treat contaminated water/sediment tend to fill by design and may, therefore, need replacing or replenishing over the long term.

Monitoring is likely to be needed. Restoration is an inexact science and the management of reservoirs to affect environmental improvements can be difficult if rigid management techniques are used, therefore adaptive management is recommended. Adaptive management acknowledges uncertainty of outcomes by making provision for monitoring and adaptation of the scheme, should the monitoring suggest that a) the intended outcomes are not being achieved, b) that there are unintended consequences of the scheme or c) that there are further opportunities for enhancement.

Monitoring should be specified against the environmental goals and any identified risks of the scheme, with expected outcomes and provisional end dates to the monitoring also set to avoid monitoring for monitoring's sake. Monitoring is likely to entail surveying appropriate biological receptors to confirm their recovery. This will require a benchmark and is typically carried out in a before-after-control-impact (BACI) scheme that allows post-discontinuance monitoring results to be compared both with pre-discontinuance surveys at the same locations, and with monitoring from 'control' sites that are not affected by the discontinuance proposals.

Ideally, monitoring schemes should also include 'pathway' variables such as water quality or physical habitat improvements by which these improvements will be achieved. Sometimes, other pressures, including third party pressures, may also be monitored. Including pathway variables and other pressures in the monitoring scheme ensures a diagnostic capability, should planned improvements in biological receptors not be achieved.

Should the reservoir removal decision be a conscious interim measure, the site management may seek to discourage colonisation by protected species.

Invasive/non-native species

The presence of invasive or non-native species may mean that a control/eradication programme needs to be implemented, which will result in a bespoke management/maintenance regime for the identified area.

11.4 Latent function of the site

Should the site require hard structures to provide a flood detention/pass forward flow control function, then, although passive control systems can be installed, there will be an ongoing requirement to carry out some form of routine general maintenance in the short term and major maintenance in the long term. A decision will be required as to whether permanent vehicular access is provided at the outset and maintained, or if vehicular access is developed when it is required. Developing vehicle access when it is required carries the risk that protected habitats could have established along the practicable vehicle access route and significant resource investment may be required to establish the required access.

If the reservoir is removed, then ideally all hard structures that impede/control the flow should be removed or modified where possible to minimise future maintenance requirements. This reduction in maintenance requirement will reduce the need for vehicular access within the site.

11.5 Sediment management

If the sediment is left within the reservoir basin after the dam has been removed, it has to be managed to prevent its uncontrolled release. Downstream ecological impacts of sediment release from reservoirs can be severe, in particular if sediment is polluted. Pollution of sediments can be a problem in the UK, particularly in the Pennines, Welsh uplands and Welsh lowlands, where pollutants from mining or industrial waste water may have accumulated in reservoir sediments (McCulloch 2008).

There are 3 overarching options to manage the sediment remaining within the reservoir basin and these are discussed here.

Mechanical removal and disposal (highest cost/lowest long-term downstream impact from sediment release):

The physical removal of the sediment from within the reservoir basin involves using mechanical methods to collect and stockpile the sediment, before using transport vehicles to either remove the material from site (to waste site/s or, if permitted, to land) or to use the material onsite for landscaping in an area where the risk of mobilisation is very low. Depending on the reservoir shape and accessibility, temporary haul roads may need to be constructed to safely move the material.

Stabilisation (medium cost/medium-long-term downstream impact from sediment release):

If sediment is to remain in the reservoir, it has to be stabilised to minimise the potential for it to mobilise during flood events, and to provide safe access to the new bank. To stabilise sediment in the reservoir, Dunne and others (2016) considered chemical treatment and consolidation, and creating partitioned cells with buried retaining structures to facilitate infilling and restoration. Vegetation also provides a certain degree of protection against river erosion, both through local increase in flow resistance and reduction in flow velocity, as well as by root systems that stabilise soils. Revegetation of the exposed sediments can be helped with materials such as geotextiles and biodegradable blankets to provide temporary erosion protection until vegetation has established.

Sediment can be further protected from river erosion by constructing a channel through or around deposits and relocating sediment away from this channel. The implementation and options for this sediment management approach will depend on whether the dam is removed completely, partially or remains in place, with only the water level being drawn down. The long-term risks are associated mainly with potential failure of the stabilised sediments during river floods, or if there are any, from flash floods from the tributaries entering the reservoir. It is important that sediment stabilisation measures are designed by experts in this field.

Naturalised riverine state of erosion and deposition (lowest cost/highest long-term downstream impact from sediment release):

Allowing release of sediment through river erosion after dam removal can be an option, if sediment is not contaminated or the biological impact is below the established threshold. This option can provide some benefits both upstream and downstream, but there is also a potentially high downstream impact risk associated with it that has to be carefully managed. If the volume of accumulated sediment is small compared to the average annual sediment yield (less than 10% is recommended in Randle and Bountry, 2017) as well as small compared to dimensions of channel features, released sediment is unlikely to have considerable impacts. Otherwise, management of sediment release should be supported by an expert-led sediment transport study that takes into account sediment properties and anticipated future hydrological conditions, to assess the potential for impacts downstream and propose mitigation measures, if necessary. It is also recommended to continue monitoring sediment concentrations and morphological changes in channel downstream.

Provided sediment releases from the reservoir after dam removal are successfully managed, they can also have positive geomorphological and environmental impacts downstream. Coarse sediment (gravel and bigger) can improve habitat for fish spawning in the downstream channel. Finer sediment sizes, while they can be problematic in rivers, can improve coastline previously lost due to lack of sediment throughput.

The actual solution used could be one of those listed above or a combination of all three. Readers should seek independent advice from a suitable professional to ensure all the factors are assessed and the most appropriate option for sediment management is achieved. The most appropriate option for the reservoir will depend on many factors, including length of watercourse, number of conurbations, number of environmental designations, size and use of watercourse, legislative requirements, public access, the designed final state of the site, and the cost and resultant risk to the downstream watercourse.

11.6 Flood management

If it has been identified that the final state of the reservoir should include a flood management function, then this will have implications on the long-term management for the site. There will be a burden of maintenance and remedial works on the site owner/operator, and the asset will have a continued risk profile that will require managing. The site management plan will need to reflect the maintenance required to ensure the site operates as designed to protect the vulnerable communities/areas.

The following main points should be considered if developing the site for a flood management purpose:

Responsibility for the structure

Identifying and agreeing who will be responsible for (own) the structure in terms of the ongoing liability. Management and any routine maintenance should be agreed and confirmed with all involved.

Sediment management

Using the site for flood management will require any sediment management strategy to consider the sediment reaction to periodic flooding and mitigate any detrimental effects.

Active or passive management

Once the owner has been established, they need to consider how the site will operate to manage flood flows.

Will the operation of the site be managed passively (no intervention required), or will it be actively managed, where either a manual or mechanical intervention is required to operate the flood management system.

There are advantages and disadvantages with both systems in relation to how they manage flood flows, the cost and risks associated with the installation, and operation of the systems and maintenance liabilities.

Maintenance regime

The decisions taken in regard to the type of flood management structure and the operational system installed will dictate the amount of routine maintenance required and the locations where vehicular access may be routinely required.

11.7 Sustainability

Sustainability is the ability to meet one's own needs without compromising the ability of future generations to meet their own. Sustainability is not just concerned with environmental aspects, it also includes economic and social aspects to provide a holistic approach.

A sustainable investment decision should consider factors that influence the overall societal cost of the project. These factors can be separated into 3 broad groups:

- economic (profit)
- social (people)
- environmental (planet)

These 3 groups form the basis of the 3 pillars of sustainability and are inextricably linked. To be sustainable there is a fine balance to find, and maximising the impact of any one group has a detrimental impact on the other two. Therefore, to ensure sustainable development, there has to be a compromise in all groups.

The member states of the United Nations (UN) all signed up to the 2030 Agenda for Sustainability Development in 2015. This agenda is an urgent call to action that is centred around 17 Sustainable Development Goals (SDGs) and is applicable to all countries (developed and developing) in a global partnership. The 17 SDGs (detailed on the UN website take action for sustainable development goals) aim to banish a whole host of social ills by 2030 by tackling climate change in conjunction with working to preserve our oceans and forests, ending poverty and other deprivations, while improving health, education, economic growth and reducing equality. As the UK is a member state of the UN, these goals should be considered as part of the sustainability of the project.

Economic

Assessment of project

There are 2 common methods to ascertain the economic benefits of projects: whole-life cost and net present value appraisals. These 2 appraisal methods provide a quantitative way of evaluating the benefit of the project in terms of estimating:

1. how much money you will spend on an asset over the course of its useful life – whole-life cost
2. the difference between the present value of cash inflow and present value of cash outflow over a period of time – net present value

Development/environmental enhancement grants

There are grants available (that may be applicable to the project) that can be used to support environmental enhancements such as tree planting, habitat development, and stewardship schemes. These should be investigated as part of the optioneering phase and advice sought from appropriate specialists.

Societal

The final state of the site can, in some instances, be of benefit to society by including leisure facilities such as footpaths and areas for human/nature interaction (bird watching). If the site is developed to include paid societal leisure resources (for example, carparking, water sports, mountain bike routes), these may bring in tourist money that provides a boost to the local economy and provides social benefits from enjoying open/natural spaces.

There are additional societal benefits if the site is developed to provide a flood detention function that will protect vulnerable downstream communities.

Environmental

Due to the change required to remove or repurpose a reservoir, there will inevitably be environmental impacts. However, there is an opportunity to mitigate these impacts during the removal or repurposing works and in the development of the final state of the reservoir. The final state of the reservoir can be developed to include environmental enhancements and biodiversity net gains.

12 Conclusions

As we have seen in this guide, removing or repurposing a large raised reservoir in the UK can be a complex process involving a multi-disciplinary team and many different stakeholders, some with contradictory objectives.

Reservoir owners/managers starting out on this process should take account of the legal framework applicable to their site (Legal overview/definitions chapter), the variety of options that may be available to achieve the end result (Optioneering chapter), the many stages of the planning process and stakeholder engagement (Planning, procedures and permissions chapter), the actual civil works that may be necessary (Remedial works chapter), and finally, the long-term management of the site post project (Long-term management chapter).

This guide offers commentary on processes, experience of previous schemes, and signposting to additional information likely to be useful to anyone considering removing or discontinuing a reservoir in the UK.

A summary checklist of the items within this guide that should be considered in future projects is shown here:

12.1 Summary checklist

A. Check legal obligations:
    a. Reservoir legislation
    b. Other legislation (Health and safety, environmental, and others)
B. Carry out optioneering process to identify most appropriate final state option (Abandonment, discontinuance, improve the reservoir (for sale or retention), sell the reservoir, repurpose the reservoir).
C. Apply for statutory planning authority permissions and all other required consents (for example, permit to work on/or adjacent to a main river).
D. Identify and engage with stakeholders.
E. Are there opportunities to research specific related topics (such as dam construction, environmental changes due to dam removal)?
F. Consider health and safety implications of work in terms of operational and public safety.
G. Remedial works:
    a. Programming – consider tasks/activity timings.
    b. Supervision of works – what supervision is required?
    c. Access – is permission required (for example, to cross third party land)? Are routes suitable?
    d. Dam removal methods – are they suitable for the type and size of the dam? Has the excavated/recovered material been considered?
    e. Construction plant – is it suitable for the planned works?
    f. Management of water and flows during construction – what happens if a storm event occurs during the work?
    g. Run-off from the works – are suitable pollution prevention methods identified?
    h. Management of the watercourse flow post dam removal works – can it convey the required flow? Does it have a flood mitigation function?
    i. Materials management and sustainability – has a materials management plan been developed? Does the plan cover the sustainable reuse/disposal of site arisings?
    j. Pollution control – will sediment deposited in the reservoir basin mobilise during drain down or during the remedial works?
    k. Final state and reinstatement – what is the required profile of the resultant landscape and river (naturalised state or a hard control structure)?
H. Long-term management:
    a. Public access – is public access to be permitted?
    b. Ecological – where possible, restore habitats and minimise long-term management.
    c. Latent function of the site – is permanent vehicular access required for management/maintenance tasks?
    d. Sediment management in the reservoir basin – consider most viable option; mechanical removal and disposal, stabilisation, naturalised riverine state of erosion and deposition.

e. Flood management – is this required? who will be responsible for the structure? is active or passive management required?
f. Sustainability – have sustainable methods been considered during the project assessment, design and implementation?

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Appendices

Appendix A – Comparison of legal terms

Abandonment

Reservoir Act 1975 (England and Wales)

- important wording from legislation: incapable of filling accidently or naturally to level that constitutes a risk.
- practical implications: can be returned to holding water by deliberate action (reconnecting pumped inflow pipes).

Reservoir (Scotland) Act 2011

- important wording from legislation: incapable of filling with water above the natural level of any part of the surrounding land.
- practical implications: the water level is not to exceed natural ground level.

Reservoir Act (Northern Ireland) 2015

- important wording from legislation: incapable of filling with water above the natural level of any part of the surrounding land.
- practical implications: the water level is not to exceed natural ground level.

Discontinuance

Reservoir Act 1975 (England and Wales)

- important wording from legislation: incapable of holding more than the minimum volume of water set out in law above natural level of any part of the surrounding land.
- practical implications: this is a permanent reduction in reservoir capacity.

Reservoir (Scotland) Act 2011

- important wording from legislation: Incapable of holding more than the minimum volume of water set out in law above the natural level of any part of the surrounding land (but still capable of holding water above the natural level of any part of that land).
- practical implications: water level permanently reduced so that the volume above the natural ground level does not exceed the threshold volume.

Reservoir Act (Northern Ireland) 2015

- important wording from legislation: incapable of holding more than the minimum volume of water set out in law above the natural level of any part of the surrounding land (but still capable of holding water above the natural level of any part of that land).
- practical implications: water level permanently reduced so that the volume above the natural ground level does not exceed the threshold volume.

Appendix B – Historic significance of reservoirs

Inspired by what has been termed ‘The English Landscape Movement’, large, artificial lakes became fashionable additions to great landscape parks during the eighteenth century, sometimes adapted from an earlier mill or fish ponds. Numerous examples survive and many exceed the legislative 10,000m³ or 25,000m³ capacity thresholds. The early modern period also saw the construction of substantial new reservoirs for industry, water power, mine working, and water supply to the expanding canal network. With industrialisation came the expansion of towns and cities, and an increased demand for fresh water. Victorian civil engineers rose to the challenge and designed dams that held back vast water supply reservoirs in natural valleys. Smaller service reservoirs were built close to or within towns, and were often integrated into public parks and open spaces. Since the passing of the Water Act in 1973, there was a new emphasis on this dual role of reservoirs for water storage and public amenity.

The important aesthetic and functional roles played by designed lakes and reservoirs has resulted in many being recognised for their historic significance. There are numerous reservoir structures that have been listed as fine examples of Georgian, Victorian and Edwardian engineering, often illustrating the works of notable designers and civil engineers such as Lancelot ‘Capability’ Brown (1716-1783), Thomas Telford (1757-1834), John Rennie (1794-1816) and Thomas Hawksley (1807-1893). Listing sometimes includes whole dams, as at Lake Vyrnwy Dam (1881-1890 listed Grade 1), and Howden Dam, Derwent Valley (1901-2), as well as the important individual built structures associated with the construction, operation or maintenance of a dam or reservoir, including valve houses, overflow structures, sluices, bridges, aqueducts, railings and lodges. For many later reservoirs, these were a display of civic pride, featuring crenellated towers and eye-catching follies, such as the distinctive domed wheelhouses on the Ringstone Edge Reservoir, Calderdale (Thomas Hawksley, 1886).

While listing identifies the value of built heritage associated with a reservoir, the significance of the waterbodies themselves may be recognised by being included within a Registered Park and Garden, a Conservation Area or a World Heritage Site. Examples include the chain of nineteenth century water supply reservoirs in Alexandra Park, Hastings, now a registered public park, or Leeming Reservoir near Bradford, lying within the Leeming Conservation Area and featuring an unusual, gazebo-style valve house. Three examples of reservoirs within World Heritage Sites include Haweswater Reservoir in the Lake District; ‘Capability’ Brown’s lakes in the grounds of Blenheim Palace; and Coity Pond, a reservoir built to supply the Forgeside site of Blaenavon Ironworks, Wales.

There are also examples where the significance of reservoirs is increased by designated heritage assets originating from the pre-reservoir landscape. For example, the Whittle Dene Reservoirs near Newcastle-upon-Tyne lie on the course of Hadrian’s Wall and its associated defensive linear structure, known as the vallum, both scheduled monuments and a World Heritage Site. In Rutland, the listed former church of St Matthew, Normanton, has become an iconic landmark sitting slightly below water level on an island in Rutland Water. Pre-reservoir structures may also have been dismantled and relocated to higher ground during the construction of a reservoir, such as the scheduled seventeenth century packhouse bridge and First World War memorial in the village of Derwent, Derbyshire. Prior to the inundation of Ladybower Reservoir in 1943 to 1944, the bridge was dismantled and moved to the head of nearby Howden Reservoir, and the memorial now stands on its western shore. The remaining ruins of Derwent village remain submerged, becoming visible when the water level is low and attracting widespread interest.

In some cases, heritage assets exist near reservoirs specifically because of the aesthetic and scenic qualities provided by a large expanse of open water. Examples include the John Scott Health Centre, a pioneering NHS medical facility built in 1948 to 1952 on the banks of the Woodberry Down reservoirs in Hackney; and Lever Park, Bolton, designed and laid out alongside the Lower Rivington Reservoir by landscape architect, Thomas Mawson, in 1901 to 1911. The reservoir is, therefore, historically significant for its role as a fundamental part of the setting of those secondary heritage assets.

While conservation designations should identify the most important heritage associated with a reservoir, consideration should also be given to the potential for undesignated heritage assets that might be affected by discontinuance. These are normally recorded on a county Historic Environment Record, maintained by the local authority. The utilitarian role and, sometimes, quite recent history of reservoirs means that assets of importance might only be recognised at this local level or by a local community. The Old Great Dam in Crookes Valley Park, Sheffield, for example, is the last remaining example of 10 eighteenth-century reservoirs that once supplied water power to the growing city. Since the early 1900s, it has been a popular boating, fishing and swimming lake for the local community. It has, therefore, high historic significance for the people of Sheffield, although its structures remain unlisted and it has not been included within the neighbouring registered park, Weston Park. Another example is Rutland Water, the surrounding landscape of which was designed under the direction of renowned landscape architect, Dame Sylvia Crowe (1901 to 1997). Crowe’s landscaping of this 1970s reservoir, which sought to make it appear like a natural lake through judicious planting, the re-profiling of hills and careful location of facilities, arguably has national significance as an example of her work, despite remaining undesignated.

Association with an event can also increase the heritage significance of a reservoir. Derwent Reservoir has a listed Edwardian dam designed by engineer, Edward Sandeman, and architectural advisor, W. Flockhart, so is nationally important as a historic structure. However, the national significance of this dam and its associated reservoir is heightened further by its use during the Second World War for practising the low-level flights needed for the famous Dambusters Raid. It emphasises how reservoirs can have several aspects that contribute to their historic significance, and highlights the importance of thoroughly researching the history of a site before exploring options for discontinuance or other modifications.

Appendix C – Case studies

Case study 1

Dam name

Baystone Bank Reservoir

Overview of dam/site

Baystone Bank Reservoir was located approximately 6km north of the village of Millom in south-west Cumbria, within the Lake District National Park.

The reservoir, constructed in 1877, supplied water to the village of Millom (Bailes and others, 2012). The reservoir had a 14m high earthfill embankment with a puddle clay core and an overall capacity of 125,000m^3. The reservoir had a bywash channel around the reservoir, leading to the original spillway structure at the right side of the dam and discharged back into Wickham Beck downstream of the toe.

By 1996, the reservoir was no longer needed for water supply purposes and was discontinued in July 2011.

Drivers for the need to discontinue/repurpose the reservoir

Baystone Bank Reservoir previously supplied the Lanthwaite Water Treatment Works (WTW). By 1996, the reservoir was no longer required for supply purposes.

Dam break studies conducted by United Utilities changed Baystone Bank Reservoir from a Hazard Category B to a Hazard Category A, as defined by Floods and Reservoir Safety (1996) (Bailes and others, 2012). Because of this, an overflow capacity study to assess the overflow capabilities of the impounding reservoir was carried out.

Overflow capacity studies (November 2002) found that spillway capacity at the site was inadequate to pass the design flood event for a Category A reservoir and, "in the interest of safety" (ITIOS), recommended that if the reservoir was to be retained, then works would be required to safety pass the design flood event.

5 options were considered and are summarised below:

Options for Baystone Bank Reservoir

1) Increase capacity of bywash spillway channel

Description: Demolition of the existing masonry spillway channel and replacing it with a larger channel.

2) Increase flood attenuation in the reservoir

Description: Infilling the bridge openings to abandon the auxiliary overflow and increasing the flood storage capacity by retaining the flood lift behind the wave wall.

3) Increase capacity of main overflow and abandonment of auxiliary overflow

Description: Infilling the bridge openings to abandon the auxiliary overflow and modifying the main overflow to take the winter Probable Maximum Flood (PMF) outflow.

4) Grass reinforced auxiliary spillway down the main embankment and abandonment of auxiliary overflow

Description: Infilling the bridge openings to abandon the auxiliary overflow and allowing controlled flows over a protected part of the downstream face.

5) Discontinuance of the reservoir

Description: Modifying the embankment and appurtenant structures so that it is incapable of storing more than 25,000m^3 of water.

United Utilities determined that Option 5, discontinuing the reservoir, would provide the cheapest whole-life cost for an asset that was no longer used to supply drinking water. This was further supported by assessment of the 1 in 100-year flood event, which concluded that this would not increase downstream flood risk.

Summary of site works

The solution aimed to achieve a full discontinuance of the reservoir, while reinstating the Whicham Beck and the natural river and floodplain processes. A suitable habitat was required, which saw the development of a pond with a minimum surface area of 4,000m^2, minimum water depth of 2m and capacity <10,000m^3 (Bailes and others, 2012).

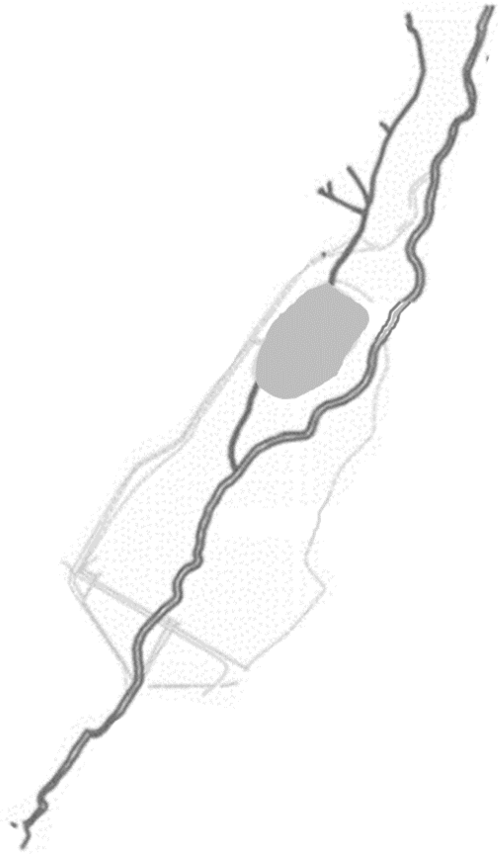

Figure C1.1: Proposed plan for the discontinuance of Baystone Bank Reservoir. Whicham Beck Tributary is top left. Whicham Beck top right. The grey oval in the centre is a new pond tributary. The thicker right-hand channel is the reinstated channel on 1838 alignment.

The proposed solution, as shown in Figure C1.1, was develop with the aim of meeting the required criteria. This design used Ordnance Survey map data from 1867 to give a pre-impoundment alignment, with the reinstated channel following the 1838 alignment. The design included the removal of the dam and associated structures, development of a pond on the Whicham Beck tributary, ensuring no barriers to downstream conveyance of sediment and estimated floodplain dimensions using the floodplains upstream and downstream of the reservoir basin.

Planning approval for the work was granted in January 2011. Eric Wright Civil Engineers mobilised to the site in February 2011 and PBA Applied Ecology Ltd were deployed for ecological and environmental management (Bailes and others, 2012).

The bywash continued to operate throughout construction, allowing the construction work to take place. The embankment had been discontinued and the impounding licence had been revoked (under Section 13(2) of the 1975 Reservoirs Act) by July 2011. During the excavation of the reservoir basin sediment and construction of new channel, sections of the original stream bed were identified and the watercourse was altered to incorporate this into the proposed design. There was no need to import materials for the site for the earth works phase, as materials produced during the discontinuance of the reservoir were stockpiled if deemed suitable for channel beds and banks. The before and after photos of the discontinuance of the reservoir can be seen in Figures C1.2 and C1.3.

Figures C1.2: Aerial photograph showing Baystone Bank Reservoir before discontinuance (source: Bailes and others, 2012)

Figure C1.3: Aerial photograph showing Baystone Bank Reservoir site after reservoir discontinuanced (source: Bailes and others, 2012)

Lessons learned/challenges faced

The need to manage the water during the works was a major challenge that was facilitated by the presence of the existing bywash channel. The operation of the bywash enabled the majority of the construction works to be carried out offline. All excavated and suitable materials were stockpiled and reused as part of the construction, meaning all materials for the channel beds and banks were sourced from the site area, limiting vehicle movements and reducing carbon.

Ecological mitigation measures were required to reduce environmental impact and comprised environmental management of the construction works, maintenance of water quality in the watercourses, and management of indigenous fish (Bailes and others, 2012).

The main lesson learned from this and other discontinuance schemes which followed this project is the need to get the right disciplines engaged early in the design process. The design needs to be led by geomorphologists and supported by engineers as there is a need to work with nature and not against it.

Case study 2

Dam name

Hafodty dam, Corris Uchaf

Overview of dam/site

In June 2012, Dwr Cymru Welsh Water (DCWW) discovered a small reservoir hidden in woods above Corris Uchaf, Gwynedd, which was later found to be within its ownership. The dam had deteriorated to a point where significant expenditure was needed to maintain its safety.

The months following the discovery focused on establishing the condition of the dam. No as-built drawings could be found (assumed to have been lost during the office move). However, site inspections showed the dam as being of slate construction, approximately 7m high and 40m wide, with a capacity of approximately 4,000m^3.

Drivers for the need to discontinue/repurpose the reservoir

A thorough check of its condition was not possible due to the dense vegetation. However, it was evident that there were a number of high-level leaks and it was prone to overtopping.

Following a number of studies, DCWW made the decision to proceed with discontinuance on the basis that the dam was no longer needed for water supply, the risk the dam posed to the public, reputational risk, and ongoing operational costs. The dam was also the highest rated risk on DCWW's 'Portfolio Risk Assessment', being placed within the 'unacceptable' risk category.

Summary of site works

The design involved the partial removal of the dam by notching it down to the original stream channel bed level. The notch consisted of 2H:1V side slopes; to achieve this, much of the dam would effectively be removed. No changes were proposed to the spillway channel apart from removing the small timber bridge spanning the channel.

An important element of the design was the restoration of the original streambed (the Nant Hafodty). The design proposed using the stone from the removal of the dam to line the new stream channel and create step pools to reduce flow velocities.

Lessons learned/challenges faced

The first phase of works involved reservoir dewatering and setting up the inflow diversion; this presented the first set of challenges for the contractor.

The narrow and steep forestry access track limited the size of plant and equipment that could be used. It was not possible to bring in specialist plant to dewater, and pump sizes were limited to 4” a 6” pumps. The extremely limited space on site also proved challenging when setting up these pumps and pipework. Hydraulic pumps were trialled, but they were ineffective in pumping from the reservoir bed due to the presence of branches and debris which constantly blocked the pumps.

The contractor was responsible for designing the inflow diversion to accommodate the 1 in 10-year flood flow. Again, the access restricted the size of pipework that could be used. It was not possible to use a single sized pipe, as the lengths were too long to transport to site. Also, the lack of space on site made it challenging to find a suitable route for the pipework with the required level of fall.

The reservoir dewatering was one of the biggest challenges for the contractor. Groundwater flows and run-off from the surrounding hillsides, as well as the stream inflow were extremely difficult to manage.

In mid-September Storm Helene caused the reservoir to fill from empty within a day. Heavy inflows overwhelmed the diversion headwall and pipework, refilling the reservoir close to the point of overtopping. The diversion pipe was overwhelmed and the outflows eroded away part of the adjacent hillside. Sediment mitigation measures were washed away. The Siltbuster and pumps had to be temporarily disconnected as, due to a lack of space, its position was blocking the spillway.

An important area where the design changed during construction was related to the management of silt.

Extra silt mitigation was implemented, including extra silt mats and a Selwood Silt Buster to help reduce effects downstream. However, given the extreme wet weather and lack of space, the silt became increasingly difficult to handle. It was not possible to load the silt into dumpy bags to dry out as originally planned.

With approval from the qualified civil engineer (QCE), the contractor proposed the idea of cutting into the right-hand hillside to form small lagoons which were used to retain the silt; the rocky/gravely nature of the valley sides would allow the silt to dewater.

Case study 3

Dam name

Prince Llewelyn Reservoir, Dolwyddelan

Overview of dam/site

Prince Llewelyn Reservoir is a small reservoir located between the villages of Dolwyddelan and Pont-y-Pant, south of Betws-y-Coed (National Grid Reference SH 7428 5305). It is a historic structure that was used to provide water to the Prince Llewelyn Slate Works downstream. It was constructed in the mid-19th century. The dam is of an unknown fill with masonry facing. It is 5.8m in height, 39m in length, with a 4m crest. There is an additional 1m shelf on the upstream face that is one metre lower than the main crest. The dam has a bottom outlet which is inoperable, as well as 2 lower points on the crest working as informal spillways.

Concerns about the dam safety were raised following the observation of severe leakages on the downstream face during recent flood events, when the reservoir water levels were high. Concerns were strengthened by the lack of a working bottom outlet, which would not allow an emergency drawdown to lower the hydrostatic pressure on the dam and reduce the leakage.

Drivers for the need to discontinue/repurpose the reservoir

Following a Reservoir Options Workshop, the decision was taken to 'discontinue' the reservoir by cutting a notch through the embankment, thereby lowering the top water level significantly. The remainder of the dam structure would be retained for its industrial heritage significance, and the exposed margins would vegetate over and create a high-quality marshy habitat. This decision was supported by the fact that the reservoir no longer served any purpose for Natural Resources Wales (NRW), no water supplies were taken from it, and no environmental designations had been applied.

Summary of site works

Design works were provided by Arcadis as principal designer, and construction works by William Hughes Civil Engineering as principal contractor. Site supervision was provided by Arup. Works were completed between November 2021 and February 2022. The sequence of works was as follows:

- excavation of hillside and installation of track to downstream toe of dam
- drawdown of reservoir. Fish rescue of 800+ coarse fish (eel, rudd, tench and roach)
- deconstruction of embankment to form notch
- construction of spillway and stepped faces using site won stone
- sealing of draw-off structure

- excavation of ‘otter pool’ downstream as mitigation for loss of habitat upstream
- installation of public safety fencing and signage

Figures C3.1 through to C3.6, photographs of Prince Llewelyn Reservoir, are arranged chronologically to give an overview of the works carried out to the dam structure.

Figure C3.1: View of downstream face of dam structure following installation of access track at downstream toe (source: Dr Andrew Hughes, Dams and Reservoirs Ltd)

Figure C3.2: View of downstream face of dam structure following completion of excavation (source: Dr Andrew Hughes, Dams and Reservoirs Ltd)

Figure C3.3: View of downstream face of dam structure following completion of spillway and sidewall construction (source: Dr Andrew Hughes, Dams and Reservoirs Ltd)

Figure C3.4: View of downstream face of dam structure following completion of spillway and sidewall construction (source: Dr Andrew Hughes, Dams and Reservoirs Ltd)

Figure C3.5: View of dam structure from upstream following completion of works (source: Dr Andrew Hughes, Dams and Reservoirs Ltd)

Figure C3.6: View of dam structure from upstream following completion of works (source: Dr Andrew Hughes, Dams and Reservoirs Ltd)

Lessons learned/challenges faced

During excavation of the dam, bedrock was found to be higher on the right-hand side than anticipated. The decision was made to construct a flat platform at the height of the first step rather than continue with the stepped notch design.

On drawdown it was revealed that the silt was approximately 500mm deeper than surveys had shown. There were concerns over the depth of silt being higher than the spillway crest. The decision was made to temporarily raise the spillway crest with a timber block to prevent silt migration downstream.

An NRW Fisheries Officer was on site during drawdown to monitor for any fish and eels mobilised by syphoning. Eels were released downstream, but due to the fish present being non-native coarse fish, they were relocated to an NRW fishery to avoid causing detriment to ecosystems downstream.

Access to the downstream toe of the dam structure was constructed using slate aggregate. Soon after, significant discolouration was observed in the downstream watercourse due to mobilisation of fines from the access track caused by constant site vehicle tracking. The top layer was removed and replaced with washed granite aggregate on a geotextile layer (to further capture any fines), together with a sump pump and settlement tank to intercept washout from the access track. These approaches will be taken forward as best practice by NRW on similar schemes in the future.

Case study 4

Dam name:

Sunnyhurst Hey

Overview of dam/site

Sunnyhurst Hey was a statutory reservoir under the Reservoirs Act 1975, located in lower Darwen, immediately below Darwen Tower. According to information that was kept in the Prescribed Form of Record, the reservoir, which was retained by a dam with a maximum height of 9.7 metres, had a capacity of 436,000m^3 and a surface area of 8.0 hectares. The reservoir was built in about 1875 for water supply. The designer was JF La Trobe Bateman.

Figure C4.1: Sunnyhurst Hey Reservoir (source: Dr Andrew Hughes, Dams and Reservoirs Ltd)

The embankment, which was 855 metres long, was originally thought to have a clay core and cut-off trench. However, the site investigation in 2008 seemed to show an absence of a clay core and cut-off trench. Upon excavation of the notch required to achieve discontinuance, a ‘text-book’ Pennine embankment with selected fill arrangement was found to be in place. (This cannot be confirmed to have been a uniform feature throughout).

Drivers for the need to discontinue/repurpose the reservoir

Seepage and stability studies by United Utilities and a Willowstick survey by Aquatrack identified that there was potential for leakage and stability issues with certain portions of the embankment. Part of the Willowstick survey is shown in Figure C4.2 as an example of the leaks and instability. Further geotechnical investigations and toolbox assessments confirmed that both structures had a higher failure probability than the minimum required of 1 in 10,000, placing them in the ‘intolerable’ zone on the Portfolio Risk Assessment (PRA).

It was, therefore, determined that remedial works would be necessary to reduce the risk of failure (slope instability and internal erosion) to an acceptable level in accordance with the ‘Manual for the Evaluation, Investigation and Remediation of Internal Erosion in UU Embankment Dams’.

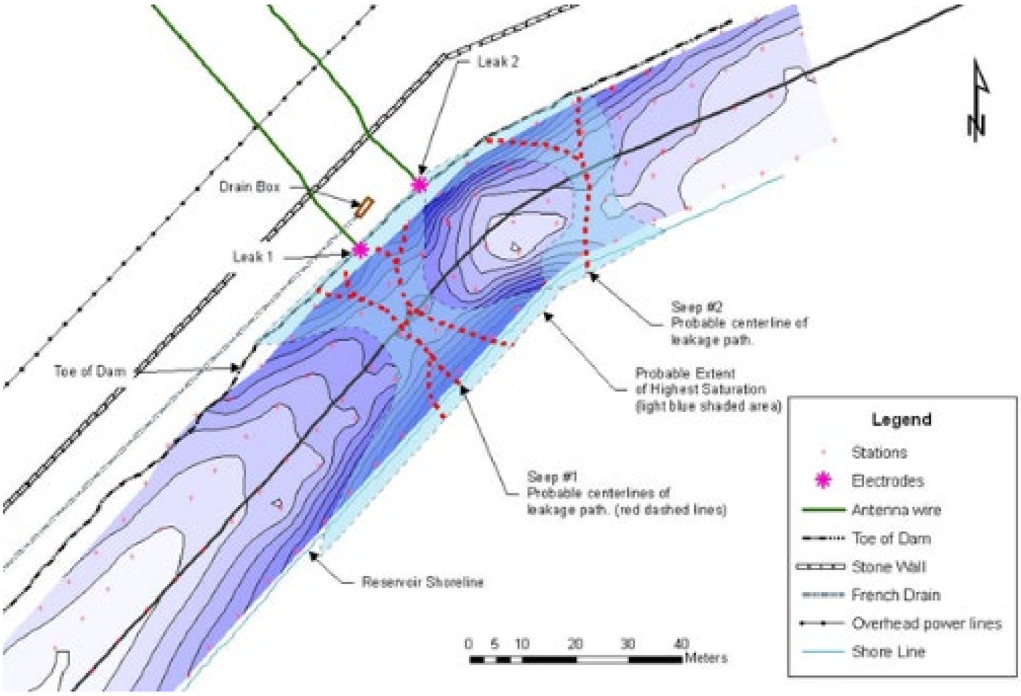

Figure C4.2: Extract from drawing showing result of Willowstick survey.

Figure 8 is a topographic drawing showing a reservoir channel section approximately 200m length and 30m width, with land features such as stone walls (black line of blocks), shore line (blue line), French drains (dashed black line) and general topography highlighted along the channel. Overhead power cables (black line with dots) and associated antennas (green line) are located to the side of the channel’s left bank. The probable center lines of leakage paths are shown as red dashed-lines crossing the width of the channel in several places. Leakage points at the side of the channel are connected to the leakage paths. Leakage points are detected by electrodes in those locations.

Summary of site works

A pipeline was installed in the reservoir basin from the former inlet, through to the base of the draw-off tower, so as to provide continuous flows from Stepback Brook to Fishmoor water treatment works (WTW) in the centre of Blackburn in times of rainfall. The aim was to keep the same mechanism for transferring water to Fishmoor in place, with the only difference being that storage no longer exists. Figure C4.3, below, is an image of the notch and works carried out. Figure C4.4 is the original southern embankment where the work was carried out. A flood attenuation pool, capable of holding circa 9ML remains at the southern end of the former reservoir, with a weir facility directing flows to Earnsdale Reservoir via the installed pipeline, if it becomes full to capacity.

Figure C4.3: An image of the notch and works carried out on Sunnyhurst Hey Reservoir (source: Dr Andrew Hughes, Dams and Reservoirs Ltd)

Figure C4.4: The original southern embankment where the work was carried out on Sunnyhurst Hey Reservoir (source: Dr Andrew Hughes, Dams and Reservoirs Ltd)

Lessons learned/challenges faced

Challenges faced

The challenges were that:

- the solution needed to ensure that abstraction from the site could remain in some form

- any works carried out had to meet the criteria of reducing/eliminating the risk of failure, alongside taking the reservoir out of the Reservoirs Act 1975, now and in future
- working in challenging conditions, including large-scale earthworks throughout the year in all conditions
- completion of the stabilisation works at neighbouring Earnsdale had to be completed concurrently (there was a restriction on Earnsdale, in that it had to be held 4m down due to safety concerns) - as part of this scheme, any flows greater than the abstraction licence would fill the lagoon and weir over into the Earnsdale pipeline, making reservoir levels more difficult to control
- there was information in the public forum at the time, discussing the future probability of water shortages in the region, meaning that an education/community forum had to be run in Lower Darwen alongside the works
- ecological issues and the public desire to see the site reclaimed by nature meant that a robust landscaping programme was required

Lessons learned

Ensure that abstraction licences are transferrable: initially in this case, the abstraction licence was for Sunnyhurst Hey Reservoir. This meant that when the new intake structure was created, flows that would be taken from Stepback Brook, were not included in the abstraction licence

Use a contractor with more fitting experience: at the time of these works, it was believed that all contractors on the framework for reservoirs would be equally suitable. This meant that although cost wasn’t completely the deciding factor, it did influence the choice of contractor massively. The contractor was proficient in specialist earthworks, but perhaps fell into traps that a more experienced contractor may have avoided. On reflection, these works could well have been carried out more efficiently by a contractor with more experience of relevant reservoir works.

Better estimation of the impact of delay on the programme of works: although some time was allowed for delays, it was severely underestimated. Conditions in these upland Pennine locations often deviate from seasonal patterns. This, in turn, made it difficult to forecast completion dates, and caused issues commercially.