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Food & Rural Affairs

Applying a Risk-Based Approach and Improving the Evidence Base Related to Small Raised Reservoirs FD2701 - Summary Report

March 2020



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Summary report - FD2701

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1 Introduction

1.1 Specification

Mott MacDonald was awarded a contract entitled “Contract for Applying a Risk-based Approach and Improving Evidence Base Related to Small Raised Reservoirs” in March 2017. The project was delivered between March 2017 and October 2019.

The high-level objectives of the contract were:

- Objective 1 (Stage 1): Provide evidence to feed into a Post Implementation Review of the first phase of the Flood and Water Management Act 2010 (FWMA 2010) reservoir provisions. This will focus on the impact of the changes and current risk methodology, including the effectiveness and suitability of the current risk assessment for Large Raised Reservoirs (LRRs).
- Objective 2 (Stage 1): Provide evidence on the number of Small Raised Reservoirs (SRRs) and the risk they pose, including those in cascade, to enable Defra to carry out an Impact Assessment related to introducing legislation for SRRs between 10,000m³ and 25,000m³.
- Objective 3 (Stage 2): Consider refinements to the current risk-based approach and methodology, including taking into account probability of failure and reservoir type (e.g. service reservoirs) for assessing reservoir risk and exemptions and to provide evidence to inform decisions about whether to implement certain aspects of the FWMA 2010, particularly for SRRs.

A full copy of the original Specification is included in Appendix A.

1.2 Deliverables

The deliverables from the research comprised a separate report for each of the objectives identified above. The titles of the reports are:

- Objective 1 – Evaluation of the Impact of the First Phase of the FWMA 2010 Reservoir Provisions in Relation to Large Raised Reservoirs
- Objective 2 – Provision of Evidence on the Number of Small Raised Reservoirs in England and the Risk they Pose
- Objective 3 – Review of the Existing Risk Methodology

1.3 Purpose of this summary report

The purpose of this report is to provide a summary of all the findings of the research project. The main body of this report is a compilation of the executive summaries of the individual reports prepared for each of the three objectives listed above.

1.4 Advisory Group

The research was carried out under the overview of an Advisory Group whose contribution is gratefully acknowledged. The members of the Advisory Group were:

Regulatory Authorities
Tony Deakin – Environment Agency

Roger Lewis – Environment Agency
Dave Hart – Environment Agency
Matt O'Brien – Natural Resource Wales

Reservoir Panel Engineers

Craig Goff – HR Wallingford
Robert Mann – Aecom

Reservoir Safety Advisory Group / British Dam Society

Alan Brown – Jacobs

Reservoir Undertakers

Ian Hope – Severn Trent Water
Mark Roberts – National Trust
Newman Booth – Yorkshire Water

Membership Bodies

Justin Neall – Fish Legal
Mark Owens – Angling Trust
Paul Hammett – National Farmers Union

2 Objective 1 – Evaluation of the Impact of the First Phase of the FWMA 2010 Reservoir Provisions in Relation to Large Raised Reservoirs

2.1 Introduction

The scope of this report is to address Objective 1.

Following the floods of 2007 and the subsequent Pitt Review, changes were implemented to the Reservoirs Act 1975 by the Flood and Water Management Act 2010.

This report is prepared to provide evidence to feed into a Post Implementation Review of the changes in legislation.

2.2 Findings

One of the main changes to reservoir safety management was the introduction of a risk designation process for all Large Raised Reservoirs (LRRs) in England. The process would permit the partial deregulation of reservoirs which were not considered to be high risk. The criteria for a reservoir being 'high risk' was prescribed in the FWMA 2010 as where *"in the event of an uncontrolled release of water from the reservoir human life could be endangered"*.

Other changes to reservoir safety management included mandatory submission of reports, statutory incident reporting, provisions for statutory maintenance and enhanced powers for the Supervising Engineer.

An Impact Assessment of the changes to the legislation was undertaken by the Department for Environment, Food & Rural Affairs (Defra) in 2011. One of the impacts identified was the substantial potential savings through partial deregulation based on the assumption that around 55% of Large Raised Reservoirs would be partially deregulated. This was based on an assumption that most Category C and D reservoirs would be partially deregulated.

The risk designation process was implemented by the Environment Agency in England. The outcome of the process has been that, of the LRRs that have been designated, only 12%, rather than the predicted 55%, of reservoirs have been designated as 'not high risk'. Evaluation of the categorisation and risk designation processes has revealed that they are not compatible, and that it should not necessarily have been expected that Category C reservoirs would be designated 'not high risk'. However, all Category D reservoirs should have been designated 'not high risk' and it must be concluded that either the original categorisation was incorrect or that the inundation maps used to inform the risk designation process were over conservative.

The approach taken by the Environment Agency in making risk designations has been fully supported by three First Tier Tribunals which have all found in favour of the designations proposed by the Environment Agency.

The 2011 Impact assessment reported a best estimate of a 50-year Present Value net saving of £101.7m through implementation of the changes to the Reservoirs Act. Due to the reduced

number of reservoirs which have been partially deregulated, the current estimated 50-year Present Value net saving is only £21.7m.

This study has included interviews with a broad selection of reservoir undertakers to canvas opinion on the impacts of the changes in legislation. The general opinion is that fewer reservoirs than anticipated had been partially deregulated, and therefore the potential benefits of the FWMA 2010 have not yet been met. The principal beneficiaries of the changes to the legislation appear to be individual or small businesses where the cost of employing Panel Engineers is significant. Larger organisations, such as water companies, have been largely unaffected by the changes. Reservoir owner groups have not reported significant queries from their members, which suggests the changes have not had an adverse effect on the reservoir industry as a whole.

3 Objective 2 – Provision of Evidence on the Number of Small Raised Reservoirs in England and the Risk they Pose

3.1 Introduction

The scope of this report is to address Objective 2. The report is split into separate chapters which are addressed individually below.

3.2 Number of small raised reservoirs

Within this research project small raised reservoirs (SRRs) are defined as reservoirs with raised volume in the range of 10,000 m³ to 25,000 m³. The number of SRRs in England has been reassessed based on an existing GIS dataset of water bodies and a desk study using Lidar data of 500 water bodies in the north of England. The approach taken was to estimate reservoir volumes for the sample based on reservoir surface area and dam height. This allowed a distribution of probability of raised volume within the required range (10,000 to 25,000 m³) against surface area to be developed. It was then possible to estimate the total number of SRRs in England by applying the probability distribution to the full population of water bodies. Allowances were also made for flood storage reservoirs and service reservoir which would not have been included in the GIS dataset.

It is estimated that there are 1,503 SRRs in England. The value compares with a number of 1,186 from previous research. The reasons for the increase are:

- a change to the methodology has identified that SRRs exist across a much wider range of surface areas than previously considered
- the previous research appears to have underestimated the number of service reservoirs and flood storage reservoirs

A Monte Carlo analysis has been undertaken to assess the potential variation in the result. It is estimated with 95% confidence that the number of SRRs in England will be in the range of 1,204 to 1,861.

3.3 Number of High Risk SRRs

The risk designation of SRRs has been assessed by undertaking “dry day” breach assessments on a sample of 50 SRRs. A trend has been identified where the percentage of reservoirs which would be designated “high risk” varies for upland and lowland reservoirs. Overall, it is estimated that, using the methodology adopted for this study, 34% of SRRs (i.e. 511 SRRs) would be high risk. The likely variation in this value for 95% confidence is 306 to 754.

3.4 SRRs in cascade

A significant proportion of this research was focused on developing a definition for cascade reservoirs. It was agreed within the project team that reservoirs on the same watercourse should only be considered as cascade reservoirs where the hazard presented by the cascade failure would be likely to be greater than that posed by high hazard individual reservoirs. On this

basis the following criteria for pairs of cascade reservoirs were adopted (note that all criteria must apply in order to be defined as cascade):

- minimum volume of either reservoir to be 15,000 m³ (i.e. combined volume of at least 30,000 m³)
- maximum separation of reservoirs to be 5 km
- maximum surface area of downstream Large Raised Reservoir to be 50,000 m²
- arrangement with upstream Large Raised Reservoirs not to be included in study

The same sample of 500 water bodies as used for identifying individual SRRs was used to identify SRRs in cascade. The findings from the sample were then extrapolated to the rest of England. It was concluded there are likely to be up to 86 SRR-SRR cascades and 45 SRR-LRR cascades in England. Of these it was estimated that up to 31 and 40 of the SRR-SRR and SRR-LRR cascades respectively could be “high risk”.

It should also be noted that an unregulated SRR can increase the probability of failure of a downstream reservoir in cascade. This does not however impact on risk designation because risk is currently based on hazard only and does not take account of probability of failure.

3.5 Summary of numbers of reservoirs

Table 1: Key Findings

	Number in England	
	Most likely	Range
Water Bodies		
Water bodies with surface area between 3,000 and 50,000 m ²	22,000	Not analysed
SRRs (including cascades of SRRs)		
SRRs	1,503	1,204 to 1,861
High risk SRRs	511	306 to 754
Cascades (excludes singular SRRs)		
SRR-SRR cascades ¹	29	1 to 86
High risk SRR-SRR cascades ¹	10	0 to 31
SRR-LRR cascades ¹	7	0 to 45
High risk SRR-LRR cascades ¹	6	0 to 40

Note 1. These are cascades under the restrictive definition adopted for this project. There will be a much greater number of occurrences of reservoirs on the same watercourse where the cascade definition is not restricted by considerations of volume, surface area and separation.

3.6 Findings of visits to SRRs

Site visits were made to 65 water bodies identified from the GIS dataset which were potentially SRRs. Of these 65 water bodies, 39 were confirmed to be SRRs. The reported condition of the SRRs was as follows:

- poor – 21%
- satisfactory – 56%
- good – 23%

Note that overall condition is an indicator of the level of maintenance at the site (i.e. coverage of the grass on embankments, the management of trees and/or mammal burrows in the

embankment and the general condition of any structures) as opposed to the extent of remedial works required.

It was further estimated that around 70% of the SRRs would be likely to require some enhancement of spillway capacity if they were to be designated “high-risk”.

3.7 Type and Ownership of SRRs

It is estimated that 61% of SRRs are in private ownership, 29% are owned by water and sewerage companies and the remaining 10% are owned by a combination of public bodies, businesses and leisure facilities.

3.8 Benefits and costs of regulating SRRs

The benefits of regulating SRRs cannot be assessed in detail without knowledge of the reduction in probability of failure which would result from regulation. This could be a subject for further research. A high-level estimation of quantified benefits has been undertaken based on the assumption that the probability of failure (POF) will decrease from 1 in 5,000 to 1 in 50,000 (per year) if an SRR becomes regulated.

The benefits of regulating SRRs have been calculated on the basis of damages derived from dam break assessments. Based on the sample of 40 SRRs, the average “Average Societal Loss of Life” (ASLL) is estimated to be 0.012 and assuming that the POF is 1 / 5,000 for an unregulated SRR, which (considering that there are estimated to be 1,503 SRRs), implies a statistical loss of life from SRRs in England of about 0.0036 persons per year. This low theoretical loss of life aligns with the fact that no lives have been lost through the failure of SRRs in England in more than 100 years.

This analysis gives an estimated benefit of regulating all SRRs as follows:

- recurring annual benefit (all SRRs) = £22,300

If only cascade SRRs, as defined for this project, were to be regulated the estimated benefit would be:

- recurring annual benefit (cascades only) = £540

Costs have not been considered for the “Do Nothing” option, and although not easily quantifiable, there is a cost associated with having different laws and regulations in England, to other parts of the UK. Consistent laws and regulations can give rise to streamlined approaches, research efficiencies, common training and better understanding of the requirements for all stakeholders.

The estimated costs of regulating all SRRs, based on the best estimate number of SRRs, are:

- capital cost – £14.5 million
- recurring annual cost – £6.2 million

If only Cascade SRRs, as defined for this project, were to be regulated the estimated cost would be:

- capital cost – £0.5 million
- recurring annual cost – £0.2 million

It should be noted that:

- a full cost-benefit analysis has not been undertaken;

- guidance (Environment Agency; 2013c) supports justifiable costs up to 10 times higher than benefits by applying a Proportion Factor (PF) to account for errors and to ensure a robustly conservative approach. In this case estimated costs are more than 100 times higher than estimated benefits therefore application of PF would not tip the balance on the basis of this research.

4 Objective 3 – Review of the Existing Risk Methodology

4.1 Introduction

The Scope of this report is to address Objective 3 (Stage 2).

Stage 2 was originally intended to focus mainly on improving the methodology for risk designation which would take into account the probability of failure. However, as by the time the project commenced, similar work has already been undertaken in Scotland, the scope was amended slightly. The amended scope included a review of the work undertaken in Scotland together with research into other areas where changes to legislation could be beneficial. Four separate tasks were therefore identified as follows:

- Task 1 – Review of the recent SEPA / Aecom Research (Aecom, 2016);
- Task 2 – Review risk designation thresholds and categories;
- Task 3 – Review criteria for the definition of a large raised reservoir;
- Task 4 – Consider the case for further deregulation of certain types of reservoir.

The research was, in part, informed by the ongoing Reservoir Flood Mapping (Environment Agency, 2016) project.

The research was largely complete at the time of the Toddbrook Reservoir incident on 1st August 2019. It is possible that recommendations following investigations into the incident may shed new light on some of the findings of this research.

The scope and findings of each task are summarised in the following sections.

4.2 Task 1 – Review of the recent SEPA / Aecom Research (Aecom, 2016)

The basis of this task was a review of the report entitled “Probability Matrix for the Risk Designation of Controlled Reservoirs under the Reservoirs (Scotland) Act 2011: Probability Matrix Development, Final Report”, (AECOM, 2016) with a view to assessing its applicability to England.

The overall conclusion is that it is not possible to meaningfully quantify the likelihood of failure of dams on the basis of information available in the public record. Notwithstanding this finding, there remains an option to incorporate likelihood of failure into the risk designation process if the process is informed by site specific risk assessments.

4.3 Task 2 – Review risk designation thresholds and categories

The objective of this task was to review whether the current interpretation of the boundary between “high-risk” and “not high-risk” is appropriate and to also consider the merits of introducing a three-tier risk designation structure.

The findings of the research into the “high-risk” threshold were that the reservoirs industry is broadly in line with other high hazard industries and that the adopted interpretation of “endangerment of life” is appropriate. The research findings are supported by the findings of first tier tribunals.

Notwithstanding the interpretation of the legislation, it is noted that the cost of regulating some lower consequence reservoirs is potentially disproportionate to the value of the benefits secured. However, it is proposed that such considerations should not be used as a basis changing the designation of “high-risk”. The reason for this is that it could result in some re-designated “not high-risk” reservoirs presenting a risk to life for individuals which is greater than the broadly acceptable limits suggested by HSE.

The review of the merits of introducing a three-tier risk designation structure concluded that there could be benefit in bringing in a three-tier risk designation structure if there is a future requirement to increase the rigour of the dam safety regulation on higher consequence reservoirs which are currently designated “high-risk”. Such recommendations might come out of investigations into the Toddbrook incident. If such a change were to be made, the boundary between “medium-risk” and high-risk” could be informed by ASLL with the boundary set by consideration of the proportionality of costs and benefits. “Medium-risk” and “high-risk” would be subsets of the existing “high-risk”, while the existing “not high-risk” would become “low-risk”. Regulatory requirements for “medium-risk” reservoirs would remain unchanged.

4.4 Task 3 – Review criteria for the definition of a large raised reservoir

The objective of this task was to review whether the current practice of regulating reservoirs on the basis of stored volume is the best way of identifying the most critical reservoirs.

The research identified that there is a stronger correlation between ASLL and dam height than between ASLL and reservoir volume. As such, if the Reservoirs Act 1975 were being rewritten, it would be preferable for the threshold for regulation to be based on height rather than volume. This would mean that, for a given number of regulated reservoirs, the average ASLL would be higher.

However, the reality is that legislation based on volume is in place, and it is anticipated that there would be reluctance to bring in a change which could result in some “high-risk” reservoirs being deregulated.

The recommendation of this research is therefore that the current 25,000 m³ volume threshold should be retained, but that, if there is a wish to regulate reservoirs smaller than 25,000 m³, these reservoirs should be selected on the basis of height. Further research would however be required to develop height criteria, and to determine the number of SRRs falling under the proposed criteria.

4.5 Task 4 – Consider the case for further deregulation

The objective of this task was to identify whether there are certain types of reservoir which could be deregulated, or designated “not high-risk” on the basis of usage, construction type or maintenance, in accordance with Section 2C of the Reservoirs Act 1975.

The research identified that the only potential candidates for deregulation, or default “not high-risk” designation, are reinforced concrete service reservoirs constructed after 1976. Such reservoirs are nearly all likely to be owned by water companies. Consultation with a number of water companies did not identify any clear appetite for deregulation. Analysis of failure modes identified that, whilst these structures are more robust than other types of dam, they are still vulnerable to over-spilling through over-pumping, pipe bursts, subsidence and structural deterioration. It was noted that although structural deficiencies may be picked up through water quality monitoring it would be inappropriate to rely on water quality monitoring to ensure the safety of the structures. On balance, it was concluded that there are insufficient grounds for the deregulation of service reservoirs.

Appendices

A. Specification

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A. Specification

SECTION 1: SPECIFICATION OF REQUIREMENTS

This Section sets out the Authority's requirements.

1. Background to the Research Project

The Flood and Water Management Act 2010 (FWMA 2010) made provision for a more risk-based approach to managing reservoir safety than embodied in previous legislation (notably the Reservoirs Act 1975). The FWMA 2010 approach involved two aspects.

In July 2013 Defra introduced new regulations to make the safety rules more risk-based, using powers under the FWMA 2010. A risk methodology was established for Large Raised Reservoirs (LRRs), which store more than 25,000m³ above ground level. LRRs were split into 'high risk' and 'not high risk' categories with only high risk reservoirs being subjected to full regulation. This aimed to allow a greater consideration of risk to be introduced and reduce the regulation for LRRs where they were deemed not to be high risk. The Impact Assessment for the 2013 Regulations predicted that 45% of LRRs (approximately 816 reservoirs) would be designated as 'high-risk', but this was based on different criteria to the final risk designation method that was subsequently applied. However, as of the end of June 2016, EA have provisionally designated 1840 reservoirs (approx. 95% of the total), which is a larger number than that anticipated by the Impact Assessment, and 91% (1683) of these have been identified as 'high-risk'. This change in legislation and introduction of a risk assessment has led to a robust hazard based approach that ensures risk to life is minimised. However, the new regulations did not implement all of the opportunities set out in the FWMA 2010; in particular it does not take into account the probability of dam failure and the implementation of exemptions for certain reservoirs. Therefore, evaluation of the impact on reservoir safety, methodology and possibly further development of the legislation may be required.

The FWMA 2010 allowed for legislation to be introduced so that designations of 'high risk' and 'not high risk' would take into account probability of dam breach or overtopping and could consider such things as the purposes for which the reservoir is used, construction materials, the way the reservoir is constructed and the maintenance of the reservoir. These aspects of the legislation were not adopted and therefore not included in the risk assessment. As a result, the EA is legally bound to make its 'high risk' decision based on whether life might be endangered if a reservoir fails catastrophically and there is no consideration of the likelihood of this happening (e.g. construction type and materials, maintenance of the dam, etc.).

The FWMA 2010 also made provision for implementing new regulation of 'high-risk' Small Raised Reservoirs (SRR) between 10,000m³ and 25,000m³, including reservoirs in "cascade". These provisions have not yet been commenced.

There is evidence that some of these smaller reservoirs may pose a risk in the event of failure, but the number of reservoirs affected and the nature of the risk posed is not sufficiently clear to justify blanket regulation. We therefore consider that further research is required.

Commencing new regulation for smaller reservoirs in England requires two things:

<p>Stage 1:</p>	<p>Knowledge of how many reservoirs would likely fall into the 10,000m³ - 25,000m³ capacity category, whether they pose an unacceptable level of risk to human life and an assessment of how many would be deemed 'high risk'.</p> <p>Research funded by the Environment Agency conducted during 2009 used Geographic Information System (GIS) techniques to measure the surface area of identifiable water bodies. Assumptions were then made about reservoir depths to calculate volumes. This study concluded there could be up to 4700 reservoirs in England and Wales in the capacity range 10,000m³ to 25,000m³ and created a database of candidate water bodies in England and Wales with a surface area between 10,000m² and 25,000m². Further studies indicated that this database is robust in identifying water bodies, including both on-line and off-line reservoirs.</p> <p>This research was built on by pilot studies commissioned by the Environment Agency between 2010 and 2012. These studies assessed with greater accuracy than the 2009 research the situation in the Midlands, Wessex area, Anglian region and Wales. Extrapolation of the findings estimated the number of SRRs as between 1150 and 1300 in England. The number of these that pose a high risk is less clear and the research used a combination of desk based studies and a limited number of site visits. Therefore, the number of reservoirs and the risk they pose needs to be verified. These reports form an annex of the Invitation to Tender (ITT).</p> <p>The British Dam Society (BDS) and Atkins have also collected information from Reservoir Engineers on incidents at Small Raised Reservoirs, which provided more evidence on the risks posed by SRRs. This is also available in the Invitation to Tender (ITT).</p>
<p>Stage 2:</p>	<p>The suitability of the existing regulation and risk methodology for these smaller reservoirs needs to be considered and whether the current system needs refining</p>

Although law doesn't currently make separate provision for reservoirs in cascade, we are including this category of reservoirs in the project. This is because we want to understand more about the likely additional risk of reservoirs in cascade and their number. For this project a reservoir in cascade is defined as two or more reservoirs or ponds which feed into each other and could have an impact on the lower reservoir.

Some reservoirs in cascade already meet the criteria to be regulated by RA75 on an individual basis, as they are over 25,000m³ and therefore these reservoirs are out of scope. This project will instead include in its scope reservoirs in cascade between 10,000m³ and 25,000m³ that are not currently regulated.

2. Project Aims

1. To evaluate the impact of the changes implemented in the first phase of the FWMA 2010 reservoir provisions in relation to large raised reservoirs (LRRs).
(Stage 1)

2. To provide evidence on the number of small raised reservoirs (SRRs) between 10,000m³ and 25,000m³ and crucially the level of risk SRRs pose in order to consider a decision on implementing Phase 2 of Reservoir Safety Regulations. **(Stage 1)**
3. To review the existing risk methodology, including consideration of any refinements such as the consideration of probability and exemptions of certain reservoir types to provide information to make decisions on potential changes to regulation. **(Stage 2)**

We envisage that a substantial programme of work will be required to fulfil these aims. The project is split into two stages of work, with a break clause after Stage 1.

Please note that this project is for England only.

3. Objectives

Our objectives for the project are to:

1. Provide evidence to feed into a Post Implementation Review of the first phase of the FWMA 2010 reservoir provisions. This will focus on the impact of the changes and current risk methodology, including the effectiveness and suitability of the current risk assessment for LRRs. **(Stage 1)**
2. Provide evidence on the number of SRRs and risk they pose, including those in cascade to enable Defra to carry out an Impact Assessment related to introducing legislation for SRRs between 10,000m³ and 25,000m³. **(Stage 1)**
3. Consider refinements to the current risk based approach and methodology, including taking account of probability and reservoir type (e.g. service reservoirs) for assessing reservoir risk and exemptions and provide evidence to inform decisions about whether to implement certain aspects of the FWMA, particularly for SRRs. **(Stage 2)**

4. Research questions

Aim 1 (Stage 1)

1. To collect and refine evidence on the number of LRRs that have been fully regulated and the impact of the changes to reservoir legislation implemented under Phase 1 of the FWMA 2010, in particular:
 - The number of LRRs that have been registered and designated as high risk.
 - Are the regulations delivering the benefits originally identified, referring back to the Impact Assessment
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/82456/120221reservoir-safety-ia.pdf?
 - Costs and benefits to reservoir undertakers and regulatory authorities (this data will be provided by the Environment Agency).
2. Evaluate the effectiveness of the current regulation in relation to the risk methodology and high risk designation processes in England.

Aim 2 (Stage 1)

3. To refine evidence on the number of smaller reservoirs between a capacity of 10,000m³ and 25,000m³. This should include:
 - The number of reservoirs between 10,000m³ and 25,000m³. Is the current assessment of between 1150 and 1300 correct?
 - The location of reservoirs between 10,000m³ and 25,000m³.
 - Confirmation of the condition, construction type and materials of a representative sample number of smaller reservoirs.
 - Number of different types of reservoir (e.g. service reservoirs, concrete, earth embankments, reservoirs in cascade).
 - Ownership and undertakers of these smaller reservoirs between 10,000m³ and 25,000m³ and what sectors are represented (e.g. farmers, country estates, local authorities, etc.)?
4. Based on site visits, assess the risk of a representative sample of SRRs in the study areas using the current risk methodology and report on the number that would be 'high risk'. This should focus on the risk they pose to human life and infrastructure. This assessment could also include the following:
 - An estimate of the population at risk.
 - Likely Loss of Life.
5. To provide evidence on whether cascade reservoirs pose an elevated risk and should therefore be regulated. A number of reservoirs in cascade should be included in the sample above and assessment should include:
 - What are the benefits (e.g. reduction in loss of life) of bringing cascades into regulation?
 - Estimate the current risk and how regulation would reduce the risk to life.
6. What will the impact of regulating SRRs be on:
 - Regulatory authority?
 - Reservoir undertakers?
7. What will be the cost of compliance per reservoir?

Aim 3 (Stage 2)

8. Review the risk assessment methodologies introduced in the UK and globally, and consider refining the existing risk methodology applied in England to include probability of breach, as well as risk to life and infrastructure. As a minimum, this should include parameters as outlined in the FWMA 2010, but not be limited to the following:
 - The purpose for which the reservoir is used (e.g. service reservoirs).
 - The materials used to construct the reservoir.
 - The way the reservoir is constructed.
 - Condition of the reservoir.
9. Consider the risk service reservoirs pose and whether these could be exempted from full regulation. What would be the impact on reservoir owners and affected communities on exempting these?
10. Assess the potential impact of this revised risk methodology on the number of existing LRRs that would be regulated and the resulting reduction in regulatory burden.

11. Assess the potential impact of a new risk based system on the number of SRRs that would be regulated and the resulting reduction in regulatory burden.

5. Methodology

The methodology should be set out in the three stages of work outlined above in the aims section. We have suggested a methodology below and we would welcome bidders' alternative suggestions providing that they also meet the project aims and objectives. Bidders should justify why they have suggested an alternative approach.

Aim 1 (Stage 1): Evaluate the first phase of implementation of reservoir provisions.

We envisage that the methods here should include both literature review to synthesise key documents and interviews with key groups including reservoir owners, reservoir undertakers, farmer and landowner groups (e.g. CLA and NFU), EA and Defra.

Specifically in relation to the evaluation of the first phase, we would like to gather evidence from those affected by the changes in terms of reservoirs included in the regulation and cases where reservoirs were deregulated. It will be important to include a range of interviewees using a purposive sampling approach to ensure a good geographical spread and coverage across a range of contexts and circumstances (e.g. EA staff, reservoir owners and emergency planners). The focus should be on an evaluative approach looking at the impact of changes and how the risk-based methodology has been used and received, as well as numbers of LRRs regulated and costs and benefits of the changes. Reference should be made to the Impact Assessment to ensure all relevant aspects are considered:

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/82456/120221reservoir-safety-ia.pdf

Aim 2 (Stage 1): Refine and verify the number of SRRs in England and the risk they pose.

As mentioned above, studies have previously been carried out in four Environment Agency areas. As separate legislation has now been implemented in Wales, the three English studies should be updated and further verified and possibly added to.

A survey should be developed to gather information about the number and type of raised reservoirs (including service reservoirs) from key owners/undertakers and Reservoir Engineers across England (e.g. water companies, Canal and River Trust, Environment Agency). We anticipate that an online survey will be the most efficient method.

We also wish to explore how the survey could be used to identify independent reservoir owners by working through key member associations such as the National Farmers Union (NFU), Country Land and Business Association (CLA) and the British Dam Society (BDS) to identify independent reservoir owners. Bidders should set out how their approach to identifying and surveying as many reservoir owners as possible.

The results of this survey should inform the sampling strategy for site visits, and it may be that a proportion of visits are targeted at independently owned reservoirs to verify the information gathered through the survey.

This project aims to test the three English regional studies by updating the desk based studies referenced above. We will require a representative number of site visits to be carried out to verify that the reservoir is raised, its size, risk and current condition. A sample of reservoirs from these desk and map studies should be selected for on-site inspections to give good coverage across the following factors:

- Service reservoirs.
- Construction methods.
- Construction materials.
- Dam types.
- Reservoirs in cascade.

Bidders should supply costings to allow Defra to be flexible in terms of the number of site visits undertaken to achieve a representative sample. Costings should be set out in options for the minimum number of visits required to achieve a robust national assessment and an enhanced number of visits which would allow for greater certainty. Bidders should set out the unit cost for visits and indicate how maximum value for money can be achieved.

In addition, we require a separate costing and method for an assessment of an upland area in England (as per the original Welsh study). This should apply the original methodology, plus any improvements based on technological developments, in an upland area of England, such as Cumbria or Lancashire.

Based on the site visits, bidders should set out how they will extrapolate the data gathered from the sample above and apply it nationally to provide an estimate of the proportion of SRRs that would be high risk in England.

The experience of Natural Resource Wales (NRW) of implementing regulation for reservoirs below 25,000m³ should be used through consultation with NRW and the Welsh Government.

In addition, the British Dam Society (BDS) should be consulted and consideration should be made to reviewing and possibly building on the Atkins report: Small Raised Reservoirs - the need for regulation, June 2013 (please see annexes).

Aim 3 (Stage 2): In relation to developing a new risk-based methodology including probability, a literature review should be carried out including international evidence to produce options for a revised risk assessment based on likelihood of breach of dam. Evidence should also be gathered from Devolved Administrations where new approaches are already being used.

Depending on decisions about adopting a new risk-based methodology, the contractor will be expected to apply the revised method to the sample of reservoirs visited as part of Aim 2 and extrapolate to SRRs in England.

6. Deliverables

The following deliverables are required:

- Monthly progress updates on the status of the work.
- Regular project group meetings and minutes.
- Steering group meetings and minutes.
- Final report including a draft final report for agreement by Defra and the steering group at the end of aim 2. This should include an Executive Summary written in non-technical language.
- Final report including a draft final report for comment by Defra and the steering group at the end of aim 3 (assuming this goes ahead). This should include an Executive Summary written in non-technical language
- GIS analysis of small raised reservoirs and cascade reservoirs.
- Fully anonymised survey datasets (either in Excel or SPSS format).
- All draft research instruments (including questionnaires, topic guides, etc.) for comment.
- Final research instruments.

7. Audience

The audiences for this work are primarily Defra policy and evidence staff, the Environment Agency and the Reservoir Safety Advisory Group (RSAG).

8. Timetable

We are aiming to hold the inception meeting in January 2017, and for the first stage of work (aims/objectives 1 & 2) to be complete by the end of 2017. Stage 2 of the work (aim/objective 3) should be complete by mid-2018 or earlier if possible.

9. Project management

Defra will nominate a project manager who will be responsible for the day-to-day management of the contract. The successful tenderer will be expected to appoint a Project Manager who will act as the principal point of contact for Defra and who will be responsible for the day-to-day management of the project. The successful tenderer will be required to regularly update the nominated Defra project manager on project progress.

A Steering Group made up of policy, technical and analytical staff and key stakeholders will guide the project. The Steering Group will monitor progress and provide advice, support and guidance on project scope, methodology, policy focus and research outputs. Tenderers should cost for up to four meetings based in the Defra office in London, including travel time, preparation and producing outputs from the meeting. This will include an inception meeting and further meetings to coincide with key project outputs (e.g. interim and final reporting stage).

10. Dissemination

Bidders should include at least one dissemination event at the completion of the project. Other events and dissemination opportunities may also be appropriate and should be highlighted in proposals.

11. Peer review

Defra may decide to separately commission an external peer review of the report and findings. Bidders should therefore accommodate responding to peer review comments in their proposals.

12. Travel and Subsistence

All Travel and Subsistence should be in line with Defra's Travel and Subsistence Policy. Claims should always be supported by valid receipts for audit purposes and must not exceed any of the stated rates below. Should the stated rate be exceeded, Defra reserve the right to reimburse only up to the stated rate.

Rail Travel

All Journeys – Standard class rail unless a clear business case demonstrating value for money can be presented. This includes international rail journeys by Eurostar and other international and overseas rail operators.

Mileage Allowance

Mileage Allowance	First 10,000 business miles in the tax year	Each business mile over 10,000 in the tax year
Private cars and vans – no public transport rate*	45p	25p
Private cars and vans – public transport rate	25p	25p
Private motor cycles	24p	24p
Passenger supplement	5p	5p
Equipment supplement**	3p	3p
Bicycle	20p	20p

*NB the 'no public transport rate' for car and van travel can only be claimed where the use of a private vehicle for the journey is essential e.g. on grounds of disability or where

there is no practical public transport alternative. If the use of the vehicle is not essential the 'public transport rate' should be claimed.

** Under HMRC rules this expense is taxable.

UK Subsistence

Location	Rate
London (Bed and Breakfast)	£115
UK Other (Bed and Breakfast)	£75

13. Performance Management

Milestone payments will be proposed by the Tenderer and agreed by negotiation with the winning bidder prior to contract signature. (Please note that negotiation relates only to when payments are made and at what level, not the total contract amount which will remain as agreed in the tender.)