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BRISTOL WATER PR09

WR1 – Cheddar Reservoir Number 2
Preliminary Design Report

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WR1 CHEDDAR RESERVOIR 2

CONTENTS

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WR1 CHEDDAR RESERVOIR 2

PART 1: PRELIMINARY DESIGN REPORT

1. INTRODUCTION

Bristol Water propose to create an additional 6000Ml of raw water storage at Cheddar by constructing a new bunded reservoir adjacent to the existing reservoir at Cheddar. This report discusses the aspects of work required to achieve this.

The construction of a major reservoir will require extensive liaison with stakeholders and will require a full Environmental Impact Assessment (EIA). It will probably trigger a public enquiry. The length of time from initial studies to the commissioning of the reservoir is likely to be 10-15 years.

This report is in two parts. The first part (sections 1 to 13) addresses the feasibility of the option being currently considered: a new 6000Ml reservoir in a site adjacent and to the west of the existing reservoir. The second part of the report (sections 14 to 19) describes the future work in decision making, design, planning and construction which would need to be undertaken in order for the reservoir to be constructed.

1.1 Suggested Activity Timeline

The table below outlines approximate timescales during which the activities may be undertaken:

AMP5	Pre Feasibility	2010	Justification of need, Desk studies, Site optioneering, Site selection, initial geotechnical investigation
		2011	
	Feasibility and Outline Design	2012	Ecological surveys and preparation of EIA Screening report, planning, Stake holder liaison, Public Enquiry, land entry and purchase, further geotechnical investigation, river modelling
		2013	
		2014	
AMP6	Detailed Design	2015	ITC preparation and Tender. Detailed design of reservoir, pipelines and intake works
		2016	
		2017	
	Construction	2018	Construction of pipelines and intake works
		2019	
AMP7		2020	Construction of Reservoir
		2021	
		2022	
		2023	
		2024	Commissioning, Handover

Notes:

1) The pipelines and intake works are being constructed first. The pipeline and intake can be used to increase flows into the existing reservoir before the new reservoir is constructed. However the pipelines and intakes works can be built concurrently with the reservoir if the construction duration needs to be compressed.
2) Earth moving for the reservoir construction will be completed during the summer seasons. It is likely to take three summer seasons to complete the earthworks.

1.2 OS references

Cheddar 2 (approx centre of site under consideration)	343200, 153600	ST4353

1.3 Detail of works required

For the site currently under consideration the works to be constructed are likely to include:

- 6000Ml reservoir with inflow weir and draw off tower and overflow;
- New intake chamber to increase the intake capacity to 250Ml/d;
- 4km new mains (1500mm diameter) from new intake pond to reservoirs;
- 1km new mains (600mm diameter) from the drawoff to Axbridge pumping station;
- Diversion of an existing Wessex Water 300mm diameter foul water pipeline;
- Diversion of Ellenge Stream at the North West side of reservoir site.

1.4 Assumptions

The existing abstraction licence at Cheddar will need to be varied subject to low flow conditions to realise the full design yield of the scheme. The reduction of flooding risk in Cheddar Gorge may be an incidental benefit to the scheme.

2. DRIVERS FOR SCHEME

The existing Raw Water Reservoir at Cheddar, constructed in the 1930's, was part of a design intended to have storage capacity of 12000Ml. At the time the decision was made not to build the second "half" but to pump water onto Barrow where the demand for water was.

Construction of the second "half" of the existing reservoir – an additional 6000Ml will provide additional yield and security of supply to a vulnerable area of the company's water supply zone. The need for this work has been identified in Bristol Water's Water Resources Plan.

The drivers for this scheme are:

- SDB1 - Growth – resources
- Additional yield to serve growth in the Weston and Glastonbury & Street supply zones. The Water Resources yield is estimated to be 20Ml/d when used conjunctively.
- Security of supply – the reservoir will provide water storage, to capture high storm flows in winter and summer and will therefore suffer little impact from climate change.

The new storage reservoir will reduce pumping requirements by holding storage locally removing the need to pump very high volumes to Barrow during periods of inflow to attain current yields.

3. OPTIONS CONSIDERED

3.1 Option selected

The option discussed and costed in this report is for a new reservoir to be constructed adjacent to the existing 6000Ml Cheddar Reservoir. Costs for design and planning studies to be undertaken during AMP5 will also be included.

3.2 Alternatives to the scheme

The Bristol Water Draft Water Resources plan describes twelve options considered for resource development to increase yield or provide new water resources. The schemes were assessed by Bristol Water using a cost-benefit approach taking into account customer willingness to pay, social and environmental costs and cost of carbon. From this analysis the schemes were ranked.

Water Resource scheme WR3 (Stand Alone Treatment) was ranked most highly and this scheme is proposed under PR09.

Scheme WR2 Floating Harbour was ranked second ahead of Cheddar reservoir. Scheme WR2 (Floating Harbour) included the abstraction of water from the city docks, transfer to Barrow and pre-treatment before discharge into the existing raw water reservoirs. The Cheddar reservoir scheme was selected by Bristol Water ahead of the Floating Harbour scheme because:

- There is less uncertainty regarding the yield associated with the Cheddar scheme;
- Its environmental impact is lower. (This was assessed in the report "Strategic Environmental Assessment of Bristol Water's Draft Water Resources Plan" prepared by Entec entitled. This report concluded that the Cheddar reservoir scheme has environmental benefits created by reduced pumping, recreational opportunities created and potential for the creation of new wildlife habitats.);
- The impact on bills is marginally lower;
- Winter storage schemes are likely to be more robust to the impact of climate change;
- There are risks associated with scheme WR2 (Floating Harbour) which are not fully understood relating to water quality uncertainty and implications for future treatment.

The ranking of these schemes may be subject to change in the Final Water Resources Plan.

3.3 Alternatives to the location

During this preliminary design phase a new reservoir adjacent to the existing reservoir has been considered. Other sites in the area may offer advantages in geology and topography at the cost of proximity to other Bristol Water assets (Cheddar Spring intake, Cheddar Water Treatment Works (WTW), Axbridge Pumping Station (PS) and Treatment Works and the existing Cheddar Reservoir).

During AMP5 a full assessment of alternative locations will need to be undertaken as part of the planning process (as described in section 15 of this report). No assessment of alternative locations has been undertaken at this stage.

4. INTERACTION WITH OTHER SCHEMES

4.1 IM2 Axbridge to Barrow Raw Water Main replacement

The Axbridge to Barrow Raw Water main currently allows for the transfer of water from Cheddar Reservoir via Axbridge PS to Barrow WTW. The whole main is due to be replaced during AMP5 and AMP6 as part of infrastructure maintenance. This replacement will provide long term durability for Cheddar transfers to and from Barrow, Banwell and Blagdon.

4.2 NIM2c Axbridge Pumping Station refurbishment

The raw water pumps at Axbridge PS (pumping to Barrow and Banwell) are due to be replaced during AMP5 as part of Non Infrastructure Maintenance. Along with the Axbridge to Barrow Raw Water Main replacement this will provide long term durability at Axbridge for transfer to and from Barrow, Banwell and Blagdon. Dependent on proposed flow volumes: additional refurbishment of the pumps at Rowberrow may be required.

5. GEOTECHNICAL SUMMARY (PRELIMINARY APPRECIATION)

A geotechnical appreciation has been undertaken for a new reservoir site adjacent and to the west of the existing Cheddar reservoir, as recorded below:

5.1 Scheme

It is planned to construct a separate 6000Ml bunded reservoir to the west of the existing bunded Cheddar Reservoir in the Cheddar Yeo alluvial flood plain to the south of Axbridge. This new reservoir would be retained by an earth-fill embankment up to around 14m high (above existing ground levels) and 3km in perimeter.

5.2 Geology

The existing reservoir is sited at the northern edge of the Alluvial flood plain. The north-eastern half of the reservoir is founded on Head (formed of clay, silt, sand and gravel) and the south-western half on Higher Estuarine Alluvium (Tidal Flat Deposits 1).

As the currently considered reservoir has to be sited further south than the existing reservoir footprint, the new reservoir embankment is expected to be founded mainly on Estuarine Alluvium (Tidal Flat Deposits). The eastern embankment and north-east corner will be largely founded on the same Higher Estuarine Alluvium (Tidal Flat Deposits) Deposit that much of the western and southern embankment of the existing reservoir is founded on.

The whole area is underlain by the Mercia Mudstone Group (MMG-MDHA). This comprises clay, mudstones (normally calcareous), occasional fine grained sandstones, and halite-stone (evaporite, containing gypsum).

The Estuarine Alluvium is expected to comprise very soft Clay with extensive inclusions of clayey Peat. Gravel may possibly be present at the base of the deposit. The area is intersected by drainage ditches. The geological map shows large areas of Peat at ground surface immediately to the west of Axbridge and in the flood plain upstream of Cheddar between Draycott and Westbury.

5.3 Existing Reservoir Embankment

The existing reservoir was completed in 1938. The embankment is 3560m long with a central puddle clay core, an upstream slope of 1 on 3 and a downstream slope 1 on 2.5. Embankment crest level is 19.2mOD and top water level is at 18.0mOD. It appears that the embankment was generally founded at around original ground level. Where the bank is over 5.2m high, stone toes were provided to both shoulders and a vertical wall drain incorporated in the downstream shoulder. The wall drain was connected to the perimeter toe drain at 18.3m intervals by horizontal pipe drains laid at foundation level. The cut-off trench depth ranged from 6.1m at the north to 18.3m in the west.

The natural ground below the existing reservoir falls from approx. 17mOD along the NE side to approx. 13.5mOD at the SE corner. There is a general slope to the west, reaching a

level of around 5.5mOD in a local depression half-way along the western side. A bed of Peat between 1.8m and 4m in depth was met in this area. The higher ground to the east is occupied by Head.

Much of the embankment length is quite shallow, being only 1m high at the NE corner. At Ch. 900ft (274m) along the NE side, the embankment height is around 3m. The foundation there was described as 'red marl and gravel over soft red marl'.

At Ch.6000ft (1829m) half-way along the western side, where the embankment height is around 13.5m above ground level, the peat was removed beneath the embankment shoulders down to the Mercia Mudstone, described as 'red marl in laminated blocks'. In this area, the cut-off trench was taken to a depth of around 13m into the Mercia Mudstone. The extent of the bed of peat along the embankment was around 230m.

The cut-off trench was taken through weathered surface marl, then more open block beds into tight compact marl. A 0.6m thick block marl marker bed which outcropped in the reservoir floor was found to dip due west under the western half of the reservoir. The block beds contained a number of vertical joints up to 50mm in width which were water bearing and partly filled with a calcite deposit. Grout pipes were installed at all vertical open joints met in the sides of the cut-off trench. These were subsequently sealed by injection with cement grout.

The fill for the embankment shoulders was won from the higher ground within the eastern half of the reservoir footprint and consisted of weathered marls with overlying surface deposits of gravel. Alluvial clay to a depth of 2.4m from beyond the SW corner of the reservoir was used as the source of puddle clay.

The inlet pipe (surrounded in concrete) at the ESE corner and the outlet culvert at the NW corner were laid in trench through the embankment foundation.

5.4 New Reservoir Embankment

It is anticipated that over much of the reservoir area Peat underlies the Alluvium. This ground will not be strong enough to support a new embankment with side slopes similar to those of the existing embankment and would need to be removed down to the Mercia Mudstone. The exception is the ground around the north-east corner and along part of the eastern embankment length, where Peat is probably absent.

Thus the embankment section is likely to be similar to that adopted at Ch 1829 for the existing embankment, viz the Alluvium will be stripped entirely beneath the embankment to the top of the Mercia Mudstone. If Gravel is present locally above the Mudstone, the excavation could be stopped at that level.

The embankment would have a central rolled clay core, with a core trench extending to sound mudstone. A base drainage blanket leading to a toe drain would be incorporated beneath the downstream shoulder.

The Alluvial clay will not be suitable as embankment fill unless it is treated in some way. The underlying Mercia Mudstone from within the reservoir area will need to be used as fill. It is anticipated that all the Mercia Mudstone should be suitable but that some selection of clay for the clay core may be necessary.

The inlet and outlet structures will also be founded on the Mercia Mudstone.

5.5 Reservoir Water-tightness

The observed presence of open joints in the puddle clay trench of the existing reservoir is a concern, particularly as excavation would have to be carried out in this stratum within the reservoir area to source the embankment fill. Ground investigation with permeability testing within the Mercia Mudstone will be necessary to assess the type of cut-off required.

Cut-off options are:

- Do nothing - If the permeability testing shows the ground to be tight, or there is sound cover over the permeable zones over the full perimeter length, no further sealing would be needed.
- Blanket the reservoir base - The alluvial clay removed from above the Mercia Mudstone could be used to blanket the reservoir basin after the Mudstone has been excavated for embankment fill. The clay may need to be dried to some extent if it is to be placed as compacted fill.
- Grouting - Unless there is a well defined permeable zone with connections to the reservoir, grouting could be difficult to define and not be cost-effective.
- Slurry trench - If permeable zones are reasonably shallow, a self-setting slurry cut-off trench dug by back-actor below the embankment should be considered.

Further study will be required during feasibility design to determine the type of cut-off required.

5.6 Construction Issues

The existing reservoir has side slopes of 1:3 upstream and 1:2.5 downstream. It is assumed that the new reservoir will have the the same slopes with a 5m wide crest. The embankment fill would have to be won from the Mercia Mudstone within the reservoir area.

If it is assumed that the Alluvium has to be stripped to 4m depth beneath the embankment along the entire length of embankment, the volume of embankment fill required is estimated to be around 1.8 million m^3. In addition approximately 1.3 million m^3 of Alluvium would need to be excavated from beneath the embankment. If it is also assumed that the Alluvium would also need to be stripped from above the borrow pit and that the Mercia Mudstone is excavated to a depth of 6m within the borrow pit then the volume of Alluvium to be removed from the borrow pit is approximately 1.6 million m^3.

A total of 2.9 million m^3 of Alluvium would need to be temporarily stored on site before being placed in the borrow pit. These figures are based on an assumed mean original ground level across the site of 5.5mAOD, an embankment crest level of 19.2mAOD, assume 1:5 excavation slopes in the Alluvium and 1:1 excavation slopes in the Mercia Mudstone and do not allow for any wastage.

These figures are shown graphically in Appendix 8.

Although these figures are only indicative, they serve to set the economic viability of the scheme in context. A preliminary site investigation is needed to gain better information on the ground conditions.

- The total volume of Alluvium to be removed beneath the embankment and above the borrow area is roughly estimated at 2.9million m^3. The disposal of this unsuitable fill will require a Waste Management Plan. The peat would need to be separated if the

alluvial clay was to be re-used. The peat is to be removed from site however there may be a market for the peat.

- The natural groundwater level will be high. Groundwater will be a problem in all excavations, and particularly in the borrow area. Dewatering of the ground will be a major issue and how this will be achieved will require further study.

- The existing reservoir will be kept in operation during the construction of the new reservoir. This will have implications for the groundwater levels and the stability of the western embankment of the existing reservoir.

- Analyses will be required to determine how close the downstream toe of the eastern embankment can be located to the toe of the existing reservoir western embankment to avoid excavation for the shoulder foundation endangering the stability of the existing embankment. This will be particularly relevant where the Alluvium was left in place beneath the existing embankment and will be more critical if the existing reservoir is kept in service.

Alternatively the western embankment of the existing reservoir could serve as a dividing embankment between the two reservoirs; but this would require the existing reservoir to be taken out of service during construction whilst the new embankment was connected. However it is not considered feasible to take the existing reservoir out of service.

The SE corner of the new reservoir encroaches on the area where the peat from Ch. 1829 was dumped beyond the SW corner of the existing reservoir.

5.7 Site Investigation

It is recommended that a preliminary ground investigation comprising approx. 6 no. x 15m deep boreholes located across the site be carried out to ascertain the depth and nature of the Alluvium and the nature of the Mercia Mudstone. This investigation is needed to enable the economic viability of the reservoir scheme to be assessed.

This would be followed by a more detailed investigation comprising (say) a further 20no. x 15m deep boreholes sunk along the embankment centreline and within the reservoir basin to prove more fully the depth and nature of the Alluvium and the nature of the Mercia Mudstone. In-situ permeability testing should be carried out within the Mercia Mudstone to assess the watertightness of the reservoir basin.

Undisturbed samples would be recovered for laboratory testing to determine index properties, the undrained strength-depth profile of the Alluvial clay, the effective strength parameters and compressibility of the Mercia Mudstone, and Proctor compaction tests on Mercia Mudstone fill. Contamination testing should also be carried out for waste management purposes.

The BGS holds a record of a borehole sunk to 12.2m within the basin of the existing reservoir, which should be studied.

Extensive dewatering will be required to construct the reservoir. It is recommended that a hydrogeological study is undertaken to determine the impact of the reservoir construction on the local marsh and nearby structures. Groundwater levels will need to be monitored both before and during the construction.

5.8 References.

BGS 1:63,360 scale Sheet 280 'Wells'.
Digital Mapping
Hall, RW (1936). 'The Construction of Cheddar Reservoir'
Water and Water Engineering, 367-376.
Cheddar Reservoir Record Drawings

6. ENVIRONMENTAL DESK STUDY

An environmental desk study has been undertaken for a new reservoir site adjacent and to the west of the existing Cheddar reservoir, as recorded below:

6.1 Scope

This high-level environmental assessment has used the GIS data provided within the attached table. It is important to note that data is not provided for all environmental receptors that may be considered in an EIA screening. For example, information on local (built) Conservation Areas, Public Rights of Way and Sites of Interest for Nature Conservation will need to be gathered following the Preliminary Environmental Assessment.

Proposed construction of a new 6000Ml reservoir adjacent to the existing reservoir at Cheddar. It is important to note that although this is part of a plan to provide overall storage capacity of 12,000 Ml at Cheddar, the proposal is to build the new reservoir adjacent to the existing one rather than to extend the existing reservoir.

The works also entail the construction of 4.6km of mains pipeline.

6.2 Overall assessment – Main Reservoir Site

The new 6000Ml reservoir does not exceed the threshold for mandatory EIA under Schedule 1 (section 10) of the EIA Regs. '99. However, a full EIA is expected to be required by the local planning authority (LPA) for the following reasons:

- The proposed works fall within Schedule 2 section 10 (i) of the EIA Regs and exceeds the indicative threshold of 1ha of works (the proposed area is c70ha).

- The proposed reservoir is also within a sensitive location as detailed further below.

- The proposed new reservoir will not fall within Bristol Waters permitted development rights and will therefore require planning permission from the LPA.

- The existing Cheddar reservoir is a SSSI which supports large numbers of wildfowl and over-wintering birds. As the proposed site for the new reservoir is directly adjacent to the existing site, consultation will be required with Natural England. There are also 4 other SSSIs within 2km of the site which will need further consideration. These sites are Axbridge Hill & Fry's Hill, Crook Peak to Shute Shelve Hill, Cheddar Wood and the Perch.

- The Mendip Hills Area of Outstanding Natural Beauty is 688m away from the proposed site. Given the scale of the reservoir it will be visible from areas within this AONB and landscape assessment will be required. Consideration will need to be given to potential landscape impacts and mitigation measures that may serve to reduce the impacts upon the environment.

- There are 2 Special Areas of Consultation (SACs) within 2km of the proposed reservoir. The closest of these sites (Mendip Limestone Grasslands) is 865m away and contains the Annex II species Greater horseshoe bat. The other SAC is the Mendip Woodlands which contains a large population of the common dormouse. As such, consultation will be required with Natural England regarding potential impacts to the interest features of these SACs and an Appendix 11 and/or Appropriate Assessment may be required.

Given the above factors, an EIA is expected to be required by the LPA and ecology surveys and method statements will need to be completed.

As part of the EIA process, consultation will be required with statutory bodies, interested parties and members of the public that may be impacted by the project.

6.3 Overall assessment – Pipelines

- Proposed 3,648m intake pipeline between a new upturned bellmouth intake at the Cheddar ponds and the proposed new Cheddar reservoir.

- Proposed 979m draw-off pipeline between the north west of the existing Cheddar reservoir and the north west of the proposed new Cheddar reservoir.

- The pipeline development on its own would not normally require planning permission as it should fall within Bristol Waters' permitted development rights. However, the pipeline forms part of the proposal for the new Cheddar reservoir which is expected to require a full Environmental Impact Assessment (EIA) and therefore permitted development rights will be lost.

- Furthermore, the area of works for the pipeline alone is over the indicative 1 hectare threshold[1], for requirement of an EIA, under Schedule 2 of the EIA Regs. '99.

- The existing Cheddar reservoir is a SSSI which supports large numbers of wildfowl and over-wintering birds. The proposed intake pipeline runs directly adjacent to this SSSI, around the south of the existing reservoir. The intake point is located directly adjacent to another SSSI, the Cheddar Complex. This SSSI area contains geological, floral and faunal interest features. Consultation will be required with Natural England regarding any potential impacts to interest features within these SSSIs. There are also 5 other SSSIs within 2km of the site which will need further consideration. These sites are Axbridge Hill & Fry's Hill, Kingdown & Middledown, The Cheddar Complex, Cheddar Wood and the Perch.

- The eastern end of the proposed intake pipeline also runs to within 24m of a Special Area of Conservation (SAC) (North Somerset & Mendip Bats) and within 500-2000m of another SAC (Mendip Woodlands) which contains a large population of the common dormouse. Another SAC is within 500-2000m (Mendip Limestone Grasslands) and contains the Annex II species Greater horseshoe bat. Consultation will be required with Natural England regarding these internationally protected areas and an Appropriate Assessment may need to be completed.

- In addition, the eastern part of the proposed pipeline runs into an Area of Outstanding Natural Beauty (the Mendip Hills).

[1] Assuming a 15m working width. An EIA is likely to be required under Schedule 2 (sec 10) (l) if the work area exceeds 1 hectare which is the equivalent of a 700m pipeline in length and 15m working width.

- All of the above factors would increase the probability of an EIA being required by the LPA for the Cheddar reservoir development and will also require ecological surveys and method statements to be agreed.

6.4 Additional environmental constraints – Main Reservoir Site

- In addition to the constraints outlined above, the proposed site also falls within 2km of 2 scheduled monuments. The closest of these scheduled monuments (which are formally defined 'sensitive areas' under the EIA Regs is 695m away. Any effects due to construction or operational activities (including site traffic) which could impact upon these monuments would be considered during the EIA screening and further consultation with the county council archaeologist will be required.

- There are 18 buildings within 50m of the site. Consultation and survey work into likely construction and operational impacts that may affect residents including noise, vibration and visual impacts will be required. This would be taken into account by the LPA in determining the required scope of the expected EIA.

- The proposed reservoir would require the removal of 2410m of minor roads and 29733m² (2.97 hectares) of woodland. It will be necessary to fell a large amount of trees and it is likely that a number of hedgerows will need to be removed to clear the required area. Consultation with the Forestry Commission and a tree felling licence will be required for this to be undertaken.

- Consultation with the LPA will be required regarding hedgerow removal. A survey will be required to ascertain the number of ecologically or archaeologically important hedgerows in the vicinity and a notice will need to be sent to the council for their approval.

- A large amount of the proposed reservoir (194, 937m²) falls within agricultural land classified as '3' which indicates that it may be seen as 'best or most versatile land'. This would be taken into consideration by the LPA during their screening.

6.5 Additional environmental constraints – Pipelines

- In addition to the constraints outlined above, the route of the pipeline also falls within 500m of two scheduled monuments (the closest of which is a roman settlement 189m away). Any effects which could impact upon these monuments would be considered during the EIA screening and further consultation with the local council will be required.

- The proposed intake pipeline route runs through a classified 'urban area' for 1712m. The route will be largely following roads through this area. There are 6 listed buildings and 274 other buildings within 50m of the route. Should the works be likely to impact upon the listed buildings, then listed building consent may need to be gained through the LPA.

- In light of the above points, further archaeological study will be required as detailed below.

- The proposed intake pipeline crosses four roads and runs alongside roads for 1941m. The drawoff pipeline crosses two minor roads and runs alongside roads for 25m as

well as running within 50m of two buildings. Although many of these sections are within the urban area, it may be necessary to fell roadside trees and hedgerows in order to make these crossings and route sections. In which case, protected species surveys such as bats, nesting bird, dormice, badgers and hedgerow surveys may be required. These ecological survey needs will be decided during an initial Phase One walkover survey.

- The proposed pipeline does not run through known contaminated land. However, 32m of the pipeline runs through potentially contaminated land (a dismantled railway and urban land towards the western extent of the pipeline) which would require further assessment.

- The large amount of the proposed pipeline (1081m) runs within agricultural land classified as 1, 2 or 3 which indicates that it is likely to be seen as the 'best or most versatile land'. This would be taken into consideration by the LPA during their screening. Hedgerow Removal Notices are also likely to be required.

- The proposed pipelines do not cross any ancient woodland. However, they run through 127m of other woodland. Protected species surveys as described above would be required and consultation will be required with the local council. The presence of the woodland would be taken into account during the EIA screening.

- 898m of the proposed pipeline passes through a flood zone 3. However, the subsurface nature of the pipeline will not result in any loss of flood storage capacity.

- There are 9 small watercourses (less than 10m width) that will require crossing. Flood defence consent may be required for this crossing (see recommendations below).

- Great crested newt surveys will be required as there are 4 ponds within 500m of the proposed pipeline.

- There are three abstractions within 50m of the proposed route. This would be taken into account in EIA screening and special construction measures may be required to reduce the risk of transmitting polluting materials to groundwater used for abstraction.

6.6 Recommendations for future surveys/investigations

- Whilst the opinion of the LPA will be sought, it is believed that this scheme will almost certainly require a full EIA.

- A planning application will be required for the reservoir and any other above ground installations. The LPA will need to be consulted regarding the exact requirement for planning permission when further scheme details are known.

- Preliminary Environmental Assessment (PEA) will be required to identify specific environmental issues.

- Consultation will be required with Natural England regarding potential affects to the interest features of the SSSIs and SACs. Specific consideration will need to be given to the need for Appropriate Assessment of the impacts to the SAC and an Appendix 11 may need to be produced to facilitate this.

- As the proposed works are located near to an AONB, consideration should be given to any impacts upon the landscape. Consultation should be held with the LPA regarding

the presence of any other locally important landscapes and their requirements for landscape assessment.

- Consultation will also be required with local residents and members of public who may be affected by the scheme.

- A phase one habitat assessment / walkover survey will be required to identify potential Protected species, invasive species and protected habitats.

- Protected species surveys such as bats, nesting bird, dormice, badgers and hedgerow surveys will be required. Further ecological survey requirements would be identified during the Phase One survey.

- Dependent on the PEA and further ecological information from the phase 1 survey, the watercourse alterations may also necessitate a watervole survey, otter survey and/or a white clawed crayfish survey.

- It will be necessary to gather information on Local Sites of Interest for Nature Conservation in order to allow potential impacts to be identified and mitigation measures proposed. This information is held by Bristol Regional Environmental Records Centre (BRERC) who make a minimum charge of £90 per enquiry.

- Information on Public Rights of Way will need to be collected and any closures or redirections to PRoW will need to be agreed with the council PRoW officer. The LPA will also need to be contacted regarding the presence of any (built) Conservation Areas and potential impacts to these.

- Consultation with county councils will be needed to establish the nature of the scheduled monuments and further archaeological survey requirements.

- Consultation will also be required with local councils to establish the nature of the listed buildings in the area and any potential impacts resulting from the works. Listed building consent may be required.

- As there are 5 ponds within 500m of the area, surveys will be required to establish if they provide habitat for Great crested newts.

- The overall footprint of the reservoir covers over a hectare of small watercourses and will require considerable watercourse realignment works. This significant alteration to drainage channels will require extensive consultation with the Environment Agency in order to obtain flood defence consents for the works. Consultation may also be required with the Internal Drainage Board and local council.

- The majority of the proposed reservoir is within a flood zone 3, indicating that the area is at a greater than 1% annual risk of flooding. In accordance with PPS25, a flood risk assessment would be required for this proposal. Special construction methods will be required to reduce the impact of any potential flooding during construction.

- Landmark and geotechnical study may be required to assess land contamination status. If contamination is identified, further phase 1 and phase 2 land quality assessment studies may be required.

- The LPA may require further field studies to be undertaken for the class 1-3 agricultural land.

It is noted that the environmental mitigation measures required may be substantial. For example it may be necessary to recreate habitats affected by the reservoir construction. The reservoir will be constructed in flood plain and there may be a requirement imposed for compensation storage to be constructed elsewhere. Further study into the likely need for the re-creation of habitats and construction of compensation storage is required.

7. HYDRAULIC REVIEW

Not considered at this stage. A full hydraulic review of the existing raw water storage pumping and distribution network will be required as part of the justification of need. An in depth hydro-geological/ water resources review will also be required at a later stage.

8. TECHNICAL DETAILS

At this stage the following technical details have been considered:

8.1 Works at Cheddar Ponds intake

The existing intake arrangement at Cheddar Ponds is to be re-designed to allow the intake capacity to increase to 250Ml/d in order to capture high winter inflows and to provide a new flow measurement weir. The works are likely to include a new intake chamber some 10m x 20m on plan to be constructed at the existing reservoir site. The works will include actuated valves, penstocks and electrical equipment to allow the compensation control to the River Axe to be automated.

The proposed top water level of the new reservoir is the same as the existing at 17.8m. The existing top water level at Cheddar Ponds intake is 20.0mAOD approximately and it is proposed that the new intake will also be constructed at this level.

8.2 Inlet Pipeline from Cheddar Ponds to Reservoir Inlet

It is proposed that 130Ml/d will gravitate from Cheddar Ponds to the southeast side of the new reservoir. To achieve this a 1500mm diameter pipe some 3.6km long is required from Cheddar Ponds, through Cheddar town and laid on the south side of the existing reservoir. A cross connection to the existing inlet pipeline will be made on the east side of the existing reservoir. This will enable both reservoirs to be kept in use if one of the inlet mains is out of service.

The pipe material will be either ductile iron or epoxy coated steel laid with imported granular bed and surround. (Note: If ductile iron is selected the standard diameters dictate either a 1400mm or 1600mm diameter pipe).

The section of the pipeline through Cheddar town will be very difficult to lay particularly at this diameter of pipe. Therefore further consideration should be given to the possibility of tunnelling the section pipe through the urban area.

The inlet pipeline has been sized to deliver 130Ml/d when the reservoir is at top water level. It may be possible to reduce this diameter by sizing it to meet this flow rate at a lower water level in the reservoir.

8.3 Inlet Arrangements

The 1500mm diameter inlet pipework will be installed through the base of the reservoir embankment and will be surround by concrete 750mm thick along its length (some 96m). On the upstream end a reinforced concrete inlet structure will be constructed with an

upturned vertical bellmouth. The inlet structure will allow the energy of the incoming flow to be dissipated before flowing into the reservoir.

8.4 Drawoff Arrangements

A drawoff tower similar to the existing tower will be constructed on the northwest side of the reservoir. A reinforced concrete draw off culvert 4m wide by 2m high will be constructed through the embankment. This will connect to a 600mm diameter drawoff pipeline from the reservoir to the existing Axbridge pumping station. The drawoff pipeline will be 1km long and will connect to the existing suction pipework upstream of the pumping station. The drawoff tower will incorporate an overflow to the Ellenge Stream.

9. BUILDABILITY

The reservoir construction method which has been costed at this stage, is similar to that used in the 1930's construction of the existing reservoir. The design has the same side slopes and cross section detail.

The process of construction will require stripping away of alluvium and peat which overly the Mercia Mudstone, in order for the dam embankment to "key in" to the natural clayey layer.

During the construction of the existing reservoir a large amount of peat was stockpiled in what will now possibly become the area for the proposed reservoir. This peat will need to be removed before construction begins.

10. RISKS AND OPPORTUNITIES

The proposed construction of a large clay fill dam/ reservoir comes with significant risks both at the planning and construction stage. The risk register which can be found in Appendix 5 of this report begins to outline what such risks would be.

11. COST INFORMATION

Costs are summarised in the table below (price base 2007/08):

Summary of Netts	£61,755,628
Summary of Contractors overheads & prelims	£20,605,214
Summary of design costs	£6,012,381
Summary of BW costs (excluding BW supervision)	£19,406,781
Contingency - to cover change of scope (10% of scheme total)	£5,428,240
BW costs	£ 4,651,208
Scheme CAPEX Total (excl. OPEX costs)	**£117,859,452**
Scheme OPEX Total (pa)	**£100,857**

More detailed cost information is included in the Cost schedule attached in Appendix 6.

12. PROGRAMME

See section 1.1 for a suggested activity timeline.

13. CONCLUSIONS

To provide additional raw water storage a 6000Ml bunded reservoir is proposed adjacent to the existing Cheddar reservoir. The works would also require the construction of 3.6km of 1500mm diameter intake pipeline and 1km of 600mm diameter drawoff pipeline. A new intake structure would need to be constructed at Cheddar Springs.

PART 2: FUTURE WORK

14. OVERVIEW OF AMP5 WORK

During AMP5 two phases of work will be required to progress the delivery of Cheddar Reservoir Number 2. The phases of work are:

- Pre-Feasibility – to identify the optimum site for the reservoir;
- Feasibility and Outline Design – to focus on more details of the reservoir at this specific site.

Under both phases the work can be split into three parallel work streams as follows:

- **Environmental/ Planning:** this includes the consideration of environmental and other constraints, gaining policy back up and general planning input, promotion of a short list of sites, selection of one site, preparation of the Environmental Statement and planning application, public relations, land entry and acquisition and legal input.

- **Engineering:** this include engineering studies to determine the reservoir site, capacity, dimensions, general arrangement, stability, intake and drawoff facilities, intake and drawoff pipeline routes and details of the Cheddar Springs intake. Engineering decisions will be made in conjunction with the environmental and water resources work.

- **Water resources:** This will include the analysis of the available yield at Cheddar Springs, analysis of demand, agreement with the Environment Agency, assessment of the reduction in flood risk produced by construction of the reservoir and consideration of the effects of the reservoir construction on the hydrology of the wider area. Studies will need to take account of both the permanent and 'under construction' conditions.

The management of the work during AMP5 must be given consideration. The work will require close coordination of the various work streams. It may be appropriate to set up an internal management team or steering group to ensure consistency and inclusiveness in the decision making process. The management team should include engineering, environmental, water resource, planning and legal experts.

There will also be a requirement for good public relations and communications. A communications team should be established to address the public relations of the scheme.

15. PRE-FEASIBILITY

During AMP5 pre-feasibility work will be carried out. This will include optioneering of the reservoir location, geotechnical and environmental studies, planning and stakeholder liaison.

To satisfy the planning requirements it needs to be demonstrated that all possible sites have been considered and that the optimum site has been selected. A site selection screening exercise is to be undertaken considering engineering, environmental, hydrological, geological and archaeological factors for a long list of sites. From this long list a short list of sites will be produced.

A Strategic Study report will be produced at this stage to describe the methodology of the selection of the long list of sites and pipe routes and the methodology of selection of the short list of sites and pipe routes.

15.1 Environmental/ Planning

(a) Justification of need

A Justification of Need will be required. This document will be key to the planning process and public enquiry that will take place. Bristol Water will need to demonstrate assessment of multiple potential sites, and alternative schemes. The Justification of Need will build on the information already covered in the Bristol Water: Water Resources Management Plan. Consultation with the Environment Agency and DEFRA will possibly be appropriate at this stage.

(b) Pre-feasibility studies and consultation leading to site identification

Environmental and planning work supporting the production of the Strategic Study is required.

Consultation with the following bodies may be appropriate at this stage:

- Natural England
- Local Planning Authority (LPA)
- Environment Agency/ DEFRA
- Upper Axe Internal Drainage Board (IDB)

15.2 Engineering

(a) Site Selection

Engineering work supporting the production of the Strategic Study is required.

It will also be necessary to demonstrate that other engineering alternatives have been considered. These may include:

- raising the existing reservoir level to provide the additional storage;
- providing the additional storage partly by raising the existing reservoir and partly by creating lagoon in the borrow pit used to provide the material to raise the reservoir.

(b) Preliminary Ground Investigation and Pre-Feasibility Study

A preliminary ground investigation of the most likely sites is to be undertaken to better understand the geology at each of the sites. Aerial and photogrametric surveys at each site are also to be undertaken. For each of the sites a pre-feasibility study is to be undertaken for a range of reservoir capacities. This will help to define the optimum size and site selection. A costing exercise will be carried out for theses sites to inform the decision making process. The outcome of this will be the selection of a single site and reservoir size.

15.3 Water Resources

(a) Data Collection

It will be necessary to gather flow data at Cheddar Springs, Cheddar Yeo, River Axe and any other local watercourses which may be affected by the works. The existing weirs at Cheddar Ponds will need to be modified to enable them to be used for accurate flow measurement. The weirs to be modified include the upstream weir from Cheddar spring, the intake weir and the overflow weir.

There is no other major contributing area to Cheddar Yeo so it is assumed that the Cheddar Springs flow is representative of the downstream flow in the Cheddar Yeo. River Axe flow is already measured at Wookey but it will need to be confirmed whether this is close enough to the proposed site to be used in any modelling of the watercourses.

It will be necessary to begin flow measurement as early as possible to obtain sufficient data to build a robust model of the water courses in the area and predict how they will be influenced by the proposals.

(b) Compensation Flow and Agreement with Environment Agency

The Environment Agency may wish to increase the compensation flow rate from Cheddar Springs to the Cheddar Yeo. In addition the Environment Agency will be interested in the affect the new reservoir has on the hydrology and ecology of the area. As such discussions with the Environment Agency should begin as early as possible. The existing abstraction licence will need to be varied.

(c) Determination of Yield

A study is to be undertaken to determine the predicted yield from the proposed reservoir. The study should include the effects of climate change and combinations of dry years. The study will help to define the required capacity of the reservoir.

16. FEASIBILITY, OUTLINE DESIGN AND SITE INVESTIGATION (AMP5)

At this stage it is assumed that a single reservoir site has been selected. Work at stage will involve more detailed study of the proposed reservoir site and better definition of the final works. In order to gain planning permission is will be necessary to carry out outline design of the reservoir at this stage.

16.1 Environmental / Planning

(a) Environmental Studies

Following desk studies a Phase One walkover surveys will be carried out on the chosen site. This will identify what ecology and other environmental surveys are required.

Expected surveys which are likely to be carried out at this stage include:

- Bat surveys
- Nesting bird surveys
- Dormice surveys
- Badger surveys
- Hedgerow surveys
- Great Crested Newt surveys
- Crayfish surveys
- Other surveys which the Phase One walkover survey recommends.

An archaeological desk study is appropriate at this stage.

These surveys would lead to the preparation of an environmental screening report.

(b) Stakeholder liaison

This will include consultation and relationship building with:

- Somerset County Council

- Sedgemoor District Council
- Relevant Parish Councils
- Members of Parliament
- Local resident groups
- Landowners
- Local, regional and national media
- Affected residents
- Local businesses
- Natural England
- Local wildlife trusts
- RSPB
- Internal Drainage Board
- Environment Agency
- Consumer Council for Water
- National Union of Farmers
- South West Regional Development Agency
- South West Regional Assembly.

(c) Land Entry and Purchase

Land entry for surveys and investigations will need to be facilitated using section 169 of the Water Industry Act 1991.

In addition some preparatory work will be required for the compulsory purchase order (CPO). The CPO will be required for the acquisition of land and rights in land for the scheme.

(d) Public Enquiry

Due to the nature of the project it is likely that the project will trigger a public enquiry. This process will involve a lot of time and continuing stake holder liaison, two years have been allowed in the programme for this.

(e) Other Impacts

Studies may need to be undertaken to assess the impact of the scheme on local businesses, local population and the wider regional economy.

16.2 Engineering

(a) Second Stage Ground Investigation and Geological Computer Modelling

A second ground investigation is to be undertaken to determine the site geology in more detail. This data will be used to create a geological computer model of the site. The computer model will then be used to undertake earthworks modelling to help define the optimum dimensions and position for the reservoir embankments. For each reservoir capacity considered a selection of different reservoir depths will be considered to select the optimum combination.

At this stage a hydrogeological study will be undertaken to determine the effect of the reservoir construction, and particularly the dewatering required during construction, on the local groundwater levels and its affect on the marsh and local structures.

(b) Reservoir Design

A stability analysis of the reservoir embankment will be undertaken to determine the construction and arrangement of the embankment. Designs will also be produced of the drawoff, overflow, intake, drawoff pipeline, intake pipeline, Cheddar ponds modifications and environmental enhancements. Such environmental enhancements might include lagoons, reed beds, trees, planting and flattening of the side slopes to improve the appearance of the reservoir embankment.

(c) Costing

Construction and design cost estimates are to be produced. Risks associated with the scheme are to be assessed and costed.

16.3 Water Resources

(a) River Modelling

It may be necessary to model the Cheddar Yeo, and possibly the River Axe, to predict their behaviour once the reservoir has been constructed.

17. DETAILED DESIGN AND PREPARATORY WORK (AMP 5/6)

17.1 Geotechnical investigation

Further geotechnical investigation will follow into the detailed design period, as the design engineers will need accurate and appropriate detail of soil and rock properties to ensure the best design for the embankment dam.

17.2 Design

Once the feasibility has been carried out, and a site, working methodology and outline design of the reservoir has been agreed the detailed design can be carried out. It is anticipated that the preparatory works will be designed first. The detailed design of the preparatory works will involve detailing the diversions of the Ellenge Stream and existing pipelines through site; the new pipelines from Cheddar Spring and Axbridge Pumping Station and the improvement to the intake.

The detail design of Cheddar reservoir number 2 will be carried out once construction has begun on the intake works. It is anticipated that there will be much liaison with contractors responsible for embankment construction at this stage for a best value solution.

18. CONSTRUCTION (AMP 6/7)

The construction of the reservoir embankment will take place over a number of years. The following stages will need to be undertaken:

18.1 Diversion of pipelines and other preparatory work

Construction of any pipeline diversions will be carried out first, while detailed design of reservoir is being carried out. This will ensure that the site is ready for the carefully planned earth moving operation in AMP7 for reservoir construction.

18.2 Construction of new pipelines to intake and drawoff

The construction of the intake pipeline will take place in two sections: the urban section from Cheddar Springs to close to the existing intake and the rural section from the existing intake to the new intake. The rural section will be open cut. The choice of construction technique for the urban section will need to be assessed. The pipeline is 1.5m diameter and it may prove economic to install this section of pipeline in a tunnel.

The drawoff pipeline construction is in a rural location and can be carried out in open cut.

18.3 Improvements at Cheddar Spring

The construction of a new intake structure at Cheddar Springs will require careful planning. The site is close to Gough's Caves which together with the gorge itself are a major tourist attraction in the region. The planning of the works will need to take this into account. The LPA may impose stringent planning constraints relating to working hours, movement of plant and environmental enhancements associated with the works.

APPENDICES

Appendix 1 – General Arrangement Drawing

Appendix 2 – Environmental Constraints Map

Appendix 3 – Environmental Schedule

Appendix 4 – Geological Map

Appendix 5 – Risk Register

Appendix 6 – Cost Schedule

Appendix 7 – Earthworks Schematic