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DOCUMENT CONTROL SHEET

Client: **National Rivers Authority**

Project: **Environmental Consultancy Support Exe/Axe Water Resources**

Title: **Wimbleball Pumped Storage Scheme**
Review of Environmental Statement (Appendix B3)
Implications for Water Quality in Wimbleball Reservoir, the River Exe (Non QUASAR parameters) and the Exe Estuary

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0. SUMMARY

South West Water Services Ltd (SWWS) has applied to the National Rivers Authority (NRA) for a licence to abstract water from the River Exe to Wimbleball Reservoir. The application was accompanied by an Environmental Statement (ES). WS Atkins (WSA) was commissioned by the NRA to review Appendix B3 (of the ES) "Water Quality – Non-QUASAR and Reservoir Analyses", to comment upon the implications for water quality in the Exe estuary and to advise on monitoring requirements.

Appendix B3 is concerned with the likely implications for water quality in the reservoir (all parameters) and the river system (parameters other than dissolved oxygen, temperature, pH, biochemical oxygen demand, ammonia and nitrate).

Regarding Wimbleball Reservoir the authors acknowledge that insufficient data are available to provide a full understanding of reservoir mechanisms. However the Statement concludes that the reservoir appears to be well mixed with destratification equipment maintaining this situation throughout the summer, that temporal water quality trends are as expected, that the current mesotrophic status will tend towards the eutrophic following scheme implication and that reservoir siltation rates will not effectively reduce reservoir capacity or lead to over-turbid conditions. Mention is also made of an apparent rise in zinc concentration.

Regarding the River, the Statement observes that insufficient data for metals and trace organics are available to confirm compliance with environmental quality standards but nevertheless suggests that non-compliance is unlikely.

Whilst the conclusions drawn are not disputed, a number of comments are raised by WSA concerning the inadequacy of reservoir profile data, nutrient balance, the use of transposed water quality data and the assumptions concerning suspended solids.

Regarding the impact of the scheme on estuary water quality, WSA concludes that, on the basis of hydrological information presented in Appendix A of the ES, whilst inflow of fresh water into the estuary will be reduced by up to 12% within the middle range of flows, the impact on tidal volume will be only 0.25% and that increases in the concentration of pollutants at the tidal limit are likely to be within the NRA's 10% guideline and should not lead to an EQS failure within the estuary.

Regarding monitoring requirements, WSA recommends that a series of six key river sampling points are monitored weekly with determinand frequency being dependant upon susceptibility to variation (minimum monthly) and that increased spatial and profile monitoring of the reservoir is undertaken to provide both continuous and discrete output of various physical, chemical and biological data. The last is considered to be important in connection with reservoir management.

Overall, despite the identified data shortfalls, WS Atkins judges that sufficient water quality information has been provided to enable the NRA to determine the Exe/Wimbleball licence application and that based on this information the proposed scheme should not result in an unacceptable deterioration in water quality in the reservoir, river or estuary.

1.0 INTRODUCTION

1.1 Background

South West Water Services Ltd (SWWS) has applied to the National Rivers Authority - South West Region (NRA) for a licence to abstract water from the River Exe near Exebridge for pumping to Wimbleball reservoir.

In detail, permission is sought to abstract 150 Ml/d (13633 Ml/annum) from the river Exe during the period 1 November to 31 May each year provided the natural river flow as measured at Exebridge exceeds 100 Ml/d (1.16 m^3/s). The abstraction to constitute no more than half the natural river flow in excess of the prescribed river flow.

SWWS has prepared and submitted an Environmental Statement in support of their application.

WSA has previously reviewed draft supporting documentation provided previously to NRA by SWWS (River Exe Resources – Environmental Impact Assessment - Final Report, Halcrow 1989) and has provided advice to NRA concerning river and estuary water quality modelling in its Interim Report : Exe/Axe Water Resources – Review of Documentation and Modelling Approach, November 1992, ref K1248.PD1/002.

1.2 Terms of Reference

The NRA has commissioned WS Atkins to:

a) review the content of one of the documents contained within the Statement, namely, "Wimbleball Pumped Storage Scheme – Appendix B3 Water Quality - Non QUASAR and Reservoir Analyses (RP-PLA-1981AO-040(01))" with particular reference to:

   i) any issues which conflict with the NRA's viewpoint
   ii) any areas of confusion
   iii) any statements which are lacking in supporting information

b) advise NRA on whether sufficient water quality information has been provided to enable NRA to determine the Exe/Wimbleball licence application.

c) advise on the significance of a reduction in flow at the tidal limit (River Exe) with respect to tidal volume and dilution of sewage effluent in the estuary under ebb tide/low water conditions.

d) advise on future monitoring requirements.

2.0 RESERVOIR ANALYSES

2.1 Introduction

This part of the Environmental Statement is concerned with the impact of the proposed scheme on water quality in Wimbleball Reservoir.

The work to be undertaken by SWWS was agreed with the NRA and comprised:

i) a trend analysis of historical data
ii) a water quality/depth profile analysis
iii) an assessment of the reservoir's trophic status and how this might change
iv) an assessment of algal data and how algal populations might be affected
v) an assessment of impact on reservoir water quality
vi) an assessment of the implications for water quality of drawdown and releases of compensation water
vii) an assessment of the input of increased suspended solids intake
viii) an assessment of potential compliance with EQS values
ix) discussions with relevant specialists

2.2 Comments on Scope of Work, Methodology and Results (Sections 2, 3 and 4)

2.2.1 The 'agreed' scope of work (Section 2 of the Report) does not refer adequately to the impact which abstraction of water from (and return of water to) the River Exe has on the river.

2.2.2 In subsection 3.5 it is admitted that insufficient data exist to enable a full understanding of the reservoir mechanisms to be gained. Hence modelling of reservoir water quality by the Vollerweider approach was not possible.

2.2.3 In subsection 3.7 item (iii), which is concerned with reservoir volumes through the winter period, is not understood.

2.2.4 Reservoir temporal water quality trends (4.3.1) are as expected. However an apparent increase in zinc concentrations requires attention.

2.2.5 The conclusion that there is "reasonably complete mixing and homogeneity of quality throughout the reservoir" spatially (4.3.2) and "reasonably good mixing throughout the water column" (4.3.3.1) cannot be drawn with any certainty in the absence of profile data for temperature, dissolved oxygen, biochemical oxygen demand, phosphates and suspended solids.

2.2.6 The effectiveness of the operation of the destratification equipment (4.3.3.2) cannot be confirmed without the profile data referred to in 6 above. Similarly, the conclusion reached in 4.3.3.3 that the majority of the data indicated a fairly well mixed and reasonably homogenous water body cannot be verified.

No attempt appears to have been made to study seasonal variations over depth for the parameters for which data does exist.

2.2.7 The 'OECD approach' for determining trophic status (4.4.1) should be sourced.

2.2.8 The ratio (4.4.2) derived for total phosphate and orthophosphate in the reservoir from data which shows no correlation anyway, cannot be assumed for the river water. The chemistry of phosphorus in the aquatic environment is too complicated to allow simple assumptions to be made. Hence the use of this data in determining trophic status is invalid.

2.2.9 Care is required in making assumptions about future algal blooms on the basis of past history – particularly in a relatively young reservoir. In 4.4.2 this assumption is hinted at when in the last two paragraphs reference is made to high phosphate concentrations not necessarily leading to massive algal blooms. It may simply be that other physical conditions were not right.

2.2.10 The final comment in 4.4.3 which suggests that nitrogen was the most important nutrient in 1992 may well be true if the blooms which occurred were predominantly phytoplankton. Altering the ratios eg by reduction of nitrogen may in fact simply lead to algal blooms of a different type.

However, any action which will reduce overall nutrient content in the reservoir is to be welcomed and it would seem that in the case of nitrogen there will be a benefit of introducing water from the Exe. It should be noted however that phosphorus is likely to increase.

2.2.11 The conclusion drawn in 4.6.2 referring to nitrogen levels being low in the reservoir in summer due to uptake by algae (last sentence) does not seem to follow what has gone before (which talks about the scheme reducing nitrate levels in the reservoir as a result of introducing river water) and phosphate is not mentioned.

2.2.12 Subsection 4.7 is concerned with the release of water from the reservoir to the Exe and the Haddeo. It is concluded that such releases will have minimal impact. Whilst there is no evidence to suggest that this will not be so, it should be noted that the reservoir waters will contain algae and may occasionally be of different pH to the river water.

2.2.13 Subsection 4.8 is concerned with suspended solids. In 4.8.1 an assumed average of 20 mg/l suspended solids has been made in the River Exe. It is not clear whether this figure represents spot samples in good weather, or just between November and May and whether spate flows are included.

2.2.14 In 4.8.2 the argument at the end of the first paragraph, which suggests the EQS for suspended solids will be achieved despite additions of river water because high values in winter will be balanced by low values in summer, is not valid.

The level of solids in suspension in the reservoir may affect both algal growth and the survival of salmonids.

The last sentence of the third paragraph refers to the EQS for solids of 80 mg/l not being violated but does not mention the requirement to meet an annual average of 25 mg/l.

2.3 Comments on Conclusions (Section 5.0)

2.3.1 The authors conclude (subsection 5.1) that EQS values are complied with for all parameters except iron in the river and zinc in the reservoir.

This is a fair assessment of the present situation. High levels of iron occur naturally in the Exe catchment and hence occasional exceedance of the EQS value is to be expected. The apparent rise in zinc levels in recent years in the reservoir however requires investigation.

2.3.2 The authors also conclude in subsection 5.1 that since in general there was no significant difference between the reservoir quality before (observed data) and after scheme implementation (simulated data), it would be very unlikely that a substantial non compliance with NRA stated EQS values would occur in the future.

This is again a fair assessment of the situation. The method of producing simulated data for the post scheme situation is acceptable.

2.3.3 In subsection 5.2 it is concluded that the "reservoir is a fairly well mixed water body". Whilst available data does not show that the reservoir is not mixed, there are insufficient profile data (DO, temperature, BOD, nutrients) to confirm the position. Ammonia and manganese concentrations do show increasing levels with depth which might indicate lower oxygen levels at depth.

2.3.4 Reference is also made, in subsection 5.2, to observed seasonal variations due to meterological conditions and microbiological activity.

Temperature, DO and nitrate are quoted as examples. It is also concluded that small changes in some parameters would be anticipated on scheme implementation the largest being nitrate (up to 40% reduction).

Whilst the above are reasonable conclusions, care is needed in the assessment of future nutrient levels since these tend to circulate and build within the reservoir through successive algal changes. Also phosphate, input of which is likely to increase, is not mentioned. The concentrations of nutrients eventually found therefore may not be quite as would be predicted through mass balance assessments.

2.3.5 Subsection 5.3 concludes that the reservoir is currently mesotrophic and is likely to become more eutrophic in character following implementation of the scheme (based on OECD procedures).

This is a reasonable conclusion and will probably happen anyway as the reservoir matures.

2.3.6 Subsection 5.4 observes that algal species over the years have become more typical of the types found in nutrient rich environments. The conclusion is drawn however that in the case of Wimbleball a reduction in nitrate concentration would be the appropriate method of reducing algal populations.

The observed apparent correlation between nitrate concentration and algal populations may be misleading since many other physical conditions also influence algal growth. The importance of phosphate as a limiting nutrient should not be underestimated.

2.3.7 In subsection 5.5 it is concluded that since the predicted change in reservoir quality as a result of the scheme is insignificant, the impact on discharges of compensation flows to the Haddeo and returned-to-Exebridge flows on the Exe would in turn also be minimal.,

Whilst this is a reasonable conclusion, it is possible that increased algal productivity in the reservoir could result in increased quantities of algae being discharged to the Haddeo and Exe.

2.3.8 Subsection 5.6 refers to suspended solids and concludes that the additional inflow of solids should not cause an unacceptable siltation problem nor an unacceptably high suspended solids concentration in the water column.

It would be wise to ensure that adequate controls are in place to prevent transfer during spate conditions. It is understood that this is the intention.

2.4 Conclusion

On the basis of the evidence presented WS Atkins concludes that introduction of a pumped storage scheme along the lines currently proposed should not adversely affect water quality in Wimbleball Reservoir.

3.0 NON-QUASAR PARAMETERS - COMPLIANCE WITH EQS VALUES

3.1 Introduction

The impact of the scheme on the River Exe has been predicted using QUASAR modelling techniques. Parameters evaluated by this approach were pH, temperature, biochemical oxygen demand, dissolved oxygen, ammonia and nitrate.

There remained a number of other parameters which required evaluation. These included other inorganic anions, toxic metals and trace organics.

Following examination of available data the NRA agreed that 1990 would be a suitable baseline year. There was also a requirement to provide information for other hydrological years. Those years were 1989 and 1976.

3.2 1990 Baseline Results (Subsection 9.1)

The approach used to determine compliance both, during 1990 and with the scheme implemented, is considered to be acceptable (except as noted below) and the results do not indicate cause for concern in implementing the scheme.

It should be noted that 1991 data, converted to 1990 by use of a hydrological factor, was used at 'Pynes Intake' because 1990 data was not available at this site. Conversion of water quality data from one year to another by application of a hydrological factor is not considered to be good practice. Hence in the opinion of WS Atkins the findings for Pynes are not valid.

It should also be noted however that no attempt has been made to assess compliance for trace organics due to inadequate data.

3.3 Years 1989 and 1976

Both these years were estimated using hydrological factors to convert water quality and therefore are considered to be invalid. This view is endorsed by the fact that in Subsection 3.7 of the Report it is admitted that no correlation could be found between flow and water quality.

3.4 Conclusion

From the evidence presented there would appear to be no cause for concern with respect to the 'Non-QUASAR' parameters examined.

4.0 HYDROLOGY AND WATER QUALITY

4.1 Introduction

This section is based on data as detailed below, taken as read from the reports prepared by Watson Hawksley and Halcrow.

Watson Hawksley:

- Flow Duration Curves Figs FDS3-81 to FDS3 - 90
- Water Quality Calibration Data (1989) for Thorverton, Stafford and Trews Weir.

Halcrow:

- Average Daily Flows in the Rivers Exe, Culm and Creedy.

4.2 Flow Duration Curves

These appear to show that the proposed abstraction scheme (Scenario 3) does not compromise the Q95 flow calculations under any degree of 'wetness'. However, for mid-range flows the proposed abstraction regime will lead to reduced flows in the river. The precise range of flows thus affected appears to be related to the 'wetness' of the year. Thus, under drought conditions (1975-76) the range of flows affected is between Q10 and Q65, whilst under wet conditions (1986) the range is extended to between Q10 and Q93. Hence under the proposed abstraction regime it can be expected that river flow will be reduced for between 55% and 83% of the time.

At Northbridge, downstream of the abstraction for Pynes WTW, the maximum reduction appears to be about 18% of the existing flow. At the tidal limit the maximum reduction is only 12% due to the contributions from the Culm and the Creedy.

The effect of these reductions on the volume of water in the estuary is minimal. Theoretical volumes in the estuary, taken from the computer model of the Exe estuary, developed by MetOcean for SWWS are :

at MHWN	44.5×10^6 m^3
at MLWN	21.1×10^6 m^3
	23.5×10^6 m^3

Assuming average daily flow (ADF) into the estuary (1.978×10^6 m^3/d) the reduction in volume in the estuary due to a 12% drop in river flow will be :

$$\frac{6 \times 1.978 \times 0.12}{24 \times 23.5} \times 100\% = 0.25\%$$

This assumes that maximum volume occurs at high tide and that the river has contributed for $\frac{6}{24}$ hours.

4.3 Water Quality - Tidal Limit

To assess the affect of reduced flows on the concentration of pollutants entering the estuary, data from three sites on the river have been considered; Thorverton gauging station (located upstream of the river Culm confluence); Stafford (downstream of the Culm); and Trews Weir (downstream of the Creedy confluence and at the tidal limit). Data for 1989 has been considered and the mean values of BOD and total ammonia for each site are given below. The year 1989 was chosen because it corresponds with the flow duration curves for 'severe dry' conditions and thus can be considered a worst case. However, it must be noted that the mean figures are based on only 5 samples.

	BOD mg/l	**AMM** mg/l
Thorverton	1.48	0.028
Stafford	1.78	0.06
Trews Weir	1.88	0.072

Assuming that the ratio of flows in the rivers Exe, Culm and Creedy are always proportional to the ratio of ADF's then a simple mass balance reveals the following concentrations in the Culm and the Creedy.

	BOD mg/l	**AMM** mg/l
Culm	2.91	0.19
Creedy	2.40	0.13

(In reality the contribution attributed to the Creedy is partly due to surface run off from Exeter)

By reducing the flow in the Exe by abstraction at Northbridge, the volume of water available for dilution of the pollutants in the Culm and the Creedy is reduced. Thus pollutant concentrations must increase at the tidal limit.

The maximum reduction of 18% which occurred at the Q55 flow at Northbridge in 1989 would lead to the following concentrations at the tidal limit (assuming zero natural decay).

	ABSOLUTE VALUE mg/l	**PERCENTAGE INCREASE** mg/l
BOD	1.94	3.2%
Ammonia	0.079	9.7%

These figures are a crude estimate of the likely effect at the tidal limit and must therefore be treated with caution. The percentage increases are within the accepted 10% reduction-in-quality limit and the absolute values are low.

4.4 Water Quality - Estuary

As a guide to the affect of reduced fluvial flow on water quality in the estuary, the impact of Countess Wear STW has been considered. The outfall is above low water and hence the worst case is represented by considering river flow only. The discharge consent conditions for the works are as follows:

BOD 15 mg/l

Ammonia 10 mg/l

Flow 48,500 m^3/d (0.56 m^3/s)

Taking the existing 50 percentile flow from 1989 (largest reduction) and assuming zero decay between the tidal limit and the STW, a mass balance across the outfall gives concentrations downstream of the STW of:

BOD 2.69 mg/l

Ammonia 0.68 mg/l

Allowing for a 12% reduction in inflow to the estuary and increased influent concentrations, the nett effect downstream of the works is :

	ABSOLUTE VALUE mg/l	PERCENTAGE INCREASE
BOD	2.84	5.5%
Ammonia	0.77 mg/l	12.1%

The cumulative effect has caused the percentage increase in ammonia to exceed the 10% guideline. However, no allowance has been made for natural purification. Moreover, the absolute value of total ammonia still represents less than 0.021 mg/l of free ammonia for the ambient conditions (pH 8.0, temp 15°C) and would not therefore be considered toxic to fish.

4.5 Conclusion

- Flow in the river and hence inflow to the estuary will be reduced within the Q10 - Q93 range as a result of implementing the proposed abstraction regime, Scenario 3. The maximum reduction is likely to be of the order of 12%, at the tidal limit.
- The impact of this on tidal volume is very small (0.25%).
- The increased abstraction will lead to increased pollutant concentrations at the tidal limit due to the poor quality of the River Culm and surface water run off from Exeter, which will receive less dilution.

- Similarly, the concentration of pollutants downstream of Countess Wear STW will increase.

- The increases are likely to be within NRA 10% guidelines and should not lead to a lower estuary classification.

5.0 MONITORING

5.1 Introduction

In arriving at proposals for a monitoring programme to evaluate the effectiveness of the proposed scheme the following were taken into account:

i) the extent of the NRA's existing monitoring programme
ii) the need to demonstrate that water quality has not deteriorated – particularly at sensitive points
iii) the need to ensure that problems are not stored up for the future
iv) regard for cost

5.2 Reservoir

The reservoir monitoring programme should provide information both spatially and through depth. The exact location and number of monitoring points is a matter for agreement between SWWS and the NRA. However, as a minimum, a representative picture of water quality throughout the reservoir is required. The principal objectives are to gain a thorough understanding of how the reservoir behaves over an extensive period of time, to determine trends and to ensure compliance with Environmental Quality Standards.

To this end continuous measurement of oxygen, temperature, pH and turbidity should be carried out at surface, mid depth and bottom levels. In addition regular sampling for biochemical oxygen demand, ammonia, suspended solids, oxidised nitrogen, total phosphorus, silica, chlorophyll *a* and manganese should be carried out at the same locations. Throughout the late spring, summer and early autumn, weekly monitoring for the above parameters is advisable together with weekly identification and quantification of algae. At a lower frequency, perhaps monthly, metals and trace organic compounds such as pesticides should also be looked for.

The results of a properly designed monitoring programme will aid the efficient use of destratification equipment and the prediction of algal blooms.

All inflows to the reservoir should be monitored at least monthly for the full range of parameters except chlorophyll *a* and algae.

5.3 River

The principal objectives of the river monitoring programme are to demonstrate no deterioration (ie less than ten percent) in water quality and to ensure that water quality objectives are not compromised. To this end a series of six sites is recommended as key monitoring points where weekly sampling should be undertaken. The parameters to be analysed on each sampling occasion should, to some extent, be determined by the concentration usually found and the degree of variation. Parameters such as dissolved oxygen, temperature, pH, biochemical oxygen demand, ammonia, suspended solids and nutrients should be carried out weekly as a minimum with other parameters such as metals and trace organics being at least monthly. A continuous monitoring station is recommended at the point of abstraction.

Recommended sites are;

River Exe above Haddeo (control site)
River Exe at Exe Bridge (intake site)
River Exe below Exe Bridge (temporary during construction period)
River Exe at Ashley (below Tiverton STW)
River Exe at Trews Weir (tidal limit)
Haddeo (below Wimbleball)

6.0 CONCLUSIONS

6.1 The document attempts to estimate the likely impact of the proposed scheme on the Wimbleball Reservoir and, in terms of 'Non QUASAR parameters' (ie water quality determinands other than those modelled using QUASAR), on the rivers Exe and Haddeo.

6.2 Some of the conclusions drawn are based on incomplete or limited data sets and as such may be open to question. However, in general the Report recognises the data shortfalls and infers that conclusions are drawn on a 'best information' basis.

Those statements which appear to the reviewer to be confusing or to lack sufficient supporting information have been identified and commented upon in the text of this Review.

6.3 No issues appear to have been identified which conflict with the NRA's requirements, although where data is lacking, eg phosphate/phosphorus levels or trace organics, it has not been possible to demonstrate complete compliance with EQS values.

The only issues of possible concern noted by the Reviewer were the expectation that the reservoir might become more phosphorus rich and the apparent rise in zinc concentration in the reservoir. The former may have implications for the trophic status of the reservoir (despite a predicted fall in nitrogen) whilst the latter might eventually result in a breach of the EQS value for zinc.

6.4 With regard to the question as to whether the NRA has sufficient information to determine the licence, the answer is probably yes. SWWS has demonstrated adequately that there is no current water quality problem associated with the reservoir or its operation and that there is good similarity between the Exe river water and the reservoir water (currently derived from its own catchment). The lack of data regarding trace organics is perhaps not a matter for concern in this area since their presence in high concentrations is perhaps not expected. The situation regarding the NRA's "not more than ten percent deterioration in water quality" rule has not been confirmed for all non-QUASAR parameters, particularly below Tiverton and Exeter sewage treatment works outfalls. However, the degree of dilution available in the river at these sites is not expected to be significantly changed under low flow conditions.

The Reviewer's own calculations (Section 4.0 of this Review) based on hydrological data contained within SWWS's Statement, indicate that water quality in the estuary is unlikely to be adversely affected by the proposals.

6.5 An improved water quality monitoring programme is required to provide adequate reservoir management information and to confirm that the scheme has no adverse impact. Improved baseline data are required for metals and trace organic compounds.

WS Atkins