ENVIRONMENT AGENCY

GIBB Environmental
LAWGIBB Group Member

MIDLANDS REGION

# AMP3 BENEFITS ASSESSMENT
## LOW FLOW ALLEVIATION SCHEMES

## FINAL REPORT
(INCLUDING BUSINESS CASES)

NOVEMBER 1998

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9 December 1998

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**For the attention of John Ratcliffe**

Dear Sirs

**AMP3 Benefits Assessment**
**Low Flow Alleviation Schemes**
**Final Report (including Business Cases)**

We are pleased to submit fourteen copies of our final report on the benefits assessment of the eleven low flow alleviation schemes proposed under AMP3.

A further copy in loose leaf form is also submitted, complete with cover sheets, tables of contents and executive summaries. The loose leaf copy will enable you to print separate Business Case documents should these be required for any of the schemes.

Yours faithfully
for GIBB Ltd

Nigel Widgery

Nigel Widgery
Project Director

GIBB

LAWGIBB Group Member

**DOCUMENT CONTROL SHEET**

**PROJECT:** AMP3 BENEFITS ASSESSMENT **PROJECT NO: J98032A**

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FINAL REPORT (INCLUDING BUSINESS CASES)

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# ENVIRONMENT AGENCY
# MIDLANDS REGION

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## FINAL REPORT
## (INCLUDING BUSINESS CASES)

**NOVEMBER 1998**

**GIBB LTD**

Cover Photograph : Pool on the River Sherbourne at Coundon Wedge near Coventry *(Photo by Gareth Ward)*

# AMP 3 BENEFITS ASSESSMENT
# LOW FLOW ALLEVIATION SCHEMES

# FINAL REPORT
# (INCLUDING BUSINESS CASES)

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# 1 INTRODUCTION

## 1.1 Background

The Environment Agency is responsible for the control of discharges to controlled waters and the licensing of abstractions under the provisions of the Water Resources Act 1991. As part of the Water Companies' Periodic Review 2000-2010 (Asset Management Planning Round 3 or AMP3) the Agency is currently preparing a submission identifying:

- sewage treatment works (STW) where improvements are necessary to ensure environmental quality objectives are met;
- low flow sites where action is required by Water Companies to alleviate low flow problems.

In undertaking its statutory duties the Environment Agency is required to take account of likely costs and benefits. As a result each STW improvement scheme and each low flow alleviation scheme, which is not driven by a statutory need, must have the environmental benefits assessed, so that both the costs and the benefits can be taken into account.

For the low flow alleviation schemes the Agency has to prepare individual business cases for the non-statutory schemes according to the guidelines in the Agency document "Periodic Review (AMP3) Sustainability Issues - Guidance on Preparation of Business Cases - November 1997". As a first step, an assessment of the benefits likely to accrue from the priority low flow schemes is required to be carried out following the guidelines in the Agency document "Low Flow Alleviation: Benefit Assessment Guidelines - Version 3 - November 1997".

## 1.2 Objectives

Following the start of the contract in mid January 1998 it was confirmed in discussions between GIBB and the Agency that the objectives of the assignment are to assess the benefits likely to accrue from the priority low flow schemes by applying the Environment Agency's "Low Flow Alleviation: Benefit Assessment Guidelines" Version 3. Cost data was made available at a later date and GIBB was also requested to undertake the comparative assessment in terms of net present values and benefit cost ratios in accordance with the Benefit Assessment Guidelines. Subsequently GIBB was requested to prepare Business Cases for each of the schemes and to assist the Agency in preparing Summary Business Case documents for submission to DETR and the Agency statutory committees.

## 1.3 Work Programme

The work programme for the study was amended in the Inception Report to facilitate the data collection and site visits by grouping the schemes into Environment Agency Areas. The revised grouping of schemes is summarised in Table 1.1, in which the type of scheme is indicated as WQ (water quality, i.e. STW improvement) or WR (water resources, i.e. low flow alleviation). The locations of the schemes within the Midlands Region are shown on Figure 1.1.

**Table 1.1 Work Packages**

| Area | Work Package A | Work Package B |
|---|---|---|
| Lower Trent | *WQ: Buxton STW*<br>WR: Dover Beck<br>WR: Rivers Noe and Ashop *<br>WR: Rainworth Water | |
| Upper Trent | *WQ: Barston STW*<br>WR: Croxden Brook<br>WR: Burntwood Pools / River Sow | |
| Lower Severn | | WR: River Sherbourne<br>WR: Hewell Grange Lake<br>WR: Bow Brook |
| Upper Severn | | WR: Battlefield, Sugar & Catshill Brooks<br>WR: River Worfe<br>WR: Blakedown Brook |

*low flow alleviation scheme also known as Jaggers Clough

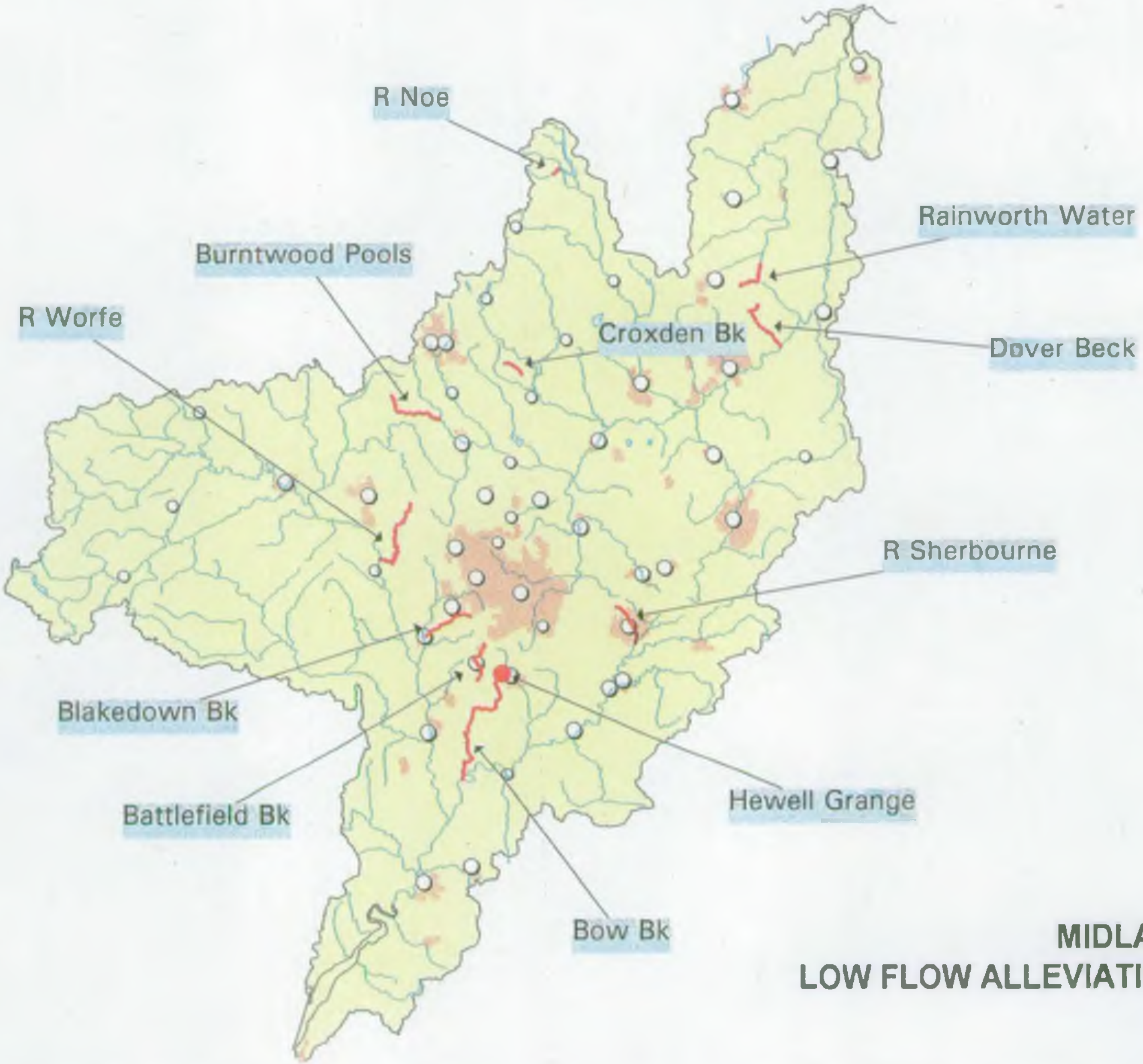
A separate volume of the Final Report presented the results for the water quality schemes (Barston and Buxton STWs) in Work Package A. The results for the low flow alleviation schemes in both Work Packages A and B are included in this report.

A preliminary benefit assessment of the schemes in Package A was included in the Interim Report which was submitted on 26 February 1998. A preliminary version of the draft final report for the Package B schemes, including the cost benefit analysis, was handed to the Agency on 8 April 1998, followed by the Package B schemes on 17 April. The formal issue of the consolidated Draft Final Report on the low flow alleviation schemes was submitted on 24 April 1998 and incorporated feedback from the Agency on the preliminary drafts.

Work on the benefit assessment of the eleven low flow schemes was completed within an overall period of about three months in which time the economic benefits were assessed and compared with the available cost estimates, based on information provided by the water companies. The analyses were based on the best information that was available within this tight timetable and a number of assumptions had to be made.

Further clarification and modification of costs was received from the Agency in early September 1998. On 15 September GIBB was requested to complete the Final Report incorporating the additional material needed for the Business Case for each scheme in accordance with the Agency Guidelines dated November 1997. In addition GIBB was requested to prepare a two page Summary Business Case for each scheme in the form required for submission to DETR and the Agency statutory committees. These requirements were confirmed at a meeting with the Agency on 22 September.

A first draft of the Summary Business Cases was submitted by e-mail on 14/15 October which incorporated further cost information received on 14 October. Following further inputs from the Agency, a revision was submitted on 11/12 November, which after a number of editorial changes by the Agency, formed the basis of the submission to the Agency Head Office and DETR.




**MIDLANDS REGION**
**LOW FLOW ALLEVIATION SCHEMES**

**Figure 1.1**

## 1.4 Approach to Analysis

### 1.4.1 Low Flow Benefit Assessment Guidelines

The economic assessment of benefits for the low flow schemes has been undertaken using the Low Flow Alleviation: Benefit Assessment Guidelines (Version 3 November 1997).

The assessments have been based predominantly on the use of the Benefit Transfer technique. This approach involves taking a value or benefit estimate acquired for a previous project or policy decision and transferring it to the project in question. There are obvious limitations in this approach and the estimates of benefits must be used with caution as the technique only provides an indication of the order of magnitude of the potential benefits. The results however are valid for comparative purposes and the range of estimates that have been derived reflects the uncertainty associated with the assessments based on this approach.

The results for the low flow alleviation schemes are in a form which allows the present value of the benefits to be input into business cases in accordance with the Agency Guidelines.

### 1.4.2 Costs

Details of cost estimates were provided by the water companies and the Agency and are included in Appendix 1. The cost estimates provided by the water companies have not been reviewed in detail by the Agency or its consultants. However, a broad overview was undertaken to ensure as far as possible that the cost estimates are consistent with the details of the schemes being proposed and, where appropriate, are consistent between the various options and schemes. It is understood that the cost estimates will be examined by the Reporter acting for the water companies and/or by OFWAT.

### 1.4.3 Discounting and Rolling Forward

The discount rates used in the assessments are 6% (the Treasury discount rate) and 7% (the water companies' cost of capital). The discounting allowed the benefits to be summed over time to produce present values of the benefits which have been expressed in Q4 1997 prices.

A countering factor in the case of the benefits is population growth which can be expected to lead to a greater intensity of use of the limited supply of environmental resources. This is reflected by using a set of weighting factors based on annual population growth. This technique is known as 'rolling forward'., For the assessments in this report the benefits have been calculated without rolling forward and, as a sensitivity analysis, with the benefits rolled forward by 0.5% per annum in accordance with the FWR Manual.

### 1.4.4 Time Horizons

The time horizon for the water resource schemes has been taken as 50 years with the Treasury discount rate of 6% in accordance with the instructions given in the Environment Agency's "Periodic Review (AMP3) Sustainability Issues - Guidance on the Preparation of Business Cases" document (November 1997). A time horizon of 30 years has been taken with the water industry cost of capital (7% discount rate) as instructed by the Agency at the meeting on 22 September 1998.

A number of the schemes assessed in this report are essentially short term measures to be implemented pending longer term measures to raise regional groundwater levels. In the draft report it was noted that a shorter time horizon might be appropriate for some of the schemes, which would have the effect of reducing the benefits in present value terms. For this Final Report the costs of additional replacement water to effect a long term solution at four of the schemes (Blakedown Brook, Hewell Grange Lake, River Sherbourne and River Worfe) have been included as an additional option. In each of these cases it is the option which includes these additional costs which has been selected as the preferred option.

### 1.4.5 Use and Non-Use Benefits

The economic value of an environmental resource is the sum of use values (direct and indirect) plus non-use values. Use values are those associated with the benefits gained from actual use of the environment. In the context of this report this includes drinking water abstraction, agricultural uses, amenity (based on increased property) values and recreational activities.

A further impact category that is included is termed 'non-use' or 'conservation' which incorporates economic values that are not related to direct or indirect use of the environment. The analysis undertaken for the various use categories has been based on aggregating values held by individuals to use the low flow sites for recreational and other purposes. However people also hold values which reflect their desire to conserve an environmental asset. These 'non-use' benefits are derived from three sources:

- option values (which reflect an individual's willingness-to-pay to secure the future of an environmental good and thus express the potential benefits of that good);
- bequest values (which is attached to the conservation of the environment so that future generations may have the use of that environmental resource); and
- existence values (derived from an individual's altruistic desire to preserve an environmental asset in the future).

Therefore in this context the term 'non-use benefits' refers to the willingness-to-pay of the public for knowing that the various rivers do not suffer from low flows more than they would in natural conditions (i.e. with no human interference).

The Agency's Low Flow Alleviation Benefit Assessment Guidelines summarise the results of previous studies which have identified two different groups of non-users:

- individuals who visit rivers but not the specific river in question;
- individuals who do not visit rivers at all.

Local residents (typically those within 3 km of the river) have been found to hold a higher willingness-to-pay value than non-local non-users. This is explained by people having a greater desire to protect environmental resources nearer to where they live.

Consequently conservation estimates for the low flow sites have been generated for:

- local residents within 3 km;
- river users among the general public who do not visit this particular river and its tributaries but do hold non-use values towards the alleviation of low flows in rivers;
- the wider general public who are not river users.

The conservation benefits have been derived using the procedures given in Section 9 of the Benefit Assessment Guidelines.

## 1.5 Structure of the Report

The Report is presented in twelve chapters.

Chapter 1 introduces the study and outlines its objectives and the approach followed in the assessments.

Chapters 2 to 6 present the Business Cases (including benefit assessment and cost benefit analysis) for the five schemes for the alleviation of low flows in the Trent area. Chapters 7 to 12 present the Business Cases for the six schemes in the Severn area.

Supporting information provided by the Agency and lists of contacts for each scheme are included in accompanying appendices.

## 1.6 Summary of Results

A summary of the results of the cost benefit analysis for the selected option in each of the schemes is given in Table 1.2.

Table 1.2 highlights the sensitivity of the benefit assessment to the extent to which non-use benefits are incorporated in the analysis. For the Business Cases presented in this report it should be noted that the assessment of benefits takes account of the local non-use values in accordance with the guidelines, together with 50% of the non-local non-use values based on the number of households in the water service company area.

Taking together the eleven low flow alleviation schemes described in this report, the present value of the total costs amounts to some £39 million, represented predominantly by the capital and operating cost for replacement water. These costs are justified by total benefits amounting in present value terms to £125 million (a benefit cost ratio of 3.2), comprising use benefits of £5 million, local non-use benefits of £22 million and non-local non-use benefits of £98 million.

## 1.7 Further Work

Most of the low flow alleviation schemes considered in this report are regarded by the Agency as interim solutions to the general problem of long term over-abstraction from a number of groundwater units. The longer term objectives and solutions will be confirmed and defined following further development of regional groundwater models.

Further refinements of the interim solutions considered in this report are expected to be carried out by the Agency over the next two years. Such further work will include additional spot gauging at a number of locations and trial releases to prove the concept of retaining flows in some of the river channels.

**Table 1.2 Summary of Costs and Benefits for Selected Options in each Scheme (£ 000 Q4 1997 expressed as present values, with central estimates of benefits)**

| Scheme | Option | Total compensation water releases (Ml/d) | Total replacement water provided (Ml/d) | 6% Discount Rate, 50 year time period | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Costs | Benefits | | | | Non-Use Benefits | | | Total NPV | | | | Benefit Cost Ratio | | | |
| | | | | | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | full non-use | local and 50% non-local non use | local non use only | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use |
| Burntwood Pools / River Sow | 1 | 1 | 1 | 838 | 10,661 | 5,523 | 385 | 224 | 10,438 | 5,300 | 162 | 9,823 | 4,685 | -453 | -615 | 12.7 | 6.6 | 0.46 | 0.27 |
| Croxden Brook | 1b | 1 | 1 | 1,017 | 5,552 | 3,052 | 552 | 259 | 5,293 | 2,792 | 292 | 4,535 | 2,035 | -465 | -758 | 5.5 | 3.0 | 0.54 | 0.25 |
| Dover Beck | 5 | 1 | 1 | 1,117 | 17,807 | 9,461 | 1,114 | 409 | 17,398 | 9,051 | 705 | 16,690 | 8,344 | -3 | -708 | 15.9 | 8.5 | 1.00 | 0.37 |
| River Noe and River Ashop | 1 | 15 | | 227 | 9,368 | 4,818 | 268 | 165 | 9,203 | 4,653 | 104 | 9,141 | 4,591 | 41 | -63 | 41.2 | 21.2 | 1.18 | 0.72 |
| Rainworth Water | 2b | 2 | 2 | 2,107 | 19,794 | 10,915 | 2,036 | 495 | 19,299 | 10,420 | 1,541 | 17,687 | 8,809 | -70 | -1,612 | 9.4 | 5.2 | 0.97 | 0.23 |
| Battlefield Brook | 3 | 2 | 2 | 1,839 | 20,604 | 11,826 | 3,048 | 605 | 19,999 | 11,221 | 2,443 | 18,764 | 9,987 | 1,209 | -1,234 | 11.2 | 6.4 | 1.66 | 0.33 |
| Blakedown Brook | 5 (long term) | 6 | 10 | 6,855 | 19,687 | 12,013 | 4,339 | 1,391 | 18,297 | 10,622 | 2,948 | 12,832 | 5,158 | -2,516 | -5,464 | 2.9 | 1.8 | 0.63 | 0.20 |
| Bow Brook | 1 | 2 | 2 | 1,843 | 33,432 | 17,904 | 2,376 | 531 | 32,902 | 17,374 | 1,846 | 31,589 | 16,061 | 533 | -1,313 | 18.1 | 9.7 | 1.29 | 0.29 |
| Hewell Grange | 1 (long term) | 0.62 | 1 | 870 | 4,831 | 3,015 | 1,200 | 261 | 4,570 | 2,754 | 939 | 3,961 | 2,145 | 329 | -609 | 5.6 | 3.5 | 1.38 | 0.30 |
| River Sherbourne | 6 (long term) | 3 | 10 | 8,145 | 39,994 | 25,099 | 10,205 | 728 | 39,266 | 24,372 | 9,477 | 31,849 | 16,954 | 2,060 | -7,417 | 4.9 | 3.1 | 1.25 | 0.09 |
| River Worfe | 6 (long term) | 8 | 17 | 13,733 | 41,496 | 21,577 | 1,658 | 90 | 41,406 | 21,487 | 1,568 | 27,763 | 7,844 | -12,075 | -13,643 | 3.0 | 1.6 | 0.12 | 0.01 |
| Totals for Selected Options | | | 47 | 38,592 | 223,226 | 125,204 | 27,182 | 5,157 | 218,069 | 120,047 | 22,024 | 184,634 | 86,612 | -11,411 | -33,435 | 5.8 | 3.2 | 0.70 | 0.13 |

# 2 BURNTWOOD POOLS / RIVER SOW

## 2.1 Scheme Objectives

During the early 1980s problems with low flow were identified on the upper reaches of the River Sow, in the vicinity of Burntwood Pools. The area is illustrated on Figure 2.1. The reduction in flow is thought to be due to a reduction in base flows as a result of over-abstraction of groundwater, particularly from the Burntwood borehole which is used for public water supply.

There are two options to be considered for enhancing flows on the upper reaches of the River Sow as summarised in Table 2.1. In both cases the compensation release will be made from the existing borehole and will discharge to the river upstream of the fishing pool adjacent to Fairoak Grange. The schemes considered involve a reduction in the abstraction for public water supply at the existing Burntwood groundwater pumping station and augmentation of the river system from the borehole. The Agency considers that a compensation release of 1 - 2 Ml/d will make up the deficit in flow.

**Table 2.1 Low Flow Alleviation Options**

| Option | Description | Improvements |
|---|---|---|
| 1 | Compensation release of 1 Ml/d to be in operation when the Agency gauging station at Walkmill is at Q50% (4.06 Ml/d) or below | Rewater 3 km, significantly increased flows 11 km. |
| 2 | Compensation release of 2 Ml/d to be in operation when the Agency gauging station at Walkmill is at Q50% (4.06 Ml/d) or below | Rewater 3 km, significantly increased flows 11 km. |

It is planned that the gauging station at Walkmill will be used to trigger the compensation when Q50% (4.06 Ml/d) has been reached and a second trigger will be used to stop the release at 5.06 Ml/d and 6.06 Ml/d for Options 1 and 2 respectively.

Flow duration/frequency curves were provided by the Agency to define the impact of the alleviation options and these are included in Appendix 2. Graphical mean daily flow data for 1990 to 1997 are also included in the Appendix. Most of the available data relates to the gauging station at Walkmill, approximately at the mid-point of the river section considered. The Agency has also provided a limited amount of data from spot gauging in 1983 for the outflow from Burntwood Pools.

The available information has been used to derive appropriate factors for the economic benefits of each option for those uses which are frequency and duration dependent. The river has been divided into two reaches for this purpose:

| | |
|---|---|
| Reach 1 | Burntwood Borehole to downstream of Fairoak (3 km) |
| Reach 2 | Downstream of Fairoak to the discharge from the sewage treatment works at Eccleshall (11 km) |

Target flows for each reach have been assessed to determine the extent to which the low flow alleviation schemes will improve the situation. Flow improvement factors have been derived from a consideration of both the **proportional flow** improvement from the existing situation at the Q95% level, and the **proportional time** improvement that the target flow is achieved. Corresponding return periods for very low flows (i.e. about 50% of the target flows) have also been assessed for the before and after situations. The figures which have been derived are summarised in Table 2.2.

**Table 2.2 Summary of Hydrological Assessment for River Sow**

| | **Reach 1** | **Reach 2** |
|---|---|---|
| **Target Flow (Ml/d)** | 2 | 4 |
| **% of Time above Target** | | |
| **Before** | 25% | 50% |
| **After** Option 1 | 75% | 80% |
| Option 2 | 95% | 96% |
| **Flow Improvement Factor** | | |
| Option 1 | 60% | 35% |
| Option 2 | 100% | 55% |
| **Return Period (years)** before → after | | |
| Option 1 | 1 → 5 | 2 → 7 |
| Option 2 | 1 → 10 | 2 → 10 |

## 2.2 Scope of Study

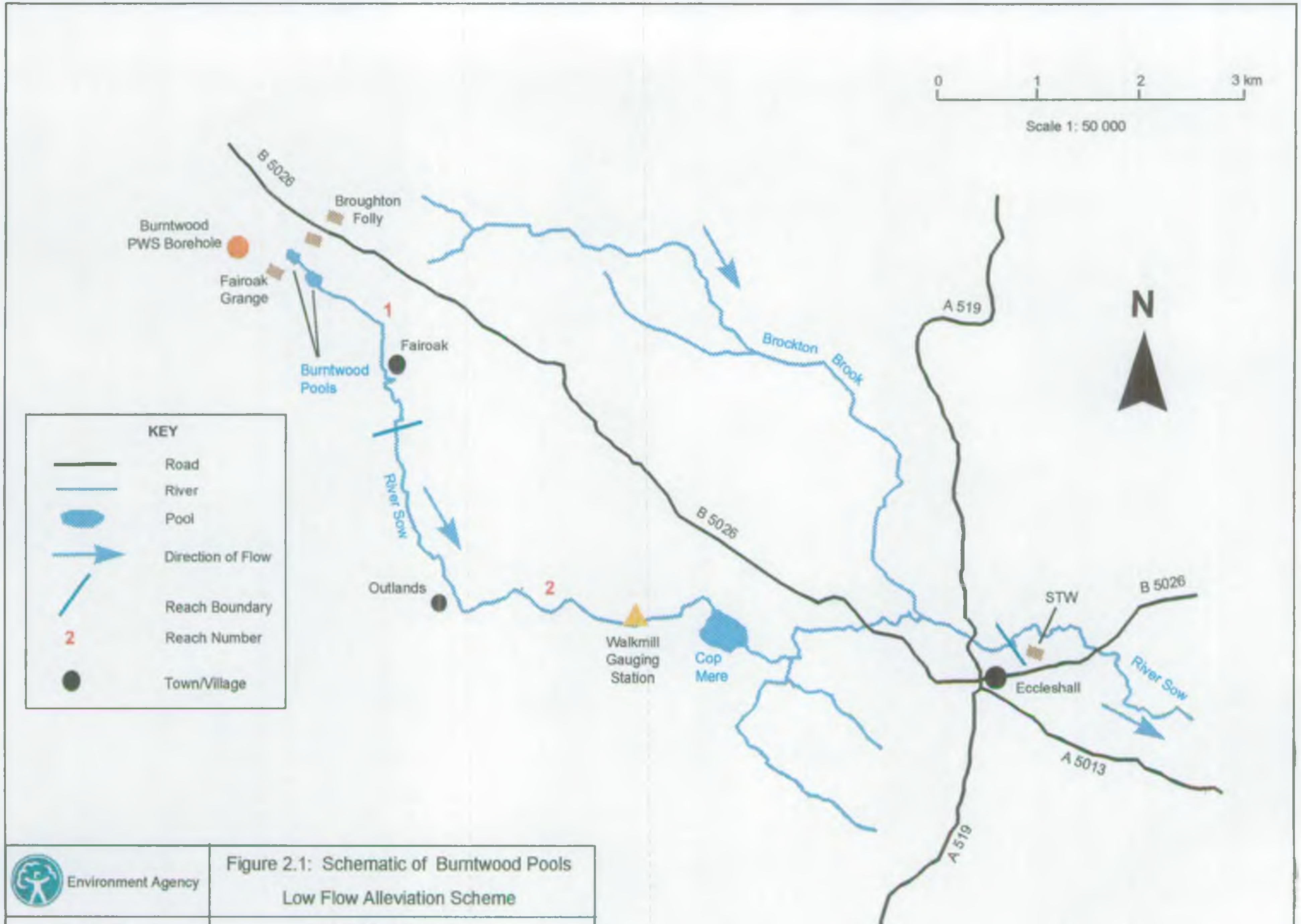
Table 2.3 has been used as a checklist to focus on those impacts which are likely to be significant and need to be included in the economic appraisal.

Restoration of the flow will improve the continuity of the river's linear wildlife habitat, which at present is not complete due to the river periodically suffering extremely low flows.

The categories that have been included in the benefit assessment are:

- informal recreation;
- angling;
- agriculture;
- property; and
- non-use.

Although the additional flow will provide some additional dilution to the discharge from the existing STW at Eccleshall, the proportional increase will be relatively small. It has therefore been agreed with the Agency that no additional economic benefits due to water quality improvements can be identified.




Environment Agency

Figure 2.1: Schematic of Burntwood Pools Low Flow Alleviation Scheme

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Consulting Engineers
Reading England

AMP 3 Benefits Assessment

SCALE 1: 50 000 | DATE April 1998 | J98032 A

Table 2.3 **Summary of Impacts**

| Impact Category | | Comments |
|---|---|---|
| Drinking Water Supply | | Groundwater abstraction at Burntwood. |
| Industrial Abstraction | | Not applicable |
| Agriculture | Livestock | Not applicable |
| | Irrigation | A number of groundwater abstractions but not considered in the analysis. |
| In-stream Recreation | Boating | Not applicable |
| | Bathing | Not applicable |
| | Angling | Fishery at Cop Mere. |
| Informal recreation | Walking, picnicking, photography | Some access along the length of the river. |
| Amenity /Aesthetics | Property prices | Some properties adjacent to watercourse. |
| Conservation (Non-Use or Passive Use) | Ecology | Yes |
| | Heritage | Not applicable |
| Other | | None |

## 2.3 Capital and Operating Costs

Severn Trent Water Ltd has provided the Agency with estimates of the capital expenditure (capex) and operating expenditure (opex) necessary to provide for the replacement of 1 or 2 Ml/d of water currently abstracted at the Burntwood borehole which would be diverted to the River Sow. In addition some minor works will be required in the vicinity of the pumping station to effect the flow augmentation. Details of the costs are summarised in Table 2.4.

**Table 2.4 Summary of Cost Estimates (£ 000 Q4 1997)**

| | Option 1 | Option 2 |
|---|---|---|
| **Capital expenditure** | | |
| Replacement water | 690 | 1379 |
| PWS option | 10 | 10 |
| Total | 700 | 1389 |
| **Operating expenditure (per annum)** | | |
| Replacement water | 9 | 21 |
| PWS Option | 3 | 6 |
| Total | 12 | 27 |

## 2.4 Estimation of Benefits

### 2.4.1 Informal Recreation

Staffordshire Wildlife Trust has a nature reserve adjacent to the River Sow at Jacksons Copse, but visitor numbers to the site are not monitored. Trust staff held the view that it was not an extensively used site. There are limited parking facilities. Trust staff believed that the site may attract around 30 visitors/day during the week and maybe 50 visitors/day at weekends and Bank Holidays. On the basis of these assumptions it is estimated that the site attracts around 13,000 visitors/year.

Staffordshire Wildlife Trust also confirmed that the area at Fairoak was quite popular with walkers. However examination of the Pathfinder Maps and further discussions with Environment Agency staff revealed that there was only limited access for the public to walk beside the River Sow in its upper reaches.

Staffordshire County Council's Countryside Services Department was also contacted and, though unable to provide any useful information on visitor numbers, was able to provide the leads that were subsequently followed up.

Stafford Borough Council was also contacted to seek assistance with estimating the potential number of visitors to the site. The Recreation Centre deals primarily with the Sow as it flows through Stafford and it was revealed that the Council would like to re-open the river in Stafford itself and introduce barges as a tourist attraction. There is also a canoeing club run by the Recreation Centre which uses the Sow for recreational purposes. Any increases in flow in the river's upper reaches will have a beneficial impact on downstream uses, but as these developments are currently being considered and low flows have not been cited as an obstacle, the associated benefits from alleviating the low flows are believed to be negligible.

For the purpose of the economic appraisal of the schemes the visitor numbers have therefore been based on the figures derived by the Wildlife Trust for Reach 2 of the river, with a nominal allowance of 3000 visitors for Reach 1 at the upper end of the catchment.

As the informal recreational activities are unpriced there is no economic rent or profit earned by the activity. The total value of the recreational activity is measured in consumer surplus or the difference between what the consumer pays for the activity (zero) and what they would be willing to pay. The Guidelines recommend the following per visit estimates of the consumer surplus, assuming that 40% of the willingness-to-pay is attributable to the presence of water:

- Upper bound estimate: £1.48 per visitor day;
- Central estimate: £0.60 per visitor day; and
- Lower bound estimate: £0.20 per visitor day.

Combining participation rates and willingness-to-pay with the flow improvement factors from Table 2.2 produces the annual incremental benefits which are presented in Table 2.5.

### 2.4.2 Angling

Discussions with Environment Agency staff revealed that Cop Mere has hardly been affected by low flows in the River Sow. The flows from the lake are well controlled which means that the water level is stable. The lake contains still water fish such as tench and these species would not move upstream of Cop Mere itself. Informed opinion was that alleviating the low flows in the Sow would make practically no difference in terms of benefits to anglers. Therefore angling benefits have not been considered further in the economic appraisal.

**Table 2.5 Annual Informal Recreation Benefits**

| | Option | Visitor Numbers by River Reach (000) | | Factored Benefit by River Reach (£000 Q4 1997) | | |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 1 | 2 | Total |
| Upper Bound | 1 | 3 | 13 | 2.7 | 6.7 | 9.4 |
| | 2 | 3 | 13 | 4.4 | 10.6 | 15.0 |
| Central Estimate | 1 | 3 | 13 | 1.1 | 2.7 | 3.8 |
| | 2 | 3 | 13 | 1.8 | 4.3 | 6.1 |
| Lower Bound | 1 | 3 | 13 | 0.4 | 0.9 | 1.3 |
| | 2 | 3 | 13 | 0.6 | 1.4 | 2.0 |

### 2.4.3 Property

Stafford Borough Council was contacted to provide Council Tax Bands for the properties identified as adjacent to the watercourses. These are summarised in Table 2.6.

**Table 2.6 Properties Adjacent to River Sow by Council Tax Band**

| Band | 1997 Midpoint (£ 000) | No of properties | | | Economic Value (£ 000 Q4 1997) |
|---|---|---|---|---|---|
| | | Reach 1 | Reach 2 | Total | |
| A | 40 | 3 | | 3 | 121 |
| B | 46 | 4 | | 4 | 186 |
| C | 61 | 2 | 3 | 5 | 303 |
| D | 79 | 9 | 3 | 12 | 945 |
| E | 105 | 2 | 3 | 5 | 525 |
| F | 141 | 2 | 1 | 3 | 424 |
| G | 242 | | 2 | 2 | 485 |
| H | 323 | | | | |
| **Total** | | **22** | **12** | **34** | **2,989** |

Source: Stafford Borough Council

By applying the formulae given in the Benefit Assessment Guidelines, using the assumed changes in return periods for the low flows indicated in Table 2.2, the benefit to property owners has been estimated in terms of once-off changes in stock.

Table 2.7 **Amenity and Aesthetic Stock Benefits (£000 Q4 1997)**

| Option | Total Incremental Benefits | | |
|---|---|---|---|
| | Upper Bound | Central Estimate | Lower Bound |
| 1 | 282 | 188 | 38 |
| 2 | 387 | 258 | 52 |

### 2.4.4 Non-Use

Non-use (conservation) benefit estimates for the River Sow have been derived for:

- local residents within 3 km;
- river users among the general public who do not visit these particular rivers but do hold non-use values towards the alleviation of low flows in rivers; and
- the wider general public who are not river users.

The non-use benefits have been derived using the procedures given in Section 9 of the Benefit Assessment Guidelines.

**Local resident non-use valuation**

It has been assumed that there are about 2,300 households within 3 km of the low flow site, approximately evenly divided between the two river reaches, based on population data obtained from the Agency GIS model and assuming 2.7 people/household.

In accordance with the Guidelines, the following values per household per annum are applied where full low flow alleviation is achieved:

| | |
|---|---|
| Upper Bound | £12.00 |
| Central Estimate | £10.00 |
| Lower Bound | £ 7.00 |

**General public non-use valuation**

It is assumed that there are 3.15 million households within Severn Trent Water's area and that 45% of the population are general river users, from which the actual number of local households already included are subtracted. The remaining 55% of the population in the service area are taken as non-users for whom a lower scale of benefits applies. The central estimates are based on the figures of £0.05 and £0.03 per household per km of river per annum for full low flow alleviation in accordance with the Guidelines, with +/- 25% for upper and lower bounds.

The annual non-use (conservation) benefits of each option, applying the flow improvement factors from Table 2.2 for each river reach, are summarised in Table 2.8 in terms of the local resident non-use benefits and the full (local resident plus general public non-use) benefits.

**Table 2.8 Annual Non-Use Benefits (£000 Q4 1997)**

| Option | Extent | Upper | Central | Lower |
|---|---|---|---|---|
| 1 | Local | 13 | 11 | 8 |
| | Full | 880 | 704 | 528 |
| 2 | Local | 21 | 18 | 12 |
| | Full | 1,410 | 1,129 | 846 |

## 2.5 Assessment of Tangibles (Cost Benefit Analysis)

The costs and the annual benefit streams have been aggregated in terms of present values in accordance with the procedures given in the Benefit Assessment Guidelines. The indicators in terms of net present values (NPV) and benefit cost ratios for the two options are presented in Table 2.9. The results are shown:

- both including and excluding non-use, together with intermediate figures: one including only 50% of the general public (i.e. non-local) non-use and the other including only local non-use;
- for the central estimates, with upper and lower bounds;
- using the different discount rates and time horizons; and
- with and without rolling forward the benefits.

For all combinations of assumptions Option 1 generates a higher benefit cost ratio than Option 2. It can therefore be concluded that the incremental benefits of the greater degree of low flow alleviation achieved with the higher rate of pumping with Option 2 may not be sufficient to justify the incremental capital and operating costs. However, Option 2 does provide a higher net present value when non-local non-use benefits are included.

The overall results are highly sensitive to the assumptions regarding non-use benefits, with benefit cost ratios in the range 6 to 17 when the full non-use benefits are included. If only 50% of the non-local non-use benefits are included, the benefit cost ratio reduces to the range 4 to 7 with the central estimates. If no non-use benefits are included the benefit cost ratio reduces below 0.5.

A summary of the assessment of tangibles (i.e the quantifiable costs and benefits) for Options 1 and 2 is presented in Table 2.10. For this analysis, which has been carried forward to the Summary Business Case, the economic benefit has been determined on the following basis:

- including 50% of the general public (i.e. non-local) non-use benefits
- central estimates without rolling forward of the benefits.

A breakdown of the total present value of the benefits for Option 1 by use category (central estimates, including 50% of the non-local non-use benefits) with the 6% Treasury discount rate, with no rolling forward, is shown on Figure 2.2, together with a breakdown of the present value of the costs.

**Table 2.9 (Sheet 1)** **Burntwood Pools / River Sow : Summary of Costs and Benefits**

**(£ 000 Q4 1997 expressed as present values)**

| Option | 7% Discount Rate, 30 year time period | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Costs | Benefits | | | | Total NPV | | | | Benefit Cost Ratio | | | |
| | | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use |
| **Upper estimates, no rolling forward** | | | | | | | | | | | | | |
| 1 | 792 | 10,450 | 5,477 | 504 | 354 | 9,658 | 4,685 | -288 | -438 | 13.2 | 6.9 | 0.64 | 0.45 |
| 2 | 1,608 | 16,687 | 8,721 | 755 | 510 | 15,079 | 7,113 | -853 | -1,098 | 10.4 | 5.4 | 0.47 | 0.32 |
| **Upper estimates, with rolling forward** | | | | | | | | | | | | | |
| 1 | 792 | 11,010 | 5,765 | 519 | 361 | 10,218 | 4,973 | -272 | -431 | 13.9 | 7.3 | 0.66 | 0.46 |
| 2 | 1,608 | 17,584 | 9,182 | 780 | 521 | 15,976 | 7,574 | -828 | -1,087 | 10.9 | 5.7 | 0.49 | 0.32 |
| **Central estimates, no rolling forward** | | | | | | | | | | | | | |
| 1 | 792 | 8,290 | 4,311 | 333 | 208 | 7,498 | 3,520 | -459 | -584 | 10.5 | 5.4 | 0.42 | 0.26 |
| 2 | 1,608 | 13,245 | 6,872 | 499 | 295 | 11,637 | 5,264 | -1,109 | -1,313 | 8.2 | 4.3 | 0.31 | 0.18 |
| **Central estimates, with rolling forward** | | | | | | | | | | | | | |
| 1 | 792 | 8,736 | 4,539 | 343 | 211 | 7,944 | 3,747 | -449 | -581 | 11.0 | 5.7 | 0.43 | 0.27 |
| 2 | 1,608 | 13,959 | 7,237 | 516 | 300 | 12,351 | 5,629 | -1,092 | -1,308 | 8.7 | 4.5 | 0.32 | 0.19 |
| **Lower estimates, no rolling forward** | | | | | | | | | | | | | |
| 1 | 792 | 6,103 | 3,119 | 135 | 47 | 5,311 | 2,327 | -657 | -744 | 7.7 | 3.9 | 0.17 | 0.06 |
| 2 | 1,608 | 9,770 | 4,991 | 211 | 68 | 8,162 | 3,383 | -1,396 | -1,540 | 6.1 | 3.1 | 0.13 | 0.04 |
| **Lower estimates, with rolling forward** | | | | | | | | | | | | | |
| 1 | 792 | 6,435 | 3,288 | 141 | 48 | 5,644 | 2,496 | -651 | -743 | 8.1 | 4.2 | 0.18 | 0.06 |
| 2 | 1,608 | 10,303 | 5,262 | 221 | 70 | 8,695 | 3,654 | -1,387 | -1,538 | 6.4 | 3.3 | 0.14 | 0.04 |

Table 2.9 (Sheet 2) **Burntwood Pools / River Sow : Summary of Costs and Benefits**

(£ 000 Q4 1997 expressed as present values)

| Option | 6% Discount Rate, 50 year time period | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Costs | Benefits | | | | Total NPV | | | | Benefit Cost Ratio | | | |
| | | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use |
| **Upper estimates, no rolling forward** | | | | | | | | | | | | | |
| 1 | 838 | 13,429 | 7,006 | 584 | 390 | 12,591 | 6,168 | -254 | -448 | 16.0 | 8.4 | 0.70 | 0.47 |
| 2 | 1,710 | 21,458 | 11,171 | 883 | 567 | 19,748 | 9,460 | -827 | -1,144 | 12.5 | 6.5 | 0.52 | 0.33 |
| **Upper estimates, with rolling forward** | | | | | | | | | | | | | |
| 1 | 838 | 14,456 | 7,533 | 611 | 402 | 13,618 | 6,695 | -227 | -436 | 17.2 | 9.0 | 0.73 | 0.48 |
| 2 | 1,710 | 23,103 | 12,015 | 927 | 586 | 21,393 | 10,305 | -783 | -1,125 | 13.5 | 7.0 | 0.54 | 0.34 |
| **Central estimates, no rolling forward** | | | | | | | | | | | | | |
| 1 | 838 | 10,661 | 5,523 | 385 | 224 | 9,823 | 4,685 | -453 | -615 | 12.7 | 6.6 | 0.46 | 0.27 |
| 2 | 1,710 | 17,043 | 8,813 | 584 | 320 | 15,333 | 7,103 | -1,127 | -1,391 | 10.0 | 5.2 | 0.34 | 0.19 |
| **Central estimates, with rolling forward** | | | | | | | | | | | | | |
| 1 | 838 | 11,479 | 5,941 | 403 | 229 | 10,641 | 5,103 | -435 | -609 | 13.7 | 7.1 | 0.48 | 0.27 |
| 2 | 1,710 | 18,353 | 9,483 | 612 | 328 | 16,643 | 7,772 | -1,098 | -1,383 | 10.7 | 5.5 | 0.36 | 0.19 |
| **Lower estimates, no rolling forward** | | | | | | | | | | | | | |
| 1 | 838 | 7,872 | 4,019 | 166 | 52 | 7,034 | 3,181 | -673 | -786 | 9.4 | 4.8 | 0.20 | 0.06 |
| 2 | 1,710 | 12,606 | 6,433 | 261 | 76 | 10,895 | 4,723 | -1,450 | -1,634 | 7.4 | 3.8 | 0.15 | 0.04 |
| **Lower estimates, with rolling forward** | | | | | | | | | | | | | |
| 1 | 838 | 8,483 | 4,329 | 176 | 54 | 7,645 | 3,491 | -662 | -784 | 10.1 | 5.2 | 0.21 | 0.06 |
| 2 | 1,710 | 13,583 | 6,931 | 278 | 79 | 11,873 | 5,220 | -1,433 | -1,632 | 7.9 | 4.1 | 0.16 | 0.05 |

**Table 2.10 Assessment of Tangibles (£000 Q4 1997)**

| Option | Agency Costs | Water Co. Costs | Economic Benefit | Net Present Value | Benefit Cost Ratio |
|---|---|---|---|---|---|
| 6% discount rate, 50 year time period | | | | | |
| **Do Nothing** | 0 | 0 | 0 | 0 | 0 |
| **Option 1** | 0 | 838 | 5,523 | 4,685 | 6.6 |
| **Option 2** | 0 | 1,710 | 8,813 | 7,103 | 5.2 |
| 7% discount rate, 30 year time period | | | | | |
| **Do Nothing** | 0 | 0 | 0 | 0 | 0 |
| **Option 1** | 0 | 792 | 4,311 | 3,520 | 5.4 |
| **Option 2** | 0 | 1,608 | 6,872 | 5,264 | 4.3 |

## 2.6 Assessment of Intangibles

The assessment of intangible benefits (or disbenefits) has been undertaken by a weighting and scoring system and is presented in Table 2.11. The intangibles considered in the table are:

1. Facilitation of Agency meeting objectives
2. Improved public relations and maintenance of credibility of Agency
3. Longer term benefits not quantified in economic analysis

Each of the intangible benefits has been allocated a weighting within the range from 5 to 0 (from most important to least important). Scores reflecting the ability of each option to deliver the intangible benefit have been allocated from 5 to 0 (from greatest ability to least ability).

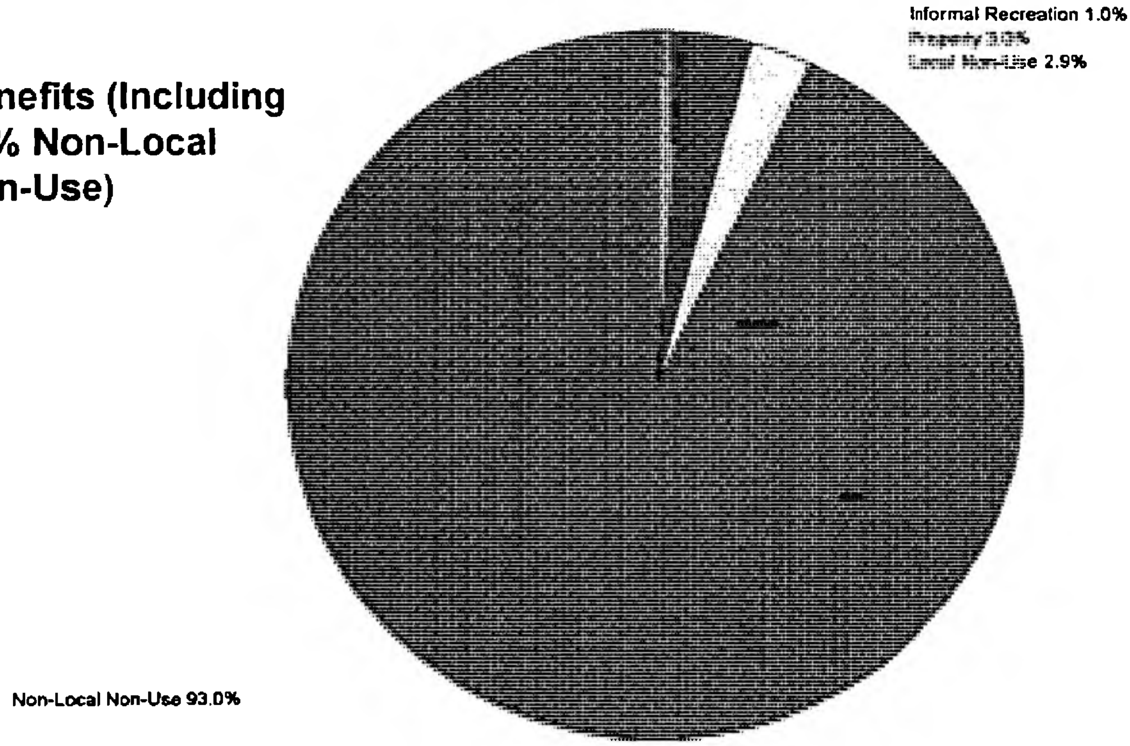
## 2.7 Risk Assessment

A risk assessment of the options has been undertaken and the results tabulated in a "Risk Register" (Table 2.12). The risks considered to be relevant in the appraisal are:

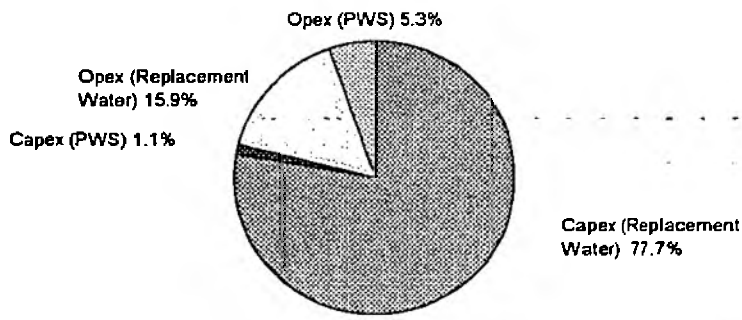
- Risk 1 Operational failure of flow alleviation
- Risk 2 Failure to provide anticipated benefits
- Risk 3 Failure to supply a sustainable solution

Within the Risk Register the likelihood of the risk happening, and the consequent effect on the solution, are classified as "high", "medium" or "low".

## Benefits (Including 50% Non-Local Non-Use)




## Costs




Note: The area of the circles is proportional to the present value of the benefits or costs at a 6% discount rate

**Burntwood Pools / River Sow Option 1**
**Present Value of Benefits and Costs**
**Figure 2.2**

**Table 2.11** **Assessment of Intangible Benefits**

| Intangible Benefit | Weighting Factor | Option 1 1 Ml/d release | | Option 2 2 Ml/d release | | Comment |
|---|---|---|---|---|---|---|
| | | points | weighted points | points | weighted points | |
| 1 | 3 | 2 | 6 | 3 | 9 | Greater flow in river with Option 2 |
| 2 | 3 | 2 | 6 | 2 | 6 | |
| 3 | 3 | 2 | 6 | 3 | 9 | STW effluent dilution downstream |
| Total weighted score | | | 18 | | 24 | |

Intangible Benefit 1: Facilitation of Agency meeting objectives
Intangible Benefit 2: Improved public relations and maintenance of credibility of Agency
Intangible Benefit 3: Longer term benefits not quantified in economic analysis

**Table 2.12** **Risk Register**

| Identified Risk | Option 1 1 Ml/d release | | Option 2 2 Ml/d release | | Comment |
|---|---|---|---|---|---|
| | Likelihood | Effect | Likelihood | Effect | |
| Operational failure of flow alleviation | L | L | L | L | |
| Failure to provide anticipated benefits | L | M | M | M | Long term yield only 1.4 Ml/d |
| Failure to supply a sustainable solution | L | M | H | M | Long term yield only 1.4 Ml/d |

Relative risks:
H high
M medium
L low

## 2.8 Selection of Preferred Option

From the assessment of tangibles presented in Table 2.10 it can be seen that Option 2 represents the most cost effective solution in terms of maximum net present value (NPV). This conclusion is supported by the assessment of intangibles. However, at a late stage in the analysis it became apparent that the long term yield of the Burntwood PWS borehole was only 1.4 Ml/d. A compensation release of 2 Ml/d for about 75% of the time is therefore not sustainable and is incompatible with the long term objective of a recovery of groundwater levels. This is reflected in the risk register in Table 2.11, where Option 2 is shown as having a medium risk of failing to provide the anticipated benefits and a high risk of not supplying a sustainable solution.

**It is therefore concluded that Option 1, with a compensation release of 1 Ml/d, should be selected as the preferred option.**

The expected improvement to the River Sow is to re-water 3 km of the river and to significantly increase the flows over 11 km. The increased flow length includes the SSSI site at Cop Mere which will help ensure the survival of these important habitats.

The assessed economic benefit takes account of these ecological improvements in addition to the increase in the amenity and recreational value of the area surrounding the watercourse.

There will also be some improvement to water quality due to the dilution of the effluent from the sewage treatment works at Eccleshall.

The benefits will be present all year round as the augmentation flow will be triggered whenever necessary. Reductions in the public water supply abstractions will allow more water to remain in the aquifer, thus reducing the amount of augmentation flow required.

## 2.9 Tasks and Dependencies

| | |
|---|---|
| Investigations: | Agency Midlands Region, Upper Trent Area |
| Design and implementation: | Severn Trent Water Ltd |

**Programme for implementation of the preferred option:**

| | |
|---|---|
| 1998 | Submission of Business Plan |
| 1999 | Investigation and Design<br>Planning and Consents |
| 2000 | Construction |

## 2.10 Cost of Preferred Option

The estimated capital and operating costs of the preferred option are given in Table 2.13. The estimates of likely future capital costs are based on the assumption that the Construction Output Index (COPI) will rise by 4 per cent per annum. In the estimation of operating costs an annual increase of 2.5 per cent per annum in the Retail Price Index (RPI) has been assumed.

**Table 2.13 Estimated Costs of the Preferred Option (£ 000)**

| Year | Water Company | | Agency | |
|---|---|---|---|---|
| ending 31/03 | Capex | Opex | Capex | Opex |
| 1999 | 0 | 0 | 4[1] | 0 |
| 2000 | 0 | 0 | 0 | 0 |
| 2001 | 787 | 13 | 0 | 0 |
| 2002 | 0 | 13 | 0 | 0 |
| 2003 | 0 | 14 | 0 | 0 |

[1] comprises submission of business plan, the cost of which has not been included in the assessment of tangibles

# 3 CROXDEN BROOK

## 3.1 Scheme Objectives

The proposed low flow alleviation scheme of Croxden Brook is a response to public complaints in recent years. The overall river system and the proposed augmentation points are shown on Figure 3.1. Trial releases into the Winnothdale Brook from the existing public water supply groundwater pumping station at Greatgate showed that there was a problem with loss of water through the brook bed. Severn Trent Water Ltd and the Agency aim to overcome this by lining a section of the bed. For the purposes of this assessment it is assumed that all the water released as compensation will remain in the watercourse until its confluence with Nothill Brook.

The currently proposed options for the alleviation of low flows on Croxden Brook are summarised in Table 3.1.

**Table 3.1 Low Flow Alleviation Options**

| Option | Description | Improvements |
|---|---|---|
| 1a | Compensation release of 1 Ml/d at all times at release point A. | Rewater 0.7 km, significantly increased flows 3.0 km |
| 1b | Compensation release of 1 Ml/d at all times at release point B. | Rewater 1.4 km, significantly increased flows 3.0 km. |
| 2 | Compensation release of 2 Ml/d at all times at release point A. | Rewater 0.7 km, significantly increased flows 3.0 km |
| 3 | Compensation releases of 1 Ml/d at all times at both release points A and B. | Rewater 1.4 km, significantly increased flows 3.0 km. |
| 4 | Compensation release of up to 2 Ml/d at all times at release point A. Replacement PWS supply from a new borehole. | Rewater 0.7 km, significantly increased flows 3.0 km |

Flow duration/frequency curves were provided by the Agency to define the impact of the alleviation options and these are included in Appendix 3. The data relates to the gauging station at Greatgate. Tabulated mean daily flows for 1996 and 1997 are also included in the Appendix. It is noted that limited data are available and that figures for 1997 show the severity of the low flow conditions. The year 1996 is representative of the three years available.

The available information has been used to derive appropriate factors for the economic benefits of each option for those uses which are frequency and duration dependent. The river has been divided into three reaches for this purpose:

| | |
|---|---|
| Reach 1 | Release point B to Release point A (0.7 km) |
| Reach 2 | Release point A to the gauging station at Greatgate (0.7 km) |
| Reach 3 | Gauging station at Greatgate to the confluence with the Nothill Brook (3.0 km). |

Target flows for each reach have been assessed to determine the extent to which the low flow alleviation schemes will improve the situation. Flow improvement factors have been derived from a consideration of both the **proportional flow** improvement from the existing situation at the Q95% level, and the **proportional time** improvement that the target flow is achieved.

the Q95% level, and the **proportional time** improvement that the target flow is achieved. Corresponding return periods for very low flows (i.e. about 50% of the target flows) have also been assessed for the before and after situations. The figures which have been derived are summarised in Table 3.2.

**Table 3.2 Summary of Hydrological Assessment for Croxden Brook**

| | | Reach 1 | Reach 2 | Reach 3 |
|---|---|---|---|---|
| **Target Flow (Ml/d)** | | 0.8 | 0.8 | 1.5 |
| **% of Time above Target** | | | | |
| **Before** | | 0% | 0% | 10% |
| **After** | Option 1a | 0% | 100% | 30% |
| | Option 1b | 100% | 100% | 30% |
| | Option 2 | 0% | 100% | 100% |
| | Option 3 | 100% | 100% | 100% |
| | Option 4 | 0% | 100% | 100% |
| **Flow Improvement Factor** | | | | |
| | Option 1a | 0% | 100% | 45% |
| | Option 1b | 100% | 100% | 45% |
| | Option 2 | 0% | 100% | 100% |
| | Option 3 | 100% | 100% | 100% |
| | Option 4 | 0% | 100% | 100% |
| **Return Period (years)** before → after | | | | |
| | Option 1a | 1.5 → 10 | 1.5 → 10 | 1.5 → 10 |
| | Option 1b | 1.5 → 10 | 1.5 → 10 | 1.5 →10 |
| | Option 2 | 1.5 → 10 | 1.5 → 10 | 1.5 → 10 |
| | Option 3 | 1.5 → 10 | 1.5 → 10 | 1.5 → 10 |
| | Option 4 | 1.5 → 10 | 1.5 → 10 | 1.5 → 10 |

## 3.2 Scope of Study

Table 3.3 has been used as a checklist to focus on those impacts which are likely to be significant and need to be included in the economic appraisal.

It is understood that there are, at present, no licences for industrial, potable or agricultural surface water abstractions. However, through correspondence with Agency staff it is understood that riparian owners may abstract water from Croxden Brook or allow livestock to feed from the river.

Restoration of the flow will improve the continuity of the brook's linear wildlife habitat (which at present is not complete due to the brook periodically drying up), will reduce the bed siltation and will provide a nursery area for brown trout.

The categories that have been included in the benefit assessment are:

- informal recreation;
- property; and
- non-use.

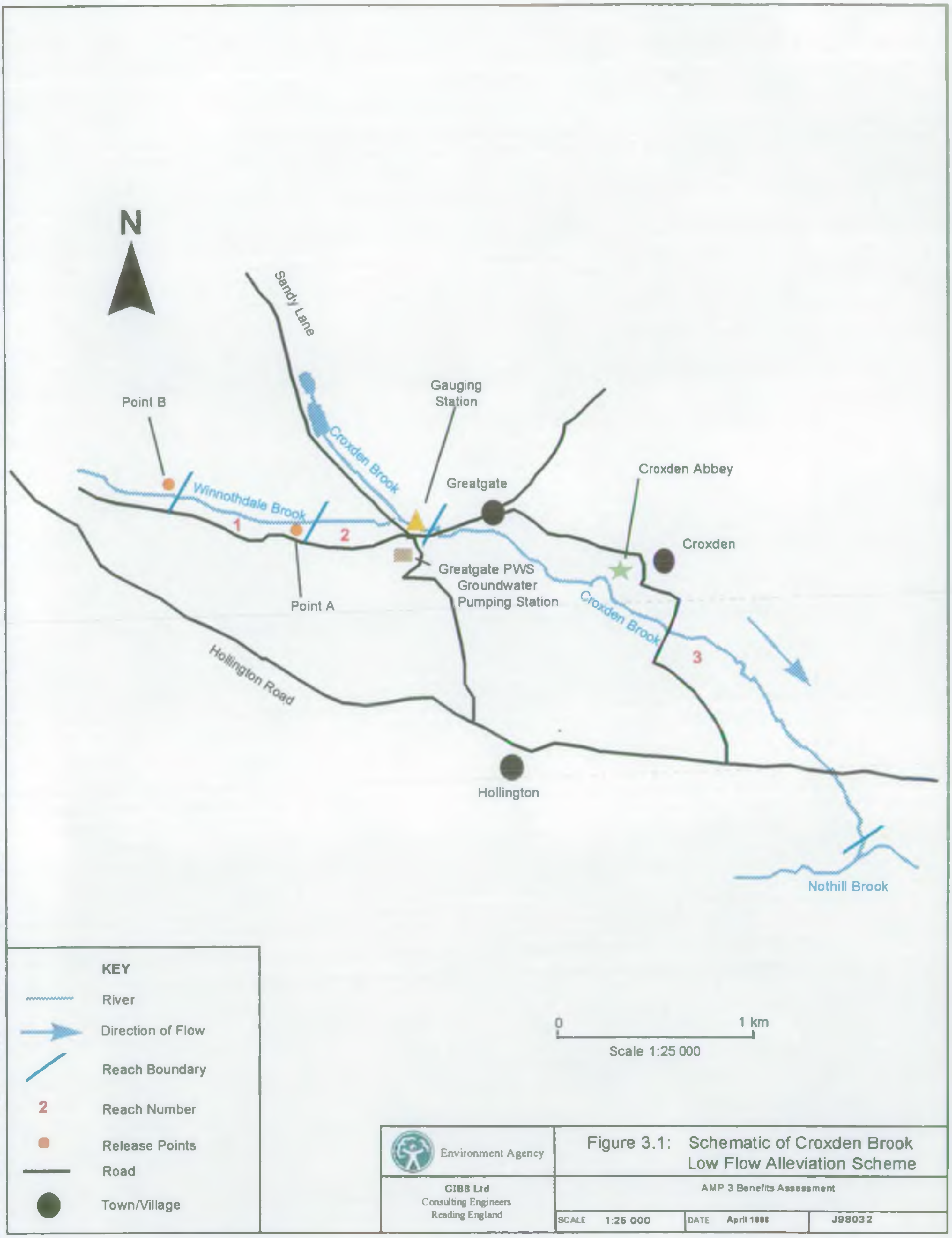



Figure 3.1: Schematic of Croxden Brook Low Flow Alleviation Scheme

AMP 3 Benefits Assessment

SCALE 1:25 000 | DATE April 1[illegible] | J98032

Table 3.3 **Summary of Impacts**

| Impact Category | | Comments |
|---|---|---|
| Drinking Water Supply | | Not applicable |
| Industrial Abstraction | | Not applicable |
| Agriculture | Livestock | No licensed abstraction |
| | Irrigation | Not applicable |
| In-stream Recreation | Boating | Not applicable |
| | Bathing | Not applicable |
| | Angling | Not applicable |
| Informal recreation | Walking, picnicking, photography | Yes, mainly at Croxden Abbey and some access along the Brook. |
| Amenity /Aesthetics | Property prices | A number of properties overlooking the brook. |
| Conservation (Non-Use or Passive Use) | Ecology | Yes |
| | Heritage | Not applicable |
| Other | | None |

## 3.3 Capital and Operating Costs

Severn Trent Water Ltd has provided the Agency with estimates of the capital expenditure (capex) and operating expenditure (opex) necessary to provide for the replacement of the water currently abstracted at the Greatgate groundwater pumping station which could be diverted to alleviate low flows in the Croxden Brook. In addition to the costs of providing replacement water, the brook bed will need lining to prevent the loss of the augmented flow. Details of the costs are summarised in Table 3.4.

Table 3.4 **Summary of Cost Estimates (£ 000 Q4 1997)**

| | Option 1a | Option 1b | Option 2 | Option 3 | Option 4 |
|---|---|---|---|---|---|
| **Capital expenditure** | | | | | |
| Replacement water | 690 | 690 | 1379 | 1379 | 1379 |
| PWS option | 10 | 80 | 10 | 80 | 4620 |
| Bed lining costs[1] | 13 | 25 | 13 | 25 | 13 |
| Total | 713 | 795 | 1402 | 1484 | 6012 |
| **Operating expenditure (per annum)** | | | | | |
| Replacement water | 14 | 14 | 29 | 29 | 21 |
| PWS Option | 4 | 4 | 8 | 8 | 6 |
| Total | 18 | 18 | 37 | 37 | 27 |

[1] Agency costs to be recharged to STW Ltd under AMP3

## 3.4 Estimation of Benefits

### 3.4.1 Informal Recreation

The ruins of Croxden Abbey are close by the watercourse. English Heritage who manage the site were contacted to ask for visitor numbers. However it is an unmanned site with no record of visitor numbers. There are no parking facilities to accommodate visitors except at the side of the road and the brook itself is at least 50 m away from the boundary of the English Heritage site. Based on experience elsewhere it would be reasonable to assume 2,000 visitors a year to Croxden Abbey.

In the absence of reliable primary sources the estimation of visitor numbers to the rest of the site has been based on the indirect approach contained in the Manual. Realistic estimates of the likely number of visits have been derived from previous experience, utilising the GIS data to distribute the numbers between the river reaches.

As the informal recreational activities are unpriced there is no economic rent or profit earned by the activity. The total value of the recreational activity is measured in consumer surplus or the difference between what the consumer pays for the activity (zero) and what they would be willing to pay. The Guidelines recommend the following per visit estimates of the consumer surplus, assuming 40% of the willingness-to-pay is attributable to the presence of water:

- Upper bound estimate: £1.48 per visitor day;
- Central estimate: £0.60 per visitor day; and
- Lower bound estimate: £0.20 per visitor day.

Combining participation rates and willingness-to-pay with the flow improvement factors from Table 3.2 produces the annual incremental benefits which are presented in Table 3.5.

**Table 3.5 Annual Informal Recreation Benefits**

| | Option | Visitor Numbers by River Reach (000) | | | | Factored Benefit by River Reach (Q4 1997) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Abbey | 1 | 2 | 3 | Abbey | 1 | 2 | 3 | Total |
| **Upper Bound** | **1a** | 2.0 | 0 | 2.1 | 6.5 | 1.3 | 0 | 3.1 | 4.3 | 8.8 |
| | **1b** | 2.0 | 2.1 | 2.1 | 6.5 | 1.3 | 3.1 | 3.1 | 4.3 | 12.7 |
| | **2** | 2.0 | 0 | 2.1 | 6.5 | 3.0 | 0 | 3.1 | 6.6 | 15.7 |
| | **3** | 2.0 | 2.1 | 2.1 | 6.5 | 3.0 | 3.1 | 3.1 | 6.6 | 18.9 |
| | **4** | 2.0 | 0 | 2.1 | 6.5 | 3.0 | 0 | 3.1 | 9.6 | 15.7 |
| **Central Estimate** | **1a** | 2.0 | 0 | 1.6 | 5.0 | 0.5 | 0 | 1.0 | 1.4 | 2.9 |
| | **1b** | 2.0 | 1.6 | 1.6 | 5.0 | 0.5 | 1.0 | 1.0 | 1.4 | 3.9 |
| | **2** | 2.0 | 0 | 1.6 | 5.0 | 1.2 | 0 | 1.0 | 3.0 | 5.2 |
| | **3** | 2.0 | 1.6 | 1.6 | 5.0 | 1.2 | 1.0 | 1.0 | 3.0 | 6.2 |
| | **4** | 2.0 | 0 | 1.6 | 5.0 | 1.2 | 0 | 1.0 | 3.0 | 5.2 |
| **Lower Bound** | **1a** | 2.0 | 0 | 1.3 | 4.0 | 0.2 | 0 | 0.3 | 0.4 | 0.8 |
| | **1b** | 2.0 | 1.3 | 1.3 | 4.0 | 0.2 | 0.3 | 0.3 | 0.4 | 1.1 |
| | **2** | 2.0 | 0 | 1.3 | 4.0 | 0.4 | 0 | 0.3 | 0.8 | 1.5 |
| | **3** | 2.0 | 1.3 | 1.3 | 4.0 | 0.4 | 0.3 | 0.3 | 0.8 | 1.7 |
| | **4** | 2.0 | 0 | 1.3 | 4.0 | 0.4 | 0 | 0.3 | 0.8 | 1.5 |

### 3.4.2 Angling

Discussions with Agency staff revealed that there are no angling interests on Croxden Brook.

### 3.4.3 Agriculture

There are no licensed abstractions for agricultural or industrial purposes on Croxden Brook.

### 3.4.4 Property

East Staffordshire District Council was contacted to provide Council Tax Bands for the properties identified as adjacent to the watercourses. These are summarised in Table 3.6. All the properties are located on Reach 3, largely around Greatgate and Croxden. The property details on which the benefits are based are summarised in Table 3.6.

**Table 3.6 Properties Adjacent to Croxden Brook by Council Tax Band**

| Band | 1997 Midpoint (£ 000) | No of properties | | | | Economic Value (£ 000 Q4 1997) |
|---|---|---|---|---|---|---|
| | | Reach 1 | Reach 2 | Reach 3 | Total | |
| A | 40 | | | 0 | 0 | 0 |
| B | 46 | | | 3 | 3 | 140 |
| C | 61 | | | 1 | 1 | 61 |
| D | 79 | | | 4 | 4 | 315 |
| E | 105 | | | 5 | 5 | 525 |
| F | 141 | | | 7 | 7 | 990 |
| G | 242 | | | 3 | 3 | 727 |
| H | 323 | | | 0 | 0 | 0 |
| Total | | None | None | 23 | 23 | 2,758 |

Source: East Staffordshire District Council

By applying the formulae given in the Benefit Assessment Guidelines, using the assumed changes in return periods for the low flows indicated in Table 3.2, the benefit to property owners has been estimated in terms of once-off changes in stock.

**Table 3.7 Amenity and Aesthetic Stock Benefits (£000 Q4 1997)**

| Option | Total Incremental Benefits | | |
|---|---|---|---|
| | Upper Bound | Central Estimate | Lower Bound |
| 1a | 340 | 227 | 45 |
| 1b | 340 | 227 | 45 |
| 2 | 340 | 227 | 45 |
| 3 | 340 | 227 | 45 |
| 4 | 340 | 227 | 45 |

### 3.4.5 Non-Use

Non-use (conservation) benefit estimates for Croxden Brook have been derived for:

- local residents within 3 km;
- river users among the general public who do not visit this particular river and its tributaries but do hold non-use values towards the alleviation of low flows in rivers;
- the wider general public who are not river users.

The non-use benefits have been derived using the procedures given in Section 9 of the Benefit Assessment Guidelines.

**Local resident non-use valuation**

It has been assumed that there are almost 3,000 households within 3 km of Croxden Brook, distributed between the three river reaches as indicated below, based on population data obtained from the Agency GIS model and assuming 2.7 people/household:

| | |
|---|---|
| Reach I | 585 |
| Reach 2 | 585 |
| Reach 3 | 1,783 |

In accordance with the Guidelines, the following values per household per annum are applied where full low flow alleviation is achieved:

| | |
|---|---|
| Upper Bound | £12.00 |
| Central Estimate | £10.00 |
| Lower Bound | £ 7.00 |

**General public non-use valuation**

It is assumed that there are 3.15 million households within Severn Trent Water's area and that 45% of the population are general river users, from which the actual number of local households already included are subtracted. The remaining 55% of the population in the service area are taken as non-users for whom a lower scale of benefits applies. The central estimates are based on the figures of £0.05 and £0.03 per household per km of river per annum for full low flow alleviation in accordance with the Guidelines, with +/- 25% for upper and lower bounds.

The annual non-use (conservation) benefits of each option, applying the flow improvement factors from Table 3.2 for each river reach, are summarised in Table 3.8 in terms of the local resident non-use benefits and the full (local resident plus general public non-use) benefits.

**Table 3.8 Annual Non-Use Benefits (£000 Q4 1997)**

| Option | Extent | Upper | Central | Lower |
|---|---|---|---|---|
| 1a | Local | 17 | 14 | 10 |
| | Full | 331 | 265 | 198 |
| 1b | Local | 24 | 20 | 14 |
| | Full | 445 | 357 | 267 |
| 2 | Local | 28 | 24 | 17 |
| | Full | 596 | 478 | 357 |
| 3 | Local | 35 | 30 | 21 |
| | Full | 710 | 569 | 426 |
| 4 | Local | 28 | 24 | 17 |
| | Full | 596 | 478 | 357 |

## 3.5 Assessment of Tangibles (Cost Benefit Analysis)

The costs and the annual benefit streams have been aggregated in terms of present values in accordance with the procedures given in the Benefit Assessment Guidelines. The indicators in terms of net present values (NPV) and benefit cost ratios for the various options are presented in Table 3.9. The results are shown:

- both including and excluding non-use, together with intermediate figures: one including only 50% of the general public (i.e. non-local) non-use and the other including only local non-use;
- for the central estimates, with upper and lower bounds;
- using the different discount rates and time horizons; and
- with and without rolling forward the benefits.

With the inclusion of some non-local non-use value, all the options produce a positive net present value (NPV) and hence benefit cost ratios greater than unity. Where non-use values are included, Option 3 consistently produces the highest NPV, although Option 1b has the highest benefit cost ratio. Options 1a and 3 have generally similar benefit cost ratios. Option 2 has lower benefit cost ratios, the cost saving compared with Option 3 with the omission of the additional upstream release point being more than offset by the reduction in benefits. With much higher costs, Option 4 gives a consistently lower NPV and benefit cost ratio.

The overall results are highly sensitive to the assumptions regarding non-use benefits, with benefit cost ratios (except for Option 4) in the range 2.4 to 7.5 when the full non-use benefits are included. If only 50% of the non-local non-use benefits are included, the benefit cost ratio reduces to the range 1.8 to 3 with the central estimates. If only the local non-use benefits are included, the benefit cost ratio reduces to less than 1 in all cases, with values below 0.2 for the lower estimates.

A summary of the assessment of tangibles (i.e the quantifiable costs and benefits) for all options is presented in Table 3.10. For this analysis, which has been carried forward to the Summary Business Case, the economic benefit has been determined on the following basis:

- including 50% of the general public (i.e. non-local) non-use benefits
- central estimates without rolling forward of the benefits.

A breakdown of the total present value of the benefits by use category for Option 1b, which, as indicated in Section 3.8 below, has been selected as the preferred option, is shown on Figure 3.2, together with a breakdown of the present value of the costs. The benefits are based on the central estimates, including 50% of the non-local non-use benefits, with the 6% Treasury discount rate, and with no rolling forward.

**Table 3.9 (Sheet 1)** **Croxden Brook : Summary of Costs and Benefits**

**(£ 000 Q4 1997 expressed as present values)**

| Option | Costs | Benefits | | | | Total NPV | | | | Benefit Cost Ratio | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 7% Discount Rate, 30 year time period | | | | | | | | | | | | |
| | | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use |
| **Upper estimates, no rolling forward** | | | | | | | | | | | | | |
| 1a | 873 | 4,198 | 2,394 | 589 | 398 | 3,325 | 1,521 | -284 | -475 | 4.8 | 2.7 | 0.68 | 0.46 |
| 1b | 950 | 5,546 | 3,128 | 706 | 434 | 4,596 | 2,176 | -243 | -515 | 5.8 | 3.3 | 0.74 | 0.46 |
| 2 | 1,735 | 7,317 | 4,060 | 804 | 478 | 5,582 | 2,326 | -931 | -1,257 | 4.2 | 2.3 | 0.46 | 0.28 |
| 3 | 1,811 | 8,664 | 4,792 | 920 | 514 | 6,853 | 2,981 | -891 | -1,298 | 4.8 | 2.6 | 0.51 | 0.28 |
| 4 | 5,929 | 7,317 | 4,060 | 804 | 478 | 1,388 | -1,868 | -5,125 | -5,451 | 1.2 | 0.7 | 0.14 | 0.08 |
| **Upper estimates, with rolling forward** | | | | | | | | | | | | | |
| 1a | 873 | 4,413 | 2,510 | 607 | 405 | 3,540 | 1,637 | -266 | -468 | 5.1 | 2.9 | 0.70 | 0.46 |
| 1b | 950 | 5,835 | 3,282 | 730 | 443 | 4,885 | 2,333 | -220 | -506 | 6.1 | 3.5 | 0.77 | 0.47 |
| 2 | 1,735 | 7,703 | 4,268 | 833 | 489 | 5,968 | 2,533 | -902 | -1,246 | 4.4 | 2.5 | 0.48 | 0.28 |
| 3 | 1,811 | 9,124 | 5,040 | 956 | 527 | 7,312 | 3,228 | -856 | -1,284 | 5.0 | 2.8 | 0.53 | 0.29 |
| 4 | 5,929 | 7,703 | 4,268 | 833 | 489 | 1,774 | -1,661 | -5,096 | -5,440 | 1.3 | 0.7 | 0.14 | 0.08 |
| **Central estimates, no rolling forward** | | | | | | | | | | | | | |
| 1a | 873 | 3,277 | 1,834 | 390 | 231 | 2,405 | 961 | -482 | -642 | 3.8 | 2.1 | 0.45 | 0.26 |
| 1b | 950 | 4,341 | 2,405 | 469 | 243 | 3,391 | 1,455 | -481 | -707 | 4.6 | 2.5 | 0.49 | 0.26 |
| 2 | 1,735 | 5,740 | 3,135 | 530 | 258 | 4,005 | 1,400 | -1,205 | -1,477 | 3.3 | 1.8 | 0.31 | 0.15 |
| 3 | 1,811 | 6,803 | 3,705 | 608 | 269 | 4,991 | 1,894 | -1,203 | -1,542 | 3.8 | 2.0 | 0.34 | 0.15 |
| 4 | 5,929 | 5,740 | 3,135 | 530 | 258 | -188 | -2,794 | -5,399 | -5,671 | 1.0 | 0.5 | 0.09 | 0.04 |
| **Central estimates, with rolling forward** | | | | | | | | | | | | | |
| 1a | 873 | 3,447 | 1,925 | 402 | 234 | 2,574 | 1,052 | -471 | -639 | 3.9 | 2.2 | 0.46 | 0.27 |
| 1b | 950 | 4,569 | 2,527 | 485 | 246 | 3,619 | 1,577 | -465 | -704 | 4.8 | 2.7 | 0.51 | 0.26 |
| 2 | 1,735 | 6,045 | 3,297 | 549 | 262 | 4,310 | 1,562 | -1,186 | -1,473 | 3.5 | 1.9 | 0.32 | 0.15 |
| 3 | 1,811 | 7,166 | 3,899 | 631 | 274 | 5,354 | 2,087 | -1,180 | -1,538 | 4.0 | 2.2 | 0.35 | 0.15 |
| 4 | 5,929 | 6,045 | 3,297 | 549 | 262 | 116 | -2,632 | -5,380 | -5,666 | 1.0 | 0.6 | 0.09 | 0.04 |
| **Lower estimates, no rolling forward** | | | | | | | | | | | | | |
| 1a | 873 | 2,326 | 1,243 | 160 | 49 | 1,453 | 370 | -712 | -824 | 2.7 | 1.4 | 0.18 | 0.06 |
| 1b | 950 | 3,114 | 1,682 | 210 | 52 | 2,165 | 713 | -739 | -898 | 3.3 | 1.8 | 0.22 | 0.05 |
| 2 | 1,735 | 4,155 | 2,201 | 247 | 57 | 2,420 | 466 | -1,488 | -1,678 | 2.4 | 1.3 | 0.14 | 0.03 |
| 3 | 1,811 | 4,943 | 2,620 | 297 | 60 | 3,132 | 808 | -1,515 | -1,752 | 2.7 | 1.4 | 0.16 | 0.03 |
| 4 | 5,929 | 4,155 | 2,201 | 247 | 57 | -1,774 | -3,728 | -5,682 | -5,872 | 0.7 | 0.4 | 0.04 | 0.01 |
| **Lower estimates, with rolling forward** | | | | | | | | | | | | | |
| 1a | 873 | 2,451 | 1,309 | 167 | 50 | 1,578 | 436 | -706 | -823 | 2.8 | 1.5 | 0.19 | 0.06 |
| 1b | 950 | 3,283 | 1,751 | 220 | 53 | 2,333 | 802 | -730 | -897 | 3.5 | 1.8 | 0.23 | 0.06 |
| 2 | 1,735 | 4,380 | 2,319 | 258 | 58 | 2,645 | 585 | -1,476 | -1,677 | 2.5 | 1.3 | 0.15 | 0.03 |
| 3 | 1,811 | 5,212 | 2,761 | 311 | 61 | 3,400 | 950 | -1,500 | -1,751 | 2.9 | 1.5 | 0.17 | 0.03 |
| 4 | 5,929 | 4,380 | 2,319 | 258 | 58 | -1,548 | -3,609 | -5,670 | -5,871 | 0.7 | 0.4 | 0.04 | 0.01 |

Table 3.9 (Sheet 2) **Croxden Brook : Summary of Costs and Benefits**

**(£ 000 Q4 1997 expressed as present values)**

| Option | Costs | Benefits | | | | Total NPV | | | | Benefit Cost Ratio | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 6% Discount Rate, 50 year time period | | | | | | | | | | | | |
| | | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use |
| Upper estimates, no rolling forward | | | | | | | | | | | | | |
| 1a | 939 | 5,341 | 3,010 | 680 | 433 | 4,401 | 2,071 | -259 | -506 | 5.7 | 3.2 | 0.72 | 0.46 |
| 1b | 1,017 | 7,081 | 3,956 | 831 | 480 | 6,064 | 2,939 | -186 | -537 | 7.0 | 3.9 | 0.82 | 0.47 |
| 2 | 1,871 | 9,368 | 5,163 | 957 | 536 | 7,497 | 3,292 | -914 | -1,335 | 5.0 | 2.8 | 0.51 | 0.29 |
| 3 | 1,948 | 11,108 | 6,108 | 1,108 | 582 | 9,160 | 4,159 | -841 | -1,366 | 5.7 | 3.1 | 0.57 | 0.30 |
| 4 | 6,072 | 9,368 | 5,163 | 957 | 536 | 3,297 | -909 | -5,115 | -5,536 | 1.5 | 0.9 | 0.16 | 0.09 |
| Upper estimates, with rolling forward | | | | | | | | | | | | | |
| 1a | 939 | 5,734 | 3,223 | 711 | 445 | 4,795 | 2,283 | -228 | -494 | 6.1 | 3.4 | 0.76 | 0.47 |
| 1b | 1,017 | 7,610 | 4,242 | 873 | 495 | 6,593 | 3,225 | -143 | -521 | 7.5 | 4.2 | 0.86 | 0.49 |
| 2 | 1,871 | 10,075 | 5,542 | 1,009 | 555 | 8,205 | 3,671 | -862 | -1,316 | 5.4 | 3.0 | 0.54 | 0.30 |
| 3 | 1,948 | 11,950 | 6,561 | 1,172 | 606 | 10,002 | 4,613 | -777 | -1,343 | 6.1 | 3.4 | 0.60 | 0.31 |
| 4 | 6,072 | 10,075 | 5,542 | 1,009 | 555 | 4,004 | -529 | -5,062 | -5,516 | 1.7 | 0.9 | 0.17 | 0.09 |
| Central estimates, no rolling forward | | | | | | | | | | | | | |
| 1a | 939 | 4,179 | 2,314 | 450 | 245 | 3,239 | 1,375 | -489 | -695 | 4.4 | 2.5 | 0.48 | 0.26 |
| 1b | 1,017 | 5,552 | 3,052 | 552 | 259 | 4,535 | 2,035 | -465 | -758 | 5.5 | 3.0 | 0.54 | 0.25 |
| 2 | 1,871 | 7,359 | 3,994 | 630 | 279 | 5,488 | 2,124 | -1,241 | -1,592 | 3.9 | 2.1 | 0.34 | 0.15 |
| 3 | 1,948 | 8,731 | 4,731 | 731 | 293 | 6,783 | 2,783 | -1,217 | -1,655 | 4.5 | 2.4 | 0.38 | 0.15 |
| 4 | 6,072 | 7,359 | 3,994 | 630 | 279 | 1,287 | -2,077 | -5,442 | -5,793 | 1.2 | 0.7 | 0.10 | 0.05 |
| Central estimates, with rolling forward | | | | | | | | | | | | | |
| 1a | 939 | 4,489 | 2,480 | 471 | 249 | 3,550 | 1,540 | -469 | -690 | 4.8 | 2.6 | 0.50 | 0.27 |
| 1b | 1,017 | 5,969 | 3,274 | 580 | 265 | 4,952 | 2,258 | -437 | -752 | 5.9 | 3.2 | 0.57 | 0.26 |
| 2 | 1,871 | 7,917 | 4,291 | 664 | 286 | 6,046 | 2,420 | -1,207 | -1,585 | 4.2 | 2.3 | 0.35 | 0.15 |
| 3 | 1,948 | 9,396 | 5,085 | 773 | 302 | 7,448 | 3,137 | -1,175 | -1,647 | 4.8 | 2.6 | 0.40 | 0.15 |
| 4 | 6,072 | 7,917 | 4,291 | 664 | 286 | 1,845 | -1,781 | -5,408 | -5,786 | 1.3 | 0.7 | 0.11 | 0.05 |
| Lower estimates, no rolling forward | | | | | | | | | | | | | |
| 1a | 939 | 2,993 | 1,594 | 196 | 52 | 2,053 | 655 | -743 | -887 | 3.2 | 1.7 | 0.21 | 0.06 |
| 1b | 1,017 | 4,011 | 2,136 | 261 | 56 | 2,994 | 1,119 | -756 | -960 | 3.9 | 2.1 | 0.26 | 0.06 |
| 2 | 1,871 | 5,355 | 2,831 | 308 | 62 | 3,484 | 960 | -1,563 | -1,809 | 2.9 | 1.5 | 0.16 | 0.03 |
| 3 | 1,948 | 6,373 | 3,373 | 373 | 66 | 4,424 | 1,424 | -1,576 | -1,882 | 3.3 | 1.7 | 0.19 | 0.03 |
| 4 | 6,072 | 5,355 | 2,831 | 308 | 62 | -717 | -3,240 | -5,764 | -6,010 | 0.9 | 0.5 | 0.05 | 0.01 |
| Lower estimates, with rolling forward | | | | | | | | | | | | | |
| 1a | 939 | 3,223 | 1,716 | 209 | 54 | 2,283 | 776 | -731 | -886 | 3.4 | 1.8 | 0.22 | 0.06 |
| 1b | 1,017 | 4,320 | 2,299 | 278 | 58 | 3,304 | 1,283 | -738 | -959 | 4.2 | 2.3 | 0.27 | 0.06 |
| 2 | 1,871 | 5,769 | 3,049 | 329 | 64 | 3,898 | 1,178 | -1,542 | -1,807 | 3.1 | 1.6 | 0.18 | 0.03 |
| 3 | 1,948 | 6,866 | 3,632 | 399 | 68 | 4,918 | 1,684 | -1,550 | -1,880 | 3.5 | 1.9 | 0.20 | 0.04 |
| 4 | 6,072 | 5,769 | 3,049 | 329 | 64 | -303 | -3,023 | -5,743 | -6,008 | 1.0 | 0.5 | 0.05 | 0.01 |

Table 3.10 **Assessment of Tangibles (£000 Q4 1997)**

| Option | Agency Costs | Water Co. Costs | Economic Benefit | Net Present Value | Benefit Cost Ratio |
|---|---|---|---|---|---|
| 6% discount rate, 50 year time period | | | | | |
| **Do Nothing** | 0 | 0 | 0 | 0 | 0 |
| **Option 1a** | 12 | 927 | 2,314 | 1,375 | 2.5 |
| **Option 1b** | 24 | 993 | 3,052 | 2,035 | 3.0 |
| **Option 2** | 12 | 1,859 | 3,994 | 2,124 | 2.1 |
| **Option 3** | 24 | 1,925 | 4,731 | 2,783 | 2.4 |
| **Option 4** | 12 | 6,060 | 3,994 | -2,077 | 0.7 |
| 7% discount rate, 30 year time period | | | | | |
| **Do Nothing** | 0 | 0 | 0 | 0 | 0 |
| **Option 1a** | 12 | 861 | 1,834 | 961 | 2.1 |
| **Option 1b** | 23 | 926 | 2,405 | 1,455 | 2.5 |
| **Option 2** | 12 | 1,723 | 3,135 | 1,400 | 1.8 |
| **Option 3** | 23 | 1,788 | 3,705 | 1,894 | 2.0 |
| **Option 4** | 12 | 5,916 | 3,135 | -2,794 | 0.5 |

## 3.6 Assessment of Intangibles

The assessment of intangible benefits (or disbenefits) has been undertaken by a weighting and scoring system and is presented in Table 3.11. The intangibles considered in the table are:

1. Facilitation of Agency meeting objectives
2. Improved public relations and maintenance of credibility of Agency
3. Longer term benefits not quantified in economic analysis

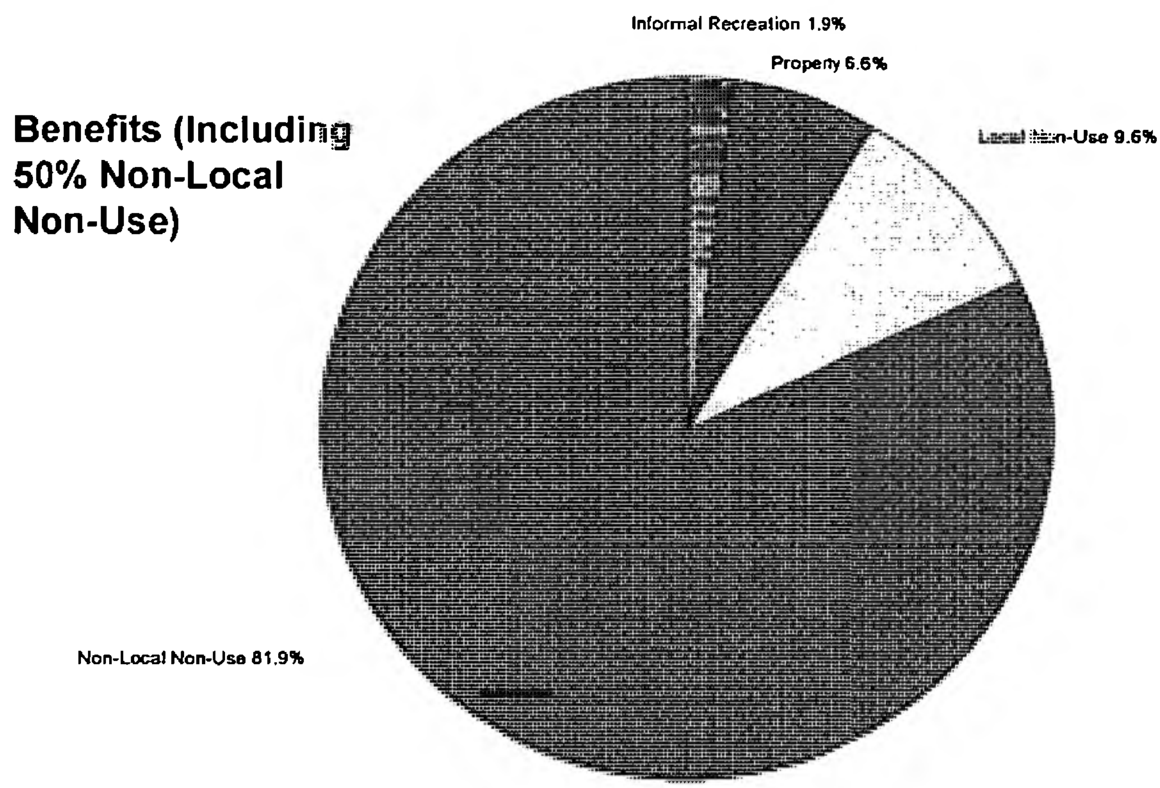
Each of the intangible benefits has been allocated a weighting within the range from 5 to 0 (from most important to least important). Scores reflecting the ability of each option to deliver the intangible benefit have been allocated from 5 to 0 (from greatest ability to least ability).

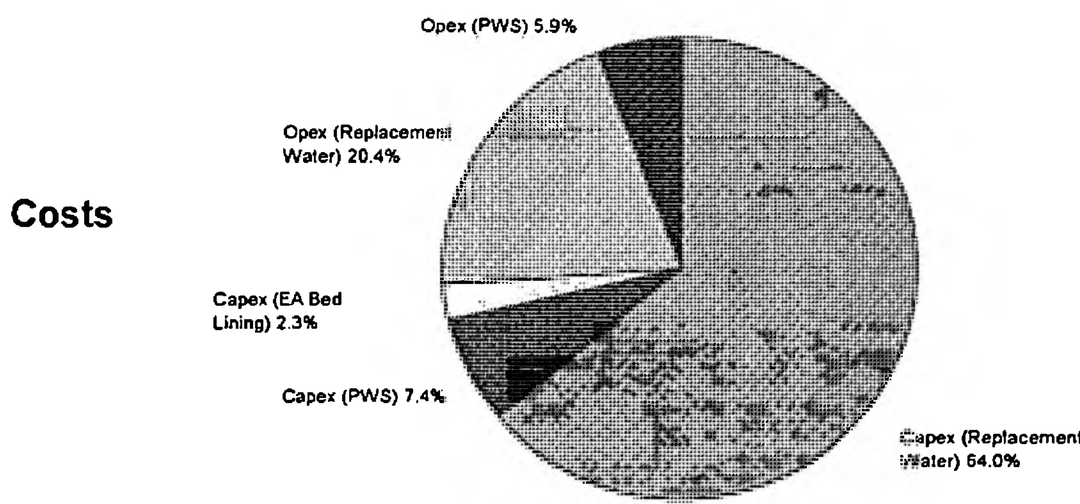
## 3.7 Risk Assessment

A risk assessment of the options has been undertaken and the results tabulated in a "Risk Register" (Table 3.12). The risks considered to be relevant in the appraisal are:

Risk 1 Operational failure of flow alleviation
Risk 2 Failure to provide anticipated benefits
Risk 3 Failure to supply a sustainable solution

Within the Risk Register the likelihood of the risk happening, and the consequent effect on the solution, are classified as "high", "medium" or "low".




Note:The area of the circles is proportional to the present value of the benefits or costs at a 6% discount rate

**Croxden Brook Option 1b**
**Present Value of Benefits and Costs**
**Figure 3.2**

**Table 3.11** **Assessment of Intangible Benefits**

| Intangible Benefit | Weighting Factor | Option 1a<br>1 Ml/d release at point A | | Option 1b<br>1 Ml/d release at point B | | Option 2<br>2 Ml/d release at point A | | Option 3<br>1 Ml/d release at both points A and B | | Option 4<br>2 Ml/d release from new borehole | | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | points | weighted points | points | weighted points | points | weighted points | points | weighted points | points | weighted points | |
| 1 | 3 | 3 | 9 | 4 | 12 | 4 | 12 | 5 | 15 | 4 | 12 | |
| 2 | 3 | 3 | 9 | 5 | 15 | 4 | 12 | 5 | 15 | 4 | 12 | |
| 3 | 3 | | | | | | | | | | | Not applicable |
| Total weighted score | | | 18 | | 27 | | 24 | | 30 | | 24 | |

Intangible Benefit 1: Facilitation of Agency meeting objectives
Intangible Benefit 2: Improved public relations and maintenance of credibility of Agency
Intangible Benefit 3: Longer term benefits not quantified in economic analysis

**Table 3.12** **Risk Register**

| Identified Risk | Option 1a<br>1 Ml/d release at point A | | Option 1b<br>1 Ml/d release at point B | | Option 2<br>2 Ml/d release at point A | | Option 3<br>1 Ml/d release at both points A and B | | Option 4<br>2 Ml/d release from new borehole | | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Likeli-hood | Effect | Likeli-hood | Effect | Likeli-hood | Effect | Likeli-hood | Effect | Likeli-hood | Effect | |
| Operational failure of flow alleviation | L | L | L | L | L | L | L | L | L | L | |
| Failure to provide anticipated benefits | L | M | L | M | M | M | M | M | L | M | Long term yield available for low flow alleviation only about 1.7 Ml/d |
| Failure to supply a sustainable solution | L | M | L | M | M | M | M | M | L | M | |

Relative risks: H high M medium L low

## 3.8 Selection of Preferred Option

From the assessment of tangibles presented in Table 3.10 it can be seen that Option 3 represents the most cost effective solution in terms of maximum net present value (NPV). This conclusion is supported by the assessment of intangibles. However, at a late stage in the analysis it became apparent that the water available for compensation releases is limited by the long term yield of the Greatgate PWS borehole. The release of 2 Ml/d required to effect Options 2 and 3 is therefore not sustainable and is incompatible with the long term objective of a recovery of groundwater levels. This is reflected in the risk register in Table 3.11, where Options 2 and 3 are shown as having a medium risk of failing to provide the anticipated benefits and a medium risk of not supplying a sustainable solution. Of the remaining options, Option 4 has excessive costs and Option 1a has substantially lower benefits compared with Option 1b, due to the shorter length of watercourse re-watered.

**It is therefore concluded that Option 1b, with a compensation release of 1 Ml/d to the upstream release point B, should be selected as the preferred option.**

The total length of the Croxden Brook and its tributaries anticipated to benefit from the improved flows is 4.4 km.

The Winnothdale Brook, the Croxden Brook downstream of the Winnothdale confluence and a water-dependent Site of Importance for Nature Conservation (SINC) further downstream will all benefit if flows are restored. It is possible that these sites will degrade significantly if the situation is not improved.

The increased flows may provide a suitable habitat for brown trout spawning and a nursery area for the juvenile fish and should also help to reduce siltation of the stream bed.

The assessed economic benefit takes account of these ecological improvements in addition to the increase in the amenity and recreational value of the area surrounding the watercourses.

## 3.9 Tasks and Dependencies

| | |
|---|---|
| Investigations: | Agency Midlands Region, Upper Trent Area |
| Design and Implementation: | Agency Midlands Region, Regional Office<br>Severn Trent Water Ltd |

**Programme for implementation of the preferred option:**

| | |
|---|---|
| 1998 | Submission of Business Plan |
| 1999 | Investigation and Design<br>Planning and Consents |
| 2000 | Construction |

## 3.10 Cost of Preferred Option

The estimated capital and operating costs of the preferred option are given in Table 3.13. The estimates of likely future capital costs are based on the assumption that the Construction Output Index (COPI) will rise by 4 per cent per annum. In the estimation of operating costs an annual increase of 2.5 per cent per annum in the Retail Price Index (RPI) has been assumed.

**Table 3.13 Estimated Costs of the Preferred Option (£ 000)**

| Year | Water Company | | Agency | |
|---|---|---|---|---|
| ending 31/03 | Capex | Opex | Capex | Opex |
| 1999 | 0 | 0 | 4[1] | 0 |
| 2000 | 0 | 0 | 0 | 0 |
| 2001 | 866 | 19 | 28[2] | 0 |
| 2002 | 0 | 20 | 0 | 0 |
| 2003 | 0 | 20 | 0 | 0 |

[1] comprises submission of business plan, the cost of which has not been included in the assessment of tangibles

[2] Agency costs for bed lining to be recharged to STW Ltd under AMP3

# 4 DOVER BECK

## 4.1 Scheme Objectives

The river system of Dover Beck, which has suffered from low flows in recent years, is shown on Figure 4.1. The Agency has recently commissioned a groundwater abstraction borehole at Oxton Golf Club. It was intended that this would rewater the Dover Beck from the borehole down to Bean Ford immediately downstream of Oxton Bogs. Downstream of this point through Thorndale Plantation the flow continues to be lost by seepage.

The Agency intends to identify the length of Dover Beck which is leaking and implement a scheme to line parts of the bed. Two options have been considered in which different lengths of the bed are lined. It has been assumed that the resulting outflow from the Oxton Bogs will be transferred to the River Trent.

On the Oxton Dumble, a tributary of the Dover Beck, a separate augmentation release from a new borehole is being considered to increase the flow. Alternatively an existing but un-used borehole might be used.

The currently proposed options for the alleviation of low flows on Dover Beck are summarised in Table 4.1.

**Table 4.1 Low Flow Alleviation Options**

| Option | Description | Improvements |
|---|---|---|
| 1 | Sealing beck bed to produce 1.0 Ml/day below Oxton Bogs when existing borehole is in operation. | Rewater 2.5 km, significantly increased flows 8 km |
| 2 | Sealing of beck bed to produce 2.5 Ml/day flow below Oxton Bogs when existing borehole is in operation. | Rewater 2.5 km, significantly increased flows 8 km |
| 3 | Compensation release into Oxton Dumble of 1 Ml/d at NGR SK 646530 | Rewater 5.3 km, significantly increased flows 8 km |
| 4 | A combination of Options 1+3 | Rewater 6 km, significantly increased flows 8 km |
| 5 | A combination of Options 2+3 | Rewater 6 km, significantly increased flows 8 km |

The gauging station at Lowdham will be used to trigger the compensation releases. This will ensure a minimum target flow at Lowdham. The Agency has stated that the target flow is 15 Ml/d which is the Q20% value (or natural flow which is exceeded for 20% of the time). Flow duration curves and and mean daily flows at Lowdham provided by the Agency are given in Appendix 4.

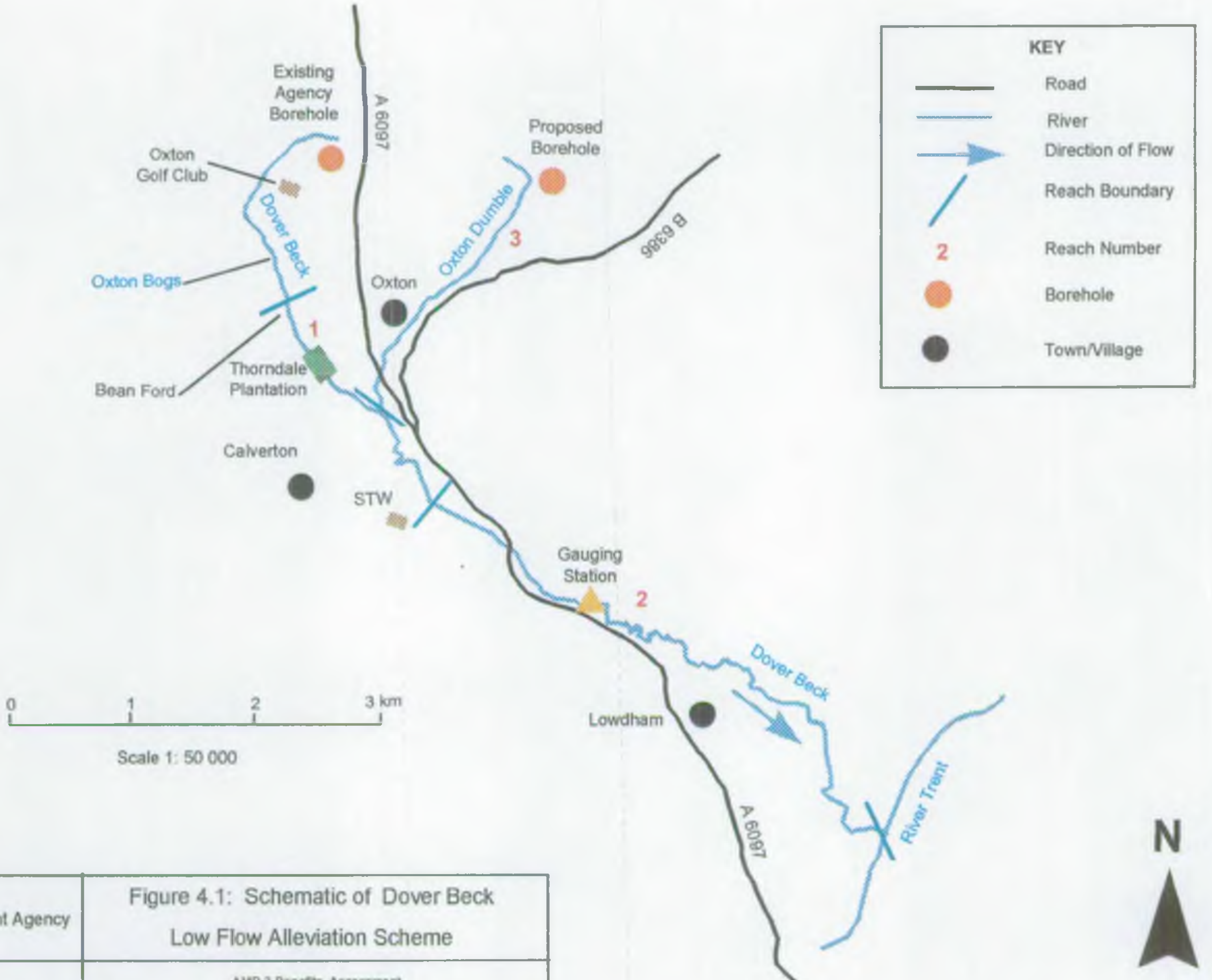
The available information has been used to derive appropriate factors for the economic benefits of each option for those uses which are frequency and duration dependent. The river has been divided into three reaches for this purpose:

| | |
|---|---|
| Reach 1 | From the outlet from Oxton Bogs at Bean Ford to the confluence with the Grimesmoor Dyke near Calverton Lido, which receives the outfall from the Calverton STW (2.5 km, except in Option 3 where the reach excludes Thorndale Plantation and is 1.8 km long) |
| Reach 2 | From Calverton Lido to the confluence with the River Trent near Caythorpe (8 km) |
| Reach 3 | From the proposed augmentation borehole on the Oxton Dumble to the confluence with the Dover Beck downstream of Thorndale Plantation (3.5 km, not included in Options 1 and 2) |

Target flows for each reach have been assessed to determine the extent to which the low flow alleviation schemes will improve the situation. Flow improvement factors have been derived from a consideration of the **proportional flow** improvement from the existing situation. In the absence of flow duration data it was not possible to estimate the **proportional time** improvement that the target flow is achieved. Corresponding return periods for very low flows (i.e. about 50% of the target flows) have also been estimated for the before and after situations. The figures which have been derived are summarised in Table 4.2.

**Table 4.2 Summary of Hydrological Assessment for Dover Beck**

| | | Reach 1 | Reach 2 | Reach 3 |
|---|---|---|---|---|
| **Target Flow (Ml/d)** | | 2 | 7 | 1 |
| **% of Time above Target** | | | | |
| **Before** | | 25% | 67% | 25% |
| **After** | Option 1 | 60% | 75% | - |
| | Option 2 | 95% | 90% | - |
| | Option 3 | 60% | 75% | 95% |
| | Option 4 (1 + 3) | 95% | 85% | 95% |
| | Option 5 (2 + 3) | 95% | 98% | 95% |
| **Flow Improvement Factor** | | | | |
| | Option 1 | 50% | 15% | - |
| | Option 2 | 100% | 35% | - |
| | Option 3 | 50% | 15% | 100% |
| | Option 4 (1 + 3) | 100% | 30% | 100% |
| | Option 5 (2 + 3) | 100% | 40% | 100% |
| **Return Period (years)** before → after | | | | |
| | Option 1 | 1 → 5 | 2 → 5 | - |
| | Option 2 | 1 → 10 | 2 → 10 | - |
| | Option 3 | 1 → 5 | 2 → 5 | 1 → 10 |
| | Option 4 (1 + 3) | 1 → 10 | 2 → 10 | 1 → 10 |
| | Option 5 (2 + 3) | 1 → 10 | 2 → 10 | 1 → 10 |




Environment Agency

Figure 4.1: Schematic of Dover Beck Low Flow Alleviation Scheme

GIBB Ltd
Consulting Engineers
Reading England

AMP 3 Benefits Assessment

| SCALE 1: 50 000 | DATE April 1998 | J98032 A |
|---|---|---|

In addition to the proposed interim remedial measures indicated above, Water Company groundwater licences in the Nottinghamshire aquifer will reduce by a total of 25 Ml/d as a result of existing licence conditions scheduled to take effect before the end of the AMP3 period. The Agency has also advised the Water Company that a further reduction totalling 40 Ml/d will be required over future AMP planning periods to bring groundwater abstractions from this aquifer down to a sustainable level. These proposals result from detailed hydrogeological modelling of the Nottinghamshire aquifer by the Agency. The Water Company has accepted these findings and the proposed cutbacks have been included in the Company's draft water resources plan. These reductions will benefit a wider area of Nottinghamshire, including the priority site on Rainworth Water, as well as assisting this local site.

## 4.2 Scope of Study

Table 4.3 has been used as a checklist to focus on those impacts which are likely to be significant and need to be included in the economic appraisal.

**Table 4.3 Summary of Impacts**

| Impact Category | | Comments |
|---|---|---|
| Drinking Water Supply | | Not applicable |
| Industrial Abstraction | | Not applicable |
| Agriculture | Livestock | Not applicable |
| | Irrigation | Intensively irrigated carrots, potatoes and sugar beet. Excellent soil for these types of crops. Mostly supplied from groundwater. |
| In-stream Recreation | Boating | Not applicable |
| | Bathing | Not applicable |
| | Angling | Discussions with Agency staff revealed that there are no angling interests on Dover Beck. |
| Informal recreation | Walking, picnicking, photography | Yes |
| Amenity /Aesthetics | Property prices | A number of properties overlooking the river. |
| Conservation (Non-Use or Passive Use) | Ecology | Yes |
| | Heritage | Not applicable |
| Other | | None |

Discussions with the Agency have clarified that the spray irrigation used for agriculture is from groundwater abstractions. There is however a fish farm, Epperstone Park Hatcheries, which has a licence to abstract from the Dover Beck. The proprietor was contacted and asked about the impact of the low flows on his surface water abstraction. He said that the fish farm had not used the Beck for at least five years due to the lack of water and as a result has found an alternative water source through sinking a borehole. Even with the alleviation of low flows the fish farm would not return to using the Beck as a water source due to its unreliability both in terms of water quality and volume. Therefore the project offers no economic benefits to this user category.

Restoration of the flow will improve the continuity of the beck's linear wildlife habitat, which at present is not complete due to the beck periodically suffering extremely low flows.

The categories that have been included in the benefit assessment are:

- informal recreation;
- property; and
- non-use.

## 4.3 Capital and Operating Costs

The Agency has provided estimates of the capital expenditure (capex) and operating expenditure (opex) necessary to line the beck course and to provide a new borehole for the compensation release to Oxton Dumble. Details of the costs are summarised in Table 4.4.

**Table 4.4 Summary of Cost Estimates (£ 000 Q4 1997)**

| | Option 1 | Option 2 | Option 3 | Option 4 | Option 5 |
|---|---|---|---|---|---|
| **Capital expenditure** | | | | | |
| [1] Replacement water | | | 690 | 690 | 690 |
| [2] Bed lining | 45 | 60 | | 45 | 60 |
| [1] New borehole | | | 120 | 120 | 120 |
| **Total** | **45** | **60** | **810** | **855** | **870** |
| **Operating expenditure (per annum)** | | | | | |
| [1] Replacement water | | | 11 | 11 | 11 |
| [1] New borehole | | | 9 | 9 | 9 |
| **Total** | **0** | **0** | **20** | **20** | **20** |

[1] By Severn Trent Water Ltd [2] By Agency (costs to be recharged to STW Ltd under AMP3)

## 4.4 Estimation of Benefits

### 4.4.1 Informal Recreation

There is limited public access to the reaches of the watercourse affected by the scheme. In addition, though the site is close to Nottingham, there are large numbers of substitute sites in the area which attract visitors in preference to Dover Beck itself. In the absence of reliable primary sources, the estimation of visitor numbers to the site has been based on the indirect approach outlined in the Agency Guidelines, related to the population within 0.8 km of the river, obtained from the Agency's GIS system. Realistic estimates of the likely number of visits have been derived from previous experience, utilising the GIS data to distribute the numbers between the river reaches.

As the informal recreational activities are unpriced there is no economic rent or profit earned by the activity. The total value of the recreational activity is measured in consumer surplus or the difference between what the consumer pays for the activity (zero) and what they would be willing to pay. The Guidelines recommend the following per visit estimates of the consumer surplus, assuming 40% of the willingness-to-pay is attributable to the presence of water:

- Upper bound estimate: £1.48 per visitor day;
- Central estimate: £0.60 per visitor day; and
- Lower bound estimate: £0.20 per visitor day.

Combining participation rates and willingness-to-pay with the flow improvement factors from Table 4.2 produces the annual incremental benefits which are presented in Table 4.5.

**Table 4.5 Annual Informal Recreation Benefits**

| | Option | Visitor Numbers by River Reach (000) | | | Factored Benefit by River Reach (£000 Q4 1997) | | | |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 1 | 2 | 3 | Total |
| **Upper Bound** | **1** | 7 | 21 | - | 5 | 5 | - | 10 |
| | **2** | 7 | 21 | - | 10 | 11 | - | 21 |
| | **3** | 5 | 21 | 3 | 4 | 5 | 4 | 13 |
| | **4** | 7 | 21 | 3 | 10 | 9 | 4 | 23 |
| | **5** | 7 | 21 | 3 | 10 | 12 | 4 | 26 |
| **Central Estimate** | **1** | 5 | 16 | - | 2 | 1 | - | 3 |
| | **2** | 5 | 16 | - | 3 | 3 | - | 6 |
| | **3** | 4 | 16 | 2 | 1 | 2 | 1 | 4 |
| | **4** | 5 | 16 | 2 | 3 | 3 | 1 | 7 |
| | **5** | 5 | 16 | 2 | 3 | 4 | 1 | 8 |
| **Lower Bound** | **1** | 4 | 13 | - | 0.4 | 0.4 | - | 0.8 |
| | **2** | 4 | 13 | - | 0.8 | 1 | - | 2 |
| | **3** | 3 | 13 | 2 | 0.3 | 0.4 | 0.3 | 1 |
| | **4** | 4 | 13 | 2 | 0.8 | 0.8 | 0.3 | 2 |
| | **5** | 4 | 13 | 2 | 0.8 | 1 | 0.3 | 2 |

### 4.4.2 Property

Newark and Sherwood District Council was contacted to provide Council Tax Bands for the properties identified as adjacent to the watercourse. These are summarised in Table 4.6

**Table 4.6 Properties Adjacent to Dover Beck by Council Tax Band**

| Band | 1997 Midpoint (£ 000) | No of properties | | | | Economic Value (£ 000 Q4 1997) |
|---|---|---|---|---|---|---|
| | | Reach 1 | Reach 2 | Reach 3 | Total | |
| A | 40 | 0 | 0 | 0 | 0 | 0 |
| B | 46 | 0 | 0 | 0 | 0 | 0 |
| C | 61 | 0 | 0 | 0 | 0 | 0 |
| D | 79 | 0 | 4 | 2 | 6 | 474 |
| E | 105 | 0 | 6 | 5 | 11 | 1,155 |
| F | 141 | 2 | 4 | 5 | 11 | 1,551 |
| G | 242 | 0 | 3 | 0 | 3 | 726 |
| H | 323 | 0 | 0 | 0 | 0 | 0 |
| **Total** | | **2** | **17** | **12** | **31** | **3,906** |

Source: Newark and Sherwood District Council

By applying the formulae given in the Benefit Assessment Guidelines, using the assumed changes in return periods for the low flows indicated in Table 4.2, the benefit to property owners has been estimated in terms of once-off changes in stock.

**Table 4.7 Amenity and Aesthetic Stock Benefits (£000 Q4 1997)**

| Option | Total Incremental Benefits | | |
|---|---|---|---|
| | Upper Bound | Central Estimate | Lower Bound |
| 1 | 163 | 109 | 22 |
| 2 | 277 | 185 | 37 |
| 3 | 371 | 248 | 50 |
| 4 | 485 | 323 | 65 |
| 5 | 485 | 323 | 65 |

### 4.4.3 Non-Use

Non-use (conservation) benefit estimates for Dover Beck have been derived for:

- local residents within 3 km;
- river users among the general public who do not visit this particular river and its tributaries but do hold non-use values towards the alleviation of low flows in rivers;
- the wider general public who are not river users.

The non-use benefits have been derived using the procedures given in Section 9 of the Benefit Assessment Guidelines.

**Local resident non-use valuation**

It has been assumed that there are about 8,000 households within 3 km of Dover Beck, distributed between the three river reaches as indicated below, based on population data obtained from the Agency GIS model and assuming 2.7 people/household:

| | |
|---|---|
| Reach I | 1,762 (options 1,2,4 and 5), 1,391 (option 3) |
| Reach 2 | 5,637 |
| Reach 3 | 741 (options 3,4 and 5) |

In accordance with the Guidelines, the following values per household per annum are applied where full low flow alleviation is achieved:

| | |
|---|---|
| Upper Bound | £12.00 |
| Central Estimate | £10.00 |
| Lower Bound | £ 7.00 |

**General public non-use valuation**

It is assumed that there are 3.15 million households within Severn Trent Water's area and that 45% of the population are general river users, from which the actual number of local households already included are subtracted. The remaining 55% of the population in the service area are taken as non-users for whom a lower scale of benefits applies. The central estimates are based on the figures of £0.05 and £0.03 per household per km of river per annum for full low flow alleviation in accordance with the Guidelines, with +/- 25% for upper and lower bounds.

The annual non-use (conservation) benefits of each option, applying the flow improvement factors from Table 4.2 for each river reach, are summarised in Table 4.8 in terms of the local resident non-use benefits and the full (local resident plus general public non-use) benefits.

**Table 4.8 Annual Non-Use Benefits (£000 Q4 1997)**

| Option | Extent | Upper | Central | Lower |
|---|---|---|---|---|
| 1 | Local | 21 | 17 | 12 |
| | Full | 396 | 317 | 237 |
| 2 | Local | 45 | 37 | 26 |
| | Full | 856 | 686 | 513 |
| 3 | Local | 27 | 23 | 16 |
| | Full | 885 | 709 | 530 |
| 4 | Local | 50 | 42 | 29 |
| | Full | 1,336 | 1,070 | 801 |
| 5 | Local | 57 | 48 | 33 |
| | Full | 1,465 | 1,174 | 878 |

## 4.5 Assessment of Tangibles (Cost Benefit Analysis)

The costs and the annual benefit streams have been aggregated in terms of present values in accordance with the procedures given in the Benefit Assessment Guidelines. The indicators in terms of net present values (NPV) and benefit cost ratios for the five options are presented in Table 4.9. The results are shown:

- both including and excluding non-use, together with intermediate figures: one including only 50% of the general public (i.e. non-local) non-use and the other including only local non-use;
- for the central estimates, with upper and lower bounds;
- using the different discount rates and time horizons; and
- with and without rolling forward the benefits.

The overall results are highly sensitive to the assumptions regarding non-use benefits, with benefit cost ratios in the range 6 to over 200 when the full non-use benefits are included. If only the local non-use benefits are included, the benefit cost ratio reduces to the range 0.5 to 15 with the central estimates. If no non-use benefits are included the ratio reduces further to a range from below 0.3 to 5. The NPV remains positive for all cases where a proportion of the non-local non-use benefits are incorporated.

Compared with Option 3, Options 1 and 2 provide consistently higher cost benefit ratios under all cases considered. This indicates that the bed lining options, on the basis of current estimates, are more cost effective than the borehole, with the extended bed lining in Option 2 giving better results than Option 1.

Option 5 (which combines Options 2 and 3) produces the highest NPV where any part of the non-local non-use value is included. However, if the non-local non-use is excluded Option 2 produces a higher NPV. Option 2 also provides a consistently higher benefit cost ratio.

A summary of the assessment of tangibles (i.e the quantifiable costs and benefits) for all options is presented in Table 4.10. For this analysis, which has been carried forward to the Summary Business Case, the economic benefit has been determined on the following basis:

- including 50% of the general public (i.e. non-local) non-use benefits
- central estimates without rolling forward of the benefits.

A breakdown of the total present value of the benefits by use category for Option 5 (central estimates, including 50% of the non-local non-use benefits) with the 6% Treasury discount rate, with no rolling forward, is shown on Figure 4.2, together with a breakdown of the present value of the costs.

Table 4.9 (Sheet 1)

**Dover Beck : Summary of Costs and Benefits**

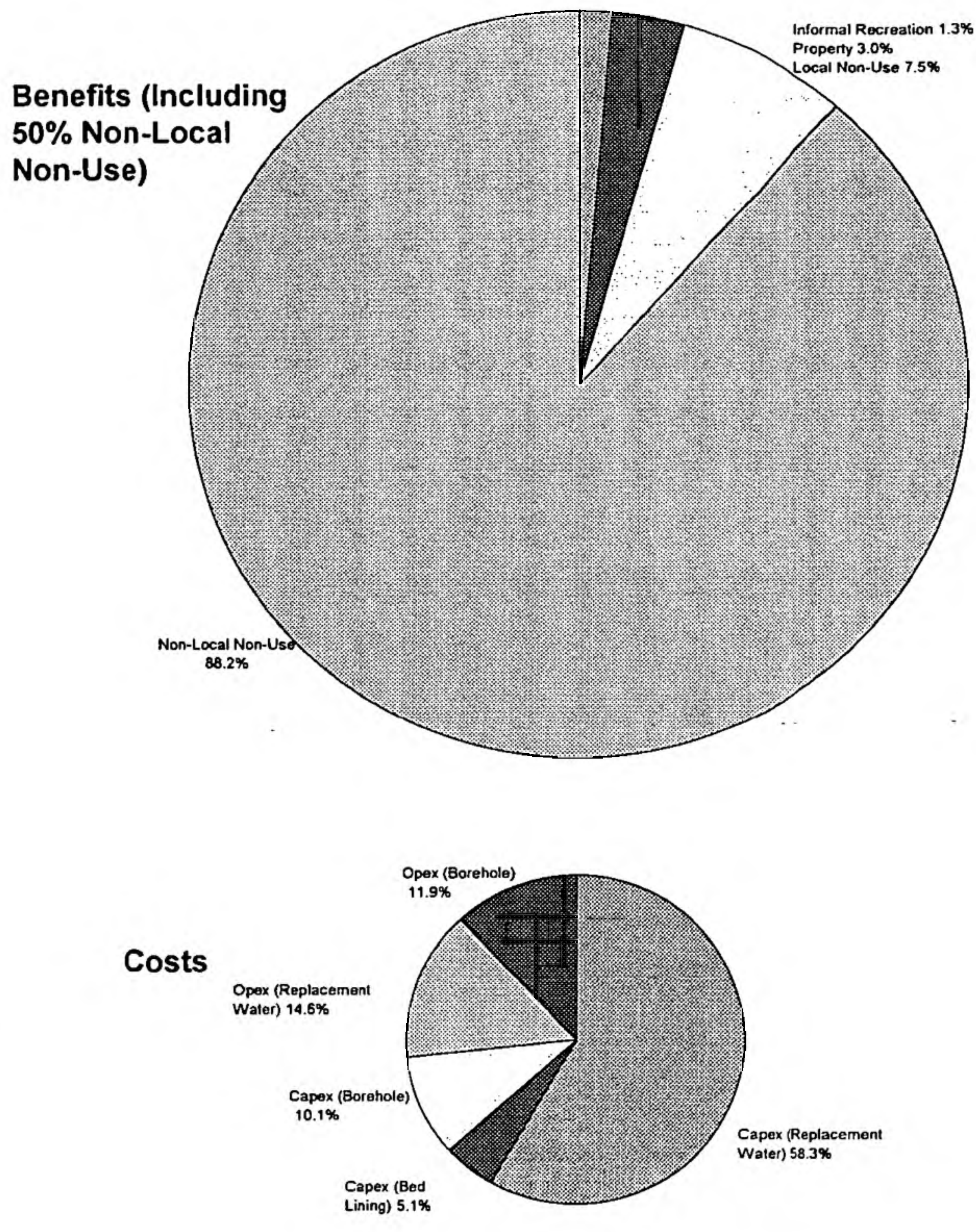
(£ 000 Q4 1997 expressed as present values)

| Option | 7% Discount Rate, 30 year time period | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Costs | Benefits | | | | Total NPV | | | | Benefit Cost Ratio | | | |
| | | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use |
| **Upper estimates, no rolling forward** | | | | | | | | | | | | | |
| 1 | 42 | 4,793 | 2,641 | 489 | 252 | 4,751 | 2,599 | 447 | 210 | 114.0 | 62.8 | 11.64 | 5.98 |
| 2 | 56 | 10,303 | 5,648 | 992 | 478 | 10,247 | 5,592 | 936 | 422 | 183.7 | 100.7 | 17.70 | 8.53 |
| 3 | 986 | 10,619 | 5,701 | 783 | 469 | 9,633 | 4,715 | -204 | -518 | 10.8 | 5.8 | 0.79 | 0.48 |
| 4 | 1,029 | 16,019 | 8,643 | 1,266 | 689 | 14,990 | 7,614 | 238 | -340 | 15.6 | 8.4 | 1.23 | 0.67 |
| 5 | 1,043 | 17,537 | 9,458 | 1,380 | 725 | 16,494 | 8,416 | 337 | -318 | 16.8 | 9.1 | 1.32 | 0.70 |
| **Upper estimates, with rolling forward** | | | | | | | | | | | | | |
| 1 | 42 | 5,049 | 2,779 | 509 | 258 | 5,007 | 2,737 | 467 | 216 | 120.0 | 66.1 | 12.11 | 6.14 |
| 2 | 56 | 10,855 | 5,945 | 1,035 | 492 | 10,799 | 5,889 | 979 | 436 | 193.6 | 106.0 | 18.45 | 8.78 |
| 3 | 986 | 11,185 | 5,997 | 810 | 478 | 10,198 | 5,011 | -177 | -508 | 11.3 | 6.1 | 0.82 | 0.48 |
| 4 | 1,029 | 16,875 | 9,095 | 1,315 | 706 | 15,846 | 8,066 | 286 | -323 | 16.4 | 8.8 | 1.28 | 0.69 |
| 5 | 1,043 | 18,476 | 9,955 | 1,434 | 743 | 17,434 | 8,913 | 392 | -299 | 17.7 | 9.5 | 1.38 | 0.71 |
| **Central estimates, no rolling forward** | | | | | | | | | | | | | |
| 1 | 42 | 3,770 | 2,049 | 327 | 129 | 3,728 | 2,007 | 285 | 87 | 89.7 | 48.7 | 7.78 | 3.07 |
| 2 | 56 | 8,112 | 4,388 | 664 | 235 | 8,056 | 4,332 | 608 | 179 | 144.7 | 78.3 | 11.83 | 4.19 |
| 3 | 986 | 8,392 | 4,458 | 523 | 261 | 7,406 | 3,471 | -463 | -725 | 8.5 | 4.5 | 0.53 | 0.27 |
| 4 | 1,029 | 12,648 | 6,748 | 847 | 365 | 11,620 | 5,719 | -182 | -663 | 12.3 | 6.6 | 0.82 | 0.36 |
| 5 | 1,043 | 13,848 | 7,385 | 922 | 377 | 12,806 | 6,343 | -120 | -666 | 13.3 | 7.1 | 0.88 | 0.36 |
| **Central estimates, with rolling forward** | | | | | | | | | | | | | |
| 1 | 42 | 3,972 | 2,156 | 340 | 131 | 3,930 | 2,114 | 298 | 89 | 94.4 | 51.3 | 8.09 | 3.13 |
| 2 | 56 | 8,548 | 4,620 | 692 | 240 | 8,492 | 4,564 | 636 | 184 | 152.4 | 82.4 | 12.34 | 4.28 |
| 3 | 986 | 8,841 | 4,691 | 541 | 265 | 7,855 | 3,705 | -445 | -722 | 9.0 | 4.8 | 0.55 | 0.27 |
| 4 | 1,029 | 13,327 | 7,103 | 879 | 371 | 12,298 | 6,074 | -150 | -657 | 13.0 | 6.9 | 0.85 | 0.36 |
| 5 | 1,043 | 14,592 | 7,776 | 959 | 383 | 13,550 | 6,733 | -84 | -659 | 14.0 | 7.5 | 0.92 | 0.37 |
| **Lower estimates, no rolling forward** | | | | | | | | | | | | | |
| 1 | 42 | 2,749 | 1,458 | 167 | 28 | 2,707 | 1,416 | 125 | -14 | 65.4 | 34.7 | 3.97 | 0.67 |
| 2 | 56 | 5,938 | 3,145 | 352 | 52 | 5,882 | 3,089 | 296 | -4 | 105.9 | 56.1 | 6.28 | 0.93 |
| 3 | 986 | 6,140 | 3,190 | 239 | 55 | 5,154 | 2,203 | -748 | -931 | 6.2 | 3.2 | 0.24 | 0.06 |
| 4 | 1,029 | 9,267 | 4,841 | 416 | 79 | 8,238 | 3,813 | -613 | -950 | 9.0 | 4.7 | 0.40 | 0.08 |
| 5 | 1,043 | 10,158 | 5,311 | 464 | 82 | 9,116 | 4,268 | -579 | -961 | 9.7 | 5.1 | 0.44 | 0.08 |
| **Lower estimates, with rolling forward** | | | | | | | | | | | | | |
| 1 | 42 | 2,899 | 1,537 | 175 | 29 | 2,857 | 1,495 | 133 | -13 | 68.9 | 36.5 | 4.16 | 0.68 |
| 2 | 56 | 6,262 | 3,316 | 370 | 53 | 6,206 | 3,260 | 314 | -3 | 111.7 | 59.1 | 6.59 | 0.95 |
| 3 | 986 | 6,475 | 3,362 | 250 | 56 | 5,488 | 2,376 | -737 | -930 | 6.6 | 3.4 | 0.25 | 0.06 |
| 4 | 1,029 | 9,772 | 5,104 | 436 | 80 | 8,743 | 4,075 | -593 | -948 | 9.5 | 5.0 | 0.42 | 0.08 |
| 5 | 1,043 | 10,712 | 5,599 | 487 | 83 | 9,669 | 4,557 | -556 | -959 | 10.3 | 5.4 | 0.47 | 0.08 |

**Table 4.9 (Sheet 2)** **Dover Beck : Summary of Costs and Benefits**

(£ 000 Q4 1997 expressed as present values)

| Option | Costs | Benefits | | | | Total NPV | | | | Benefit Cost Ratio | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 6% Discount Rate, 50 year time period | | | | | | | | | | | | |
| | | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use |
| **Upper estimates, no rolling forward** | | | | | | | | | | | | | |
| 1 | 42 | 6,152 | 3,372 | 593 | 286 | 6,109 | 3,330 | 551 | 244 | 144.9 | 79.4 | 13.97 | 6.74 |
| 2 | 57 | 13,240 | 7,228 | 1,216 | 552 | 13,183 | 7,171 | 1,159 | 495 | 233.9 | 127.7 | 21.48 | 9.74 |
| 3 | 1,061 | 13,626 | 7,274 | 923 | 517 | 12,565 | 6,214 | -138 | -544 | 12.8 | 6.9 | 0.87 | 0.49 |
| 4 | 1,103 | 20,571 | 11,046 | 1,520 | 774 | 19,468 | 9,943 | 417 | -329 | 18.7 | 10.0 | 1.38 | 0.70 |
| 5 | 1,117 | 22,532 | 12,099 | 1,666 | 820 | 21,415 | 10,982 | 549 | -297 | 20.2 | 10.8 | 1.49 | 0.73 |
| **Upper estimates, with rolling forward** | | | | | | | | | | | | | |
| 1 | 42 | 6,620 | 3,624 | 629 | 298 | 6,577 | 3,582 | 586 | 255 | 155.9 | 85.4 | 14.81 | 7.02 |
| 2 | 57 | 14,252 | 7,772 | 1,292 | 577 | 14,196 | 7,716 | 1,236 | 520 | 251.8 | 137.3 | 22.83 | 10.19 |
| 3 | 1,061 | 14,662 | 7,816 | 971 | 533 | 13,602 | 6,756 | -90 | -527 | 13.8 | 7.4 | 0.92 | 0.50 |
| 4 | 1,103 | 22,141 | 11,874 | 1,607 | 803 | 21,038 | 10,771 | 504 | -300 | 20.1 | 10.8 | 1.46 | 0.73 |
| 5 | 1,117 | 24,254 | 13,010 | 1,765 | 853 | 23,137 | 11,892 | 648 | -264 | 21.7 | 11.6 | 1.58 | 0.76 |
| **Central estimates, no rolling forward** | | | | | | | | | | | | | |
| 1 | 42 | 4,843 | 2,620 | 397 | 141 | 4,801 | 2,578 | 354 | 98 | 114.1 | 61.7 | 9.35 | 3.32 |
| 2 | 57 | 10,432 | 5,623 | 813 | 260 | 10,376 | 5,566 | 757 | 203 | 184.3 | 99.3 | 14.37 | 4.59 |
| 3 | 1,061 | 10,779 | 5,698 | 617 | 279 | 9,719 | 4,637 | -444 | -782 | 10.2 | 5.4 | 0.58 | 0.26 |
| 4 | 1,103 | 16,258 | 8,637 | 1,016 | 395 | 15,155 | 7,534 | -87 | -708 | 14.7 | 7.8 | 0.92 | 0.36 |
| 5 | 1,117 | 17,807 | 9,461 | 1,114 | 409 | 16,690 | 8,344 | -3 | -708 | 15.9 | 8.5 | 1.00 | 0.37 |
| **Central estimates, with rolling forward** | | | | | | | | | | | | | |
| 1 | 42 | 5,213 | 2,817 | 421 | 145 | 5,171 | 2,774 | 378 | 102 | 122.8 | 66.4 | 9.91 | 3.41 |
| 2 | 57 | 11,232 | 6,048 | 864 | 268 | 11,176 | 5,992 | 808 | 211 | 198.4 | 106.9 | 15.27 | 4.73 |
| 3 | 1,061 | 11,602 | 6,125 | 649 | 284 | 10,541 | 5,065 | -412 | -776 | 10.9 | 5.8 | 0.61 | 0.27 |
| 4 | 1,103 | 17,502 | 9,288 | 1,075 | 405 | 16,399 | 8,185 | -28 | -698 | 15.9 | 8.4 | 0.97 | 0.37 |
| 5 | 1,117 | 19,172 | 10,176 | 1,180 | 420 | 18,055 | 9,059 | 63 | -697 | 17.2 | 9.1 | 1.06 | 0.38 |
| **Lower estimates, no rolling forward** | | | | | | | | | | | | | |
| 1 | 42 | 3,545 | 1,878 | 210 | 31 | 3,503 | 1,835 | 168 | -11 | 83.5 | 44.2 | 4.95 | 0.74 |
| 2 | 57 | 7,660 | 4,053 | 446 | 58 | 7,604 | 3,996 | 389 | 2 | 135.3 | 71.6 | 7.88 | 1.03 |
| 3 | 1,061 | 7,918 | 4,107 | 296 | 60 | 6,858 | 3,047 | -764 | -1,001 | 7.5 | 3.9 | 0.28 | 0.06 |
| 4 | 1,103 | 11,952 | 6,237 | 521 | 86 | 10,849 | 5,134 | -582 | -1,017 | 10.8 | 5.7 | 0.47 | 0.08 |
| 5 | 1,117 | 13,103 | 6,843 | 584 | 90 | 11,986 | 5,726 | -533 | -1,027 | 11.7 | 6.1 | 0.52 | 0.08 |
| **Lower estimates, with rolling forward** | | | | | | | | | | | | | |
| 1 | 42 | 3,820 | 2,023 | 225 | 32 | 3,777 | 1,980 | 183 | -10 | 90.0 | 47.6 | 5.31 | 0.76 |
| 2 | 57 | 8,254 | 4,366 | 478 | 61 | 8,198 | 4,310 | 422 | 4 | 145.8 | 77.1 | 8.45 | 1.07 |
| 3 | 1,061 | 8,531 | 4,424 | 316 | 61 | 7,471 | 3,363 | -744 | -999 | 8.0 | 4.2 | 0.30 | 0.06 |
| 4 | 1,103 | 12,878 | 6,718 | 558 | 89 | 11,775 | 5,615 | -545 | -1,014 | 11.7 | 6.1 | 0.51 | 0.08 |
| 5 | 1,117 | 14,119 | 7,372 | 625 | 93 | 13,002 | 6,255 | -492 | -1,024 | 12.6 | 6.6 | 0.56 | 0.08 |




Note: The area of the circles is proportional to the present value of the benefits or costs at a 6% discount rate

**Dover Beck Option 5**
**Present Value of Benefits and Costs**
**Figure 4.2**

**Table 4.10 Assessment of Tangibles (£000 Q4 1997)**

| Option | Agency Costs | Water Co. Costs | Economic Benefit | Net Present Value | Benefit Cost Ratio |
|---|---|---|---|---|---|
| 6% discount rate, 50 year time period | | | | | |
| **Do Nothing** | 0 | 0 | 0 | 0 | 0 |
| **Option 1** | 42 | 0 | 2,620 | 2,578 | 62 |
| **Option 2** | 57 | 0 | 5,623 | 5,566 | 99 |
| **Option 3** | 0 | 1061 | 5,698 | 4,637 | 5.4 |
| **Option 4** | 42 | 1061 | 8,637 | 7,534 | 7.8 |
| **Option 5** | 57 | 1061 | 9,461 | 8,344 | 8.5 |
| 7% discount rate, 30 year time period | | | | | |
| **Do Nothing** | 0 | 0 | 0 | 0 | 0 |
| **Option 1** | 42 | 0 | 2,049 | 2,007 | 49 |
| **Option 2** | 56 | 0 | 4,388 | 4,332 | 78 |
| **Option 3** | 0 | 986 | 4,458 | 3,471 | 4.5 |
| **Option 4** | 42 | 986 | 6,748 | 5,719 | 6.6 |
| **Option 5** | 56 | 986 | 7,385 | 6,343 | 7.1 |

## 4.6 Assessment of Intangibles

The assessment of intangible benefits (or disbenefits) has been undertaken by a weighting and scoring system and is presented in Table 4.11. The intangibles considered in the table are:

1. Facilitation of Agency meeting objectives
2. Improved public relations and maintenance of credibility of Agency
3. Longer term benefits not quantified in economic analysis

Each of the intangible benefits has been allocated a weighting within the range from 5 to 0 (from most important to least important). Scores reflecting the ability of each option to deliver the intangible benefit have been allocated from 5 to 0 (from greatest ability to least ability).

## 4.7 Risk Assessment

A risk assessment of the options has been undertaken and the results tabulated in a "Risk Register" (Table 4.12). The risks considered to be relevant in the appraisal are:

Risk 1 Operational failure of flow alleviation
Risk 2 Failure to provide anticipated benefits
Risk 3 Failure to supply a sustainable solution

Within the Risk Register the likelihood of the risk happening, and the consequent effect on the solution, are classified as "high", "medium" or "low".

**Table 4.11** **Assessment of Intangible Benefits**

| Intangible Benefit | Weighting Factor | Option 1 1 Ml/d below Oxton Bogs | | Option 2 2.5 Ml/d below Oxton Bogs | | Option 3 1 Ml/d release to Oxton Dumble | | Option 4 Options 1 + 3 | | Option 5 Options 2 + 3 | | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | points | weighted points | points | weighted points | points | weighted points | points | weighted points | points | weighted points | |
| 1 | 3 | 3 | 9 | 3 | 9 | 2 | 6 | 4 | 12 | 5 | 15 | |
| 2 | 3 | 3 | 9 | 3 | 9 | 3 | 9 | 5 | 15 | 5 | 15 | |
| 3 | 3 | 2 | 6 | 4 | 12 | 2 | 6 | 3 | 9 | 5 | 15 | STW effluent dilution and enhanced flows at fish farm downstream |
| Total weighted score | | | 24 | | 30 | | 21 | | 36 | | 45 | |

Intangible Benefit 1: Facilitation of Agency meeting objectives
Intangible Benefit 2: Improved public relations and maintenance of credibility of Agency
Intangible Benefit 3: Longer term benefits not quantified in economic analysis

**Table 4.12** **Risk Register**

| Identified Risk | Option 1 1 Ml/d below Oxton Bogs | | Option 2 2.5 Ml/d below Oxton Bogs | | Option 3 1 Ml/d release to Oxton Dumble | | Option 4 Options 1 + 3 | | Option 5 Options 2 + 3 | | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Likelihood | Effect | Likelihood | Effect | Likelihood | Effect | Likelihood | Effect | Likelihood | Effect | |
| Operational failure of flow alleviation | L | L | M | M | L | L | L | L | M | M | |
| Failure to provide anticipated benefits | L | M | M | M | M | M | M | M | M | M | |
| Failure to supply a sustainable solution | L | L | L | L | M | M | M | M | M | M | In the long term, reductions in groundwater abstractions will provide a sustainable solution |

Relative risks: H high M medium L low

## 4.8 Selection of Preferred Option

From the assessment of tangibles presented in Table 4.10 it can be seen that Option 5 represents the most cost effective solution in terms of maximum net present value (NPV). This conclusion is supported by the assessment of intangibles in Table 4.11.

Although the risk register presented in Table 4.12 suggests that Option 5, a combination of the options with maximum impact on low flows, may have slightly higher risks than some of the other options, these risks will be mitigated by further investigations before implementation. Monitoring of the flows will be undertaken to confirm the leakage lengths along the affected watercourses. Also, further refinement of the control rules for triggering compensation releases will be undertaken following the initial operation of the scheme.

**It is therefore concluded that Option 5, comprising extended sealing of the bed of the Dover Beck below Oxton Bogs and a compensation release of 1 Ml/d from a new borehole on the Oxton Dumble, should be selected as the preferred option.**

The proposed remedial measures will re-water 6 km of the Dover Beck and the Oxton Dumble as well as significantly increasing the flow in a further 8 km down to the River Trent.

In the longer term, with reduced groundwater abstractions, rising groundwater levels should restore some baseflow to these watercourses, with a subsequent reduction in the requirements for compensation releases.

The re-instatement and increase of flows should improve the continuity of the linear wildlife habitat which is currently incomplete due to the negligible flows within the river reaches for several months of the year.

The assessed economic benefit takes account of these ecological improvements in addition to the increase in the amenity and recreational value of the area surrounding the watercourses.

Increases in flows further downstream could also result in some improvement to water quality as a result of better dilution of the effluent from the Calverton sewage treatment works.

## 4.9 Tasks and Dependencies

| | |
|---|---|
| Investigations: | Agency Midlands Region, Lower Trent Area |
| Design and Implementation: | Agency Midlands Region, Lower Trent Area<br>Agency Midlands Region, Regional Office<br>Severn Trent Water Ltd |

**Programme for implementation of the preferred option:**

| | |
|---|---|
| 1998 | Submission of Business Plan |
| 1999 | Investigation and Design<br>Planning and Consents |
| 2000 | Construction Part 1 (bed lining) |
| 2001 | Construction Part 2 (new borehole) |

## 4.10 Cost of Preferred Option

The estimated capital and operating costs of the preferred option are given in Table 4.13. The estimates of likely future capital costs are based on the assumption that the Construction Output Index (COPI) will rise by 4 per cent per annum. In the estimation of operating costs an annual increase of 2.5 per cent per annum in the Retail Price Index (RPI) has been assumed.

**Table 4.13 Estimated Costs of the Preferred Option (£ 000)**

| Year | Water Company | | Agency | |
|---|---|---|---|---|
| ending 31/03 | Capex | Opex | Capex | Opex |
| 1999 | 0 | 0 | 4[1] | 0 |
| 2000 | 0 | 0 | 0 | 0 |
| 2001 | 0 | 0 | 67[2] | 0 |
| 2002 | 948 | 12 | 0 | 0 |
| 2003 | 0 | 12 | 0 | 0 |

1 comprises submission of business plan, the cost of which has not been included in the assessment of tangibles
2 Agency costs for bed lining to be recharged to STW Ltd under AMP3

# 5 RIVER NOE AND RIVER ASHOP

## 5.1 Scheme Objectives

Both the River Noe and the River Ashop are diverted to the Derwent Valley Reservoirs with very little flow finding its way into the river channels below the points of diversion, which are indicated on Figure 5.1. On the River Noe there is a weir 2 km upstream of its confluence with Jaggers Clough and all water except at high flows is diverted by aqueduct to the reservoir system. To compensate for this loss, a flow of 17 Ml/d is discharged from the aqueduct into Jaggers Clough. This results in an unsightly dry river channel for 2 km of the River Noe. To alleviate this situation the proposed scheme will allow a compensation flow of 10 or 15 Ml/d to remain in the River Noe.

It was initially considered that the compensation release at Jaggers Clough should be split between Jaggers Clough and the River Noe diversion. This has now been discounted. The water course below Jaggers Clough is producing a reliable fishery and should not be modified. Therefore it has been decided that the Ladybower Reservoir compensation release of 57 Ml/d should be considered for variation in order to allow the rewatering of the 2 km dry section of the River Noe. The options to be considered are releases of 10 and 15 Ml/d. This is expected to improve the visual appearance of the river as well as providing an additional salmonid fishery.

On the River Ashop the diversion weir is just downstream of the confluence of the River Alport, some 3 km upstream of Ladybower Reservoir. Little water proceeds down the natural river channel, the majority of it being diverted by tunnel to the Derwent Reservoir. This results in a dry river bed for 3 km. The low flow alleviation scheme currently being considered would involve allowing some flow down the Ashop in order to allow the rewatering of the 3 km dry section of the river. There is currently no compensation requirement at the abstraction point from the River Ashop to the Derwent Reservoir. The options to be considered (as for the River Noe) are releases of 10 and 15 Ml/d. This will enable the River Ashop to be brought back as a salmonid fishery and enhance the appearance of the river.

For this assessment the modifications to be considered are:

- Option 1 — Compensation release from Ladybower Reservoir (Yorkshire Bridge) 47 Ml/d
  Compensation release at River Noe diversion 10 Ml/d
  Compensation release at River Ashop diversion 10 Ml/d

- Option 2 — Compensation release from Ladybower Reservoir (Yorkshire Bridge) 42 Ml/d
  Compensation release at River Noe diversion 15 Ml/d
  Compensation release at River Ashop diversion 15 Ml/d

Information provided by the Agency is given in Appendix 5. In the absence of further information, both in relation to the existing and naturalised flow regime and the impact of the proposed changes on the quality of fishery expected to be created, it has not been possible to distinguish benefits between the two options.

A PHABSIM investigation has recently been undertaken by the Agency to provide further information, although the results were not available in time for this analysis.

Final details of the compensation release facilities and associated fish passes at the existing weirs, including possible seasonal variations in the pattern of releases, are being investigated by the Agency and Severn Trent Water Limited.

## 5.2 Scope of Study

Table 5.1 has been used as a checklist to focus on those impacts which are likely to be significant and need to be included in the economic appraisal.

**Table 5.1 Checklist of Impacts**

| **Impact Category** | | **Comments** |
|---|---|---|
| Drinking Water Supply | | Not applicable |
| Industrial Abstraction | | Not applicable |
| Agriculture | Livestock | Not applicable |
| | Irrigation | Not applicable |
| In stream recreation | Boating | Not applicable |
| | Bathing | Not applicable |
| | Angling | Yes |
| Informal recreation | Walking, picnicking, photography | Yes |
| Amenity /Aesthetics | Property Prices | No |
| Conservation (Non-Use or Passive Use) | Ecology | Yes |
| | Heritage | Not applicable |
| Other | | Not applicable |

A schematic diagram of the river system is shown in Figure 5.1. The two lengths of dry river bed have been aggregated to a single 5 km reach for the purpose of the economic assessment; specifically these two lengths are:

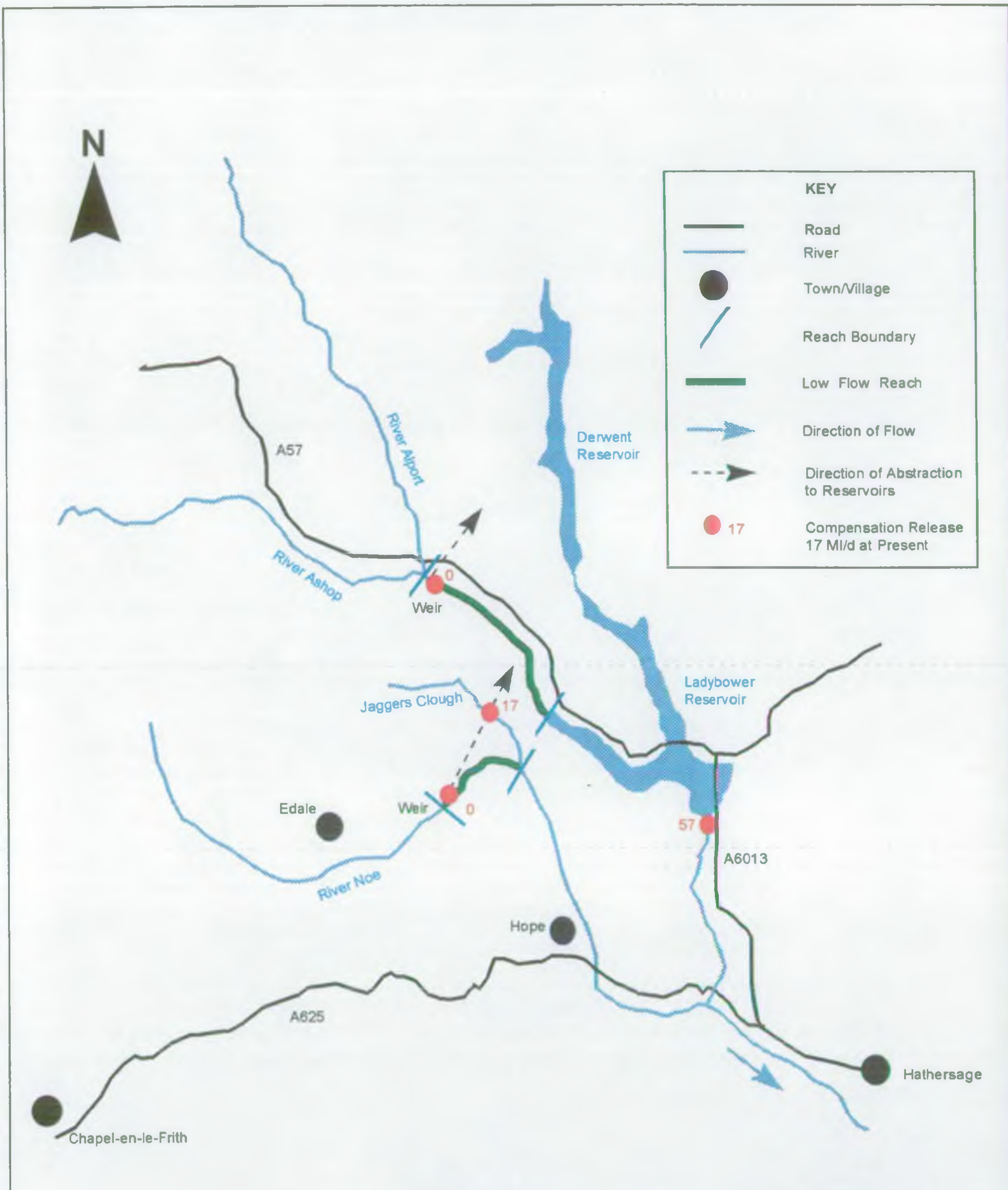
- River Noe from SK 147 858 to the confluence with Jaggers Clough at SK 162 863 (2 km); and
- River Ashop from SK 141 895 to the point where it enters Ladybower Reservoir at SK 164 878 (3 km).

These lengths of the Noe and the Ashop are included for angling purposes within longer reaches designated by the Agency, namely:

- River Noe: SK 123 851 to SK 175832; and
- River Ashop: SK 109 915 to SK 141 895.

Both of these longer reaches are classified as RE1 and the River Noe is a designated salmonid fishery. This suggests that if water is allowed to flow through the low flow reaches a viable fishery could be created.

A site visit (23 January 1998) and discussions with Agency staff suggest that currently there is no expectation of a flow of water in the river channels of the low flow reaches. Consequently there are no abstractions and virtually no agricultural uses except the occasional *ad hoc* watering of stock when overflow from the weirs allows it. There is no property on the reaches. The benefits would therefore be derived by creating a fishery potential and gaining some




0 2 4 6 km

Scale 1: 100 000

Environment Agency

GIBB Ltd
Consulting Engineers
Reading England

Figure 5.1: Schematic of River Noe and River Ashop Low Flow Alleviation Scheme

AMP 3 Benefits Assessment

| SCALE 1:100 000 | DATE April 1998 | J98032A |
|---|---|---|

informal recreational benefit by making the areas more aesthetically pleasing and therefore attracting walkers and visitors to the areas. Despite being part of the Peak District National Park neither of these two locations currently attracts many visitors.

Therefore the uses that have been included in the appraisal are:

- informal recreation;
- angling; and
- non use.

## 5.3 Capital and Operating Costs

Severn Trent Water Ltd has provided the Agency with estimates of the capital expenditure (capex) necessary to provide modifications to the existing weirs, including compensation release facilities and fish passes. No change in existing operating expenditure (opex) is envisaged. In addition, the Agency has provided details of costs of the PHABSIM study. Details of the costs are summarised in Table 5.2.

**Table 5.2 Summary of Cost Estimates (£ 000 Q4 1997)**

<table>
<tr><th></th><th>River Noe</th><th>River Ashop</th></tr>
<tr><td>Capital expenditure</td><td></td><td></td></tr>
<tr><td>Modifications to existing weirs, including compensation release facilities and fish passes</td><td>100</td><td>100</td></tr>
<tr><td>- PHABSIM study (Agency costs)</td><td colspan="2">41</td></tr>
<tr><td>Operating expenditure (per annum)</td><td>no extra cost</td><td>no extra cost</td></tr>
</table>

## 5.4 Estimation of Benefits

### 5.4.1 Informal Recreation

During 1994 this area of the Peak District National Park (Kinder and the High Peak Fringe) attracted only 5% of day trip visitors and 13% of holiday makers (1994 All Parks Visitor Survey: The Peak National Park). The 1986/87 visitor survey identified 1,240,000 people as visiting the Upper Derwent and Woodlands Valleys and 250,000 as visiting the Vale of Edale. These are the areas which contain the dry river reaches.

The figures suggest that the visitor potential for these reaches is good, while the site visit suggested that other parts of these areas are currently visited in preference as the dry river channels do not present attractive locations for walking or picnicking. It is envisaged that informal recreation would take place more readily on the River Ashop as it is more accessible and there are footpaths nearby. The River Noe is less accessible and does not currently have a network of footpaths although it is on National Trust Land with the viewpoints of Hollins Cross and Lose Hill nearby.

Use of the Low Flow Guidelines to ascertain the numbers of visitors to the sites is unlikely to provide an accurate assessment. The sites fit into neither the honeypot nor the local park descriptions. They will attract fewer visitors than honeypot sites and are more similar to local parks in the context of the guidelines but, unlike local parks, these sites are likely to attract visitors from further afield as they lie within the National Park. Both sites lie close to major roads and other visitor attractions. The River Noe in the Vale of Edale is close to National Trust land off the A625. Based on experience, in view of the lack of data and inappropriateness in this case of the procedures given in the Guidelines it is assumed that the potential number of visitors would be within the range of 2,500 to 7,500 per annum. The uncertainty associated with these estimates is reflected in the wide range.

As the informal recreational activities are unpriced there is no economic rent or profit earned by the activity. The total value of the recreational activity is measured in consumer surplus or the difference between what the consumer pays for the activity (zero) and what they would be willing to pay. The Guidelines recommend the following per visit estimates of the consumer surplus, assuming that 40% of the willingness-to-pay is attributable to the presence of water:

- Upper bound estimate: £1.48 per visitor day;
- Central estimate: £0.60 per visitor day; and
- Lower bound estimate: £0.20 per visitor day.

The impact of the options on the frequency of low flows has not been provided by the Agency. For the purpose of this analysis it has been assumed that future low flows would be avoided by both options and that the benefit would apply to all trips.

Combining this assumption with the willingness-to-pay values and participation rates generates annual informal recreation benefits of between £500 and £11,100 for the scheme as shown in Table 5.3.

**Table 5.3 Annual Informal Recreation Benefits**

| | Visitor Numbers | £000 Q4 1997 |
|---|---|---|
| **Upper bound** | 2,500 | 11.1 |
| **Central estimate** | 5,000 | 3.0 |
| **Lower bound** | 7,500 | 0.5 |

### 5.4.2 Angling

The natural brown trout populations in the Noe and the Ashop suffer from the low flows associated with the operation of the reservoir system (Derbyshire Derwent LEAP 3.6). The Agency expects that the proposed investment will allow the fish population to spread and become more secure. This will not only require a change in the regime of water release but also the construction of fish passes in the weirs on the Noe and Ashop to allow the migration of trout populations.

Currently there is no angling on these low flow reaches as there are negligible quantities of water flowing down them. It is hoped that the "with project" scenario of allowing some flow down the river channels and creating fish passes will create a viable trout fishery.

The River Noe is currently fished by the Peak Forest Angling Club (PFAC), whilst the Ashop has no angling interests. Discussions with the PFAC have provided primary data concerning the number of anglers active in the area. They have exclusive rights to the Noe with a bailiff on site and there is a membership of 30. The river is stocked below the confluence with Jaggers Clough; few fish find their way above the railway/road bridge at SK167858, 2 km north of Hope village. Therefore the trout in the upper parts of the Noe are wild stock and it is these which would be expected to migrate into the new areas. However the fishing is considered of good quality by those who fish it. The alleviation of the low flow in this section of the Noe would result in the creation of 2 km of new trout fishery.

The Low Flow Benefit Assessment Guidelines suggest anglers willingness-to-pay values for the creation of new trout fisheries, depending on their quality, as follows:

- Good: £16.28/person/trip
- Moderate: £10.39/person/trip
- Poor: £8.92/person/trip

The Manual also provides figures for the number of trips made per angler per year to new fisheries:

**Table 5.4 Estimates of the number of trips/angler/year to new fisheries.**

| From | To | Number |
|---|---|---|
| No Fishery | Poor Trout Fishery | 3.02 trips/person/year |
| No Fishery | Moderate Trout Fishery | 13.02 trips/person/year |
| No Fishery | Good Trout Fishery | 10.98 trips/person/year |

The quality of the fishery below the bridge is considered to be good but this is artificially stocked. The rest of the fishery below Jaggers Clough relies on wild stocks and is of moderate quality. Therefore the central estimate for the benefit of relieving the low flows in the dry reaches of the rivers is based on the creation of a moderate trout fishery.

However there remain some uncertainties. These include habitat queries and the lack of access to a large proportion of the river banks.

Engineering works may be required to provide the necessary wetted perimeter for trout in the newly watered river channels. This may cost a significant sum and negate any benefits gained from the few kilometres of fishing created. As there is currently no water flowing in the river channels there are no fish stocks. If the proposed fish passes fail to encourage the natural stocks to migrate, a further outlay would be required to stock the river to a suitable level to attract fishermen from the alternative sites in the vicinity.

On the River Noe there is no network of footpaths to provide access for the fishermen who may be attracted to the site. Although there is better access to the Ashop it is still not adequate to provide complete access to the whole 3 km reach.

It is therefore considered that the most realistic way to estimate the likely number of anglers who will be attracted to the new sites (which will include the reaches upstream of the existing weirs) is to assume that new fisheries will be created on each river with a similar number of members as the existing membership of the PFAC.

Combining the total of 60 new anglers with the number of trips per angler provides an estimate of the potential economic value to be derived based on the willingness-to-pay figures given above. These are summarised in Table 5.5.

**Table 5.5 Annual Angling Benefits**

| Quality of Fishery | Annual Benefit (£000 Q4 1997) |
|---|---|
| Upper bound (good) | 10.6 |
| Central estimate (moderate) | 8.1 |
| Lower bound (poor) | 1.6 |

It may be noted that similar benefits can be derived using the indirect approach given in the Manual, based on Agency estimates for rod licence sales of about 8000 within a 17 km radius of the site, assuming 20% of these are trout anglers and allowing for an overall increase in angling visits of about 5% due to the prevalence of substitute sites.

### 5.4.3 Conservation/Non Use

Non-use (conservation) benefit estimates for the Rivers Noe and Ashop have been derived for:

- local residents within 3 km;
- river users among the general public who do not visit these particular rivers but do hold non-use values towards the alleviation of low flows in rivers; and
- the wider general public who are not river users.

The non-use benefits have been derived using the procedures given in Section 9 of the Benefit Assessment Guidelines.

**Local resident non-use valuation**

It has been assumed that there are about 700 households within 3 km of the low flow sites, based on population data obtained from the Agency GIS model and assuming 2.7 people/household:

In accordance with the Guidelines, the following values per household per annum are applied where full low flow alleviation is achieved:

| | |
|---|---|
| Upper Bound | £12.00 |
| Central Estimate | £10.00 |
| Lower Bound | £ 7.00 |

**General public non-use valuation**

It is assumed that there are 3.15 million households within Severn Trent Water's area and that 45% of the population are general river users, from which the actual number of local households already included are subtracted. The remaining 55% of the population in the service area are taken as non-users for whom a lower scale of benefits applies. The central estimates are based on the figures of £0.05 and £0.03 per household per km of river per annum for full low flow alleviation in accordance with the Guidelines, with +/- 25% for upper and lower bounds.

The annual non-use (conservation) benefits are summarised in Table 5.6 in terms of the local resident non-use benefits and the full (local resident plus general public non-use) benefits.

**Table 5.6 Annual Non-Use Benefits (£000 Q4 1997)**

| Extent | Upper | Central | Lower |
|---|---|---|---|
| Local | 8 | 7 | 5 |
| Full | 776 | 621 | 465 |

## 5.5 Assessment of Tangibles (Cost Benefit Analysis)

The costs and the annual benefit streams have been aggregated in terms of present values in accordance with the procedures given in the Benefit Assessment Guidelines. The indicators in terms of net present values (NPV) and benefit cost ratios for the two options are presented in Table 5.7. The results are shown:

- both including and excluding non-use, together with intermediate figures: one including only 50% of the general public (i.e. non-local) non-use and the other including only local non-use;
- for the central estimates, with upper and lower bounds;
- using the different discount rates and time horizons; and
- with and without rolling forward the benefits.

The overall results are highly sensitive to the assumptions regarding non-use benefits, with benefit cost ratios in the range 24 to over 50 when the full non-use benefits are included. If only the local non-use benefits are included, the benefit cost ratio reduces to the range 0.9 to 1.3 with the central estimates.

It should be noted that no disbenefit has been evaluated for the reduction from 57 to 47 Ml/d in the 4 km of river downstream of Ladybower Reservoir.

A summary of the assessment of tangibles (i.e. the quantifiable costs and benefits) is presented in Table 5.8. For this analysis, which has been carried forward to the Summary Business Case, the economic benefit has been determined on the following basis:

- including 50% of the general public (i.e. non-local) non-use benefits
- central estimates without rolling forward of the benefits.

A breakdown of the total present value of the benefits by use category (central estimates, including 50% of the non-local non-use benefits) with the 6% Treasury discount rate, with no rolling forward, is shown on Figure 5.2, together with a breakdown of the present value of the costs.

**Table 5.7 (Sheet 1)** **River Noe and River Ashop : Summary of Costs and Benefits**

**(£ 000 Q4 1997 expressed as present values)**

| Option | Costs | Benefits | | | | Total NPV | | | | Benefit Cost Ratio | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 7% Discount Rate, 30 year time period | | | | | | | | | | | |
| | | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use |
| **Upper estimates, no rolling forward** | | | | | | | | | | | | | |
| 1 / 2 | 225 | 9,153 | 4,750 | 346 | 249 | 8,928 | 4,524 | 120 | 24 | 40.6 | 21.1 | 1.53 | 1.11 |
| **Upper estimates, with rolling forward** | | | | | | | | | | | | | |
| 1 / 2 | 225 | 9,655 | 5,010 | 365 | 263 | 9,429 | 4,784 | 139 | 38 | 42.9 | 22.2 | 1.62 | 1.17 |
| **Central estimates, no rolling forward** | | | | | | | | | | | | | |
| 1 / 2 | 225 | 7,254 | 3,731 | 208 | 128 | 7,029 | 3,506 | -17 | -98 | 32.2 | 16.6 | 0.92 | 0.57 |
| **Central estimates, with rolling forward** | | | | | | | | | | | | | |
| 1 / 2 | 225 | 7,651 | 3,935 | 219 | 135 | 7,426 | 3,710 | -6 | -91 | 34.0 | 17.5 | 0.97 | 0.60 |
| **Lower estimates, no rolling forward** | | | | | | | | | | | | | |
| 1 / 2 | 225 | 5,365 | 2,723 | 80 | 24 | 5,140 | 2,498 | -145 | -201 | 23.8 | 12.1 | 0.36 | 0.11 |
| **Lower estimates, with rolling forward** | | | | | | | | | | | | | |
| 1 / 2 | 225 | 5,659 | 2,872 | 85 | 26 | 5,434 | 2,647 | -140 | -200 | 25.1 | 12.8 | 0.38 | 0.11 |

Table 5.7 (Sheet 2) **River Noe and River Ashop : Summary of Costs and Benefits**
**(£ 000 Q4 1997 expressed as present values)**

| Option | 6% Discount Rate, 50 year time period | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Costs | Benefits | | | | Total NPV | | | | Benefit Cost Ratio | | | |
| | | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use |
| Upper estimates, no rolling forward | | | | | | | | | | | | | |
| 1 / 2 | 227 | 11,821 | 6,134 | 446 | 322 | 11,594 | 5,906 | 219 | 95 | 52.0 | 27.0 | 1.96 | 1.42 |
| Upper estimates, with rolling forward | | | | | | | | | | | | | |
| 1 / 2 | 227 | 12,741 | 6,611 | 481 | 347 | 12,514 | 6,384 | 254 | 120 | 56.0 | 29.1 | 2.12 | 1.53 |
| Central estimates, no rolling forward | | | | | | | | | | | | | |
| 1 / 2 | 227 | 9,368 | 4,818 | 268 | 165 | 9,141 | 4,591 | 41 | -63 | 41.2 | 21.2 | 1.18 | 0.72 |
| Central estimates, with rolling forward | | | | | | | | | | | | | |
| 1 / 2 | 227 | 10,097 | 5,193 | 289 | 178 | 9,870 | 4,966 | 62 | -50 | 44.4 | 22.8 | 1.27 | 0.78 |
| Lower estimates, no rolling forward | | | | | | | | | | | | | |
| 1 / 2 | 227 | 6,929 | 3,516 | 104 | 31 | 6,701 | 3,289 | -123 | -196 | 30.5 | 15.5 | 0.46 | 0.14 |
| Lower estimates, with rolling forward | | | | | | | | | | | | | |
| 1 / 2 | 227 | 7,468 | 3,790 | 112 | 34 | 7,241 | 3,563 | -115 | -194 | 32.8 | 16.7 | 0.49 | 0.15 |

**Table 5.8 Assessment of Tangibles (£000 Q4 1997)**

| Option | Agency Costs | Water Co. Costs | Economic Benefit | Net Present Value | Benefit Cost Ratio |
|---|---|---|---|---|---|
| 6% discount rate, 50 year time period | | | | | |
| **Do Nothing** | 0 | 0 | 0 | 0 | 0 |
| **Option 1** | 39 | 189 | 4,818 | 4,591 | 21.2 |
| **Option 2** | 39 | 189 | 4,818 | 4,591 | 21.2 |
| 7% discount rate, 30 year time period | | | | | |
| **Do Nothing** | 0 | 0 | 0 | 0 | 0 |
| **Option 1** | 38 | 187 | 3,731 | 3,506 | 16.6 |
| **Option 2** | 38 | 187 | 3,731 | 3,506 | 16.6 |

## 5.6 Assessment of Intangibles

The assessment of intangible benefits (or disbenefits) has been undertaken by a weighting and scoring system and is presented in Table 5.9. The intangibles considered in the table are:

1. Facilitation of Agency meeting objectives
2. Improved public relations and maintenance of credibility of Agency
3. Longer term benefits not quantified in economic analysis

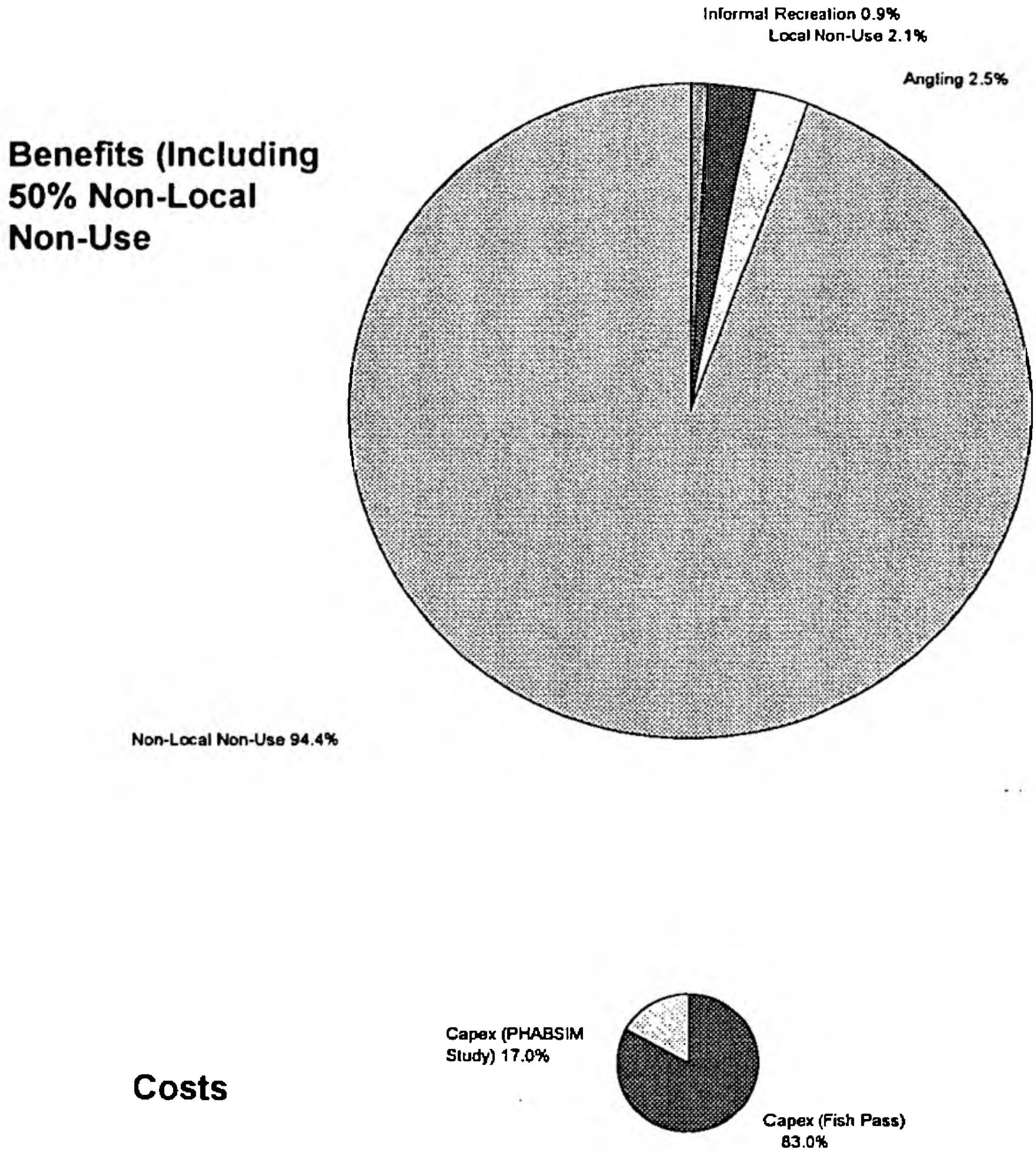
Each of the intangible benefits has been allocated a weighting within the range from 5 to 0 (from most important to least important). Scores reflecting the ability of each option to deliver the intangible benefit have been allocated from 5 to 0 (from greatest ability to least ability).

## 5.7 Risk Assessment

A risk assessment of the options has been undertaken and the results tabulated in a "Risk Register" (Table 5.10). The risks considered to be relevant in the appraisal are:

| | |
|---|---|
| Risk 1 | Operational failure of flow alleviation |
| Risk 2 | Failure to provide anticipated benefits |
| Risk 3 | Failure to supply a sustainable solution |

Within the Risk Register the likelihood of the risk happening, and the consequent effect on the solution, are classified as "high", "medium" or "low".




Note: The area of the circles is proportional to the present value of the benefits or costs at a 6% discount rate

**River Noe and River Ashop Option 1/2**
**Present Value of Benefits and Costs**
**Figure 5.2**

**Table 5.9 Assessment of Intangible Benefits**

| Intangible Benefit | Weighting Factor | Option 1 10 Ml/d releases | | Option 2 15 Ml/d releases | | Comment |
|---|---|---|---|---|---|---|
| | | points | weighted points | points | weighted points | |
| 1 | 3 | 3 | 9 | 4 | 12 | Greater flow will facilitate meeting objectives |
| 2 | 3 | 4 | 12 | 4 | 12 | |
| 3 | 3 | | | | | Not applicable |
| Total weighted score | | | 21 | | 24 | |

Intangible Benefit 1: Facilitation of Agency meeting objectives
Intangible Benefit 2: Improved public relations and maintenance of credibility of Agency
Intangible Benefit 3: Longer term benefits not quantified in economic analysis

**Table 5.10 Risk Register**

| Identified Risk | Option 1 10 Ml/d releases | | Option 2 15 Ml/d releases | | Comment |
|---|---|---|---|---|---|
| | Likelihood | Effect | Likelihood | Effect | |
| Operational failure of flow alleviation | L | L | L | L | |
| Failure to provide anticipated benefits | L | M | L | M | |
| Failure to supply a sustainable solution | L | L | L | L | |

Relative risks:
H high
M medium
L low

## 5.8 Selection of Preferred Option

As noted in Section 5.1, it has not been possible to differentiate the tangible benefits between the two levels of compensation releases considered - i.e. 10 Ml/d with Option 1 and 15 Ml/d with Option 2. However, as indicated in the assessment of intangibles presented in Table 5.9, it is considered that the higher compensation releases with Option 2 will facilitate the Agency meeting its objectives to a greater extent than Option 1.

**It is therefore concluded that Option 2, with compensation releases of 15 Ml/d at each of the two existing weirs, should be selected as the preferred option.**

Some 2 km of the River Noe and 3 km of the River Ashop will be re-watered.

The re-instatement of flows through the low flow reaches on both the Noe and the Ashop will improve the continuity of the linear wildlife habitat which is currently interrupted by the negligible flows within the river reaches at present.

The water flowing above and below the current diversion points is of the highest water quality classification (RE1) which supports populations of brown trout. Increasing the flow within the dry sections should allow the creation of a viable fishery with both economic and ecological benefits. The provision of fish passes should allow the new fishery to extend to the reaches upstream of the existing weirs.

The popularity of the Peak District National Park means that there are large numbers of visitors. This area of the Park does not reach its full potential due to the unsightly nature of the dry reaches. With improved flows more people will visit these areas, providing more income for local services and relieving pressure on more traditionally popular areas within the Park.

Local farmers will benefit by being able to water their stock on an *ad hoc* basis in the reaches with an increased flow.

## 5.9 Tasks and Dependencies

| | |
|---|---|
| Investigations: | Agency Midlands Region, Lower Trent Area and Regional Office |
| Design and implementation: | Severn Trent Water Ltd. |

**Programme for implementation of preferred option:**

| | |
|---|---|
| 1998 | Submission of Business Plan<br>PHABSIM Investigation |
| 1999 | Investigation and Design<br>Planning and Consents |
| 2000/2001 | Construction |

## 5.10 Cost of Preferred Option

The estimated capital and operating costs of the preferred option are given in Table 5.11. The estimates of likely future capital costs are based on the assumption that the Construction Output Index (COPI) will rise by 4 per cent per annum. In the estimation of operating costs an annual increase of 2.5 per cent per annum in the Retail Price Index (RPI) has been assumed.

**Table 5.11 Estimated Costs of the Preferred Option (£ 000)**

| Year | Water Company | | Agency | |
|---|---|---|---|---|
| ending 31/03 | Capex | Opex | Capex | Opex |
| 1999 | 0 | 0 | 45[1] | 0 |
| 2000 | 0 | 0 | 0 | 0 |
| 2001 | 225 | 0 | 0 | 0 |
| 2002 | 0 | 0 | 0 | 0 |
| 2003 | 0 | 0 | 0 | 0 |

[1] includes submission of business plan, the cost of which has not been included in the assessment of tangibles

# 6 RAINWORTH WATER

## 6.1 Scheme Objectives

The reach of the river known as Rainworth Water which is considered under this Low Flow Alleviation Scheme runs from L Lake (SK585583) to Rufford Country Park (SK647650), a total length of some 12 km as shown on Figure 6.1. The Rainworth Water scheme is driven by the need to ensure the SSSI wetland habitat at L Lake (SK585583) remains watered. English Nature has designated L Lake as a Wetland Site of Special Scientific Interest. It is thought that L Lake itself is supported by a perched water table within the Sherwood Sandstones, but the woodland adjacent to the outfall stream could be affected by abstraction from groundwater for public water supply.

The existing flow in Rainworth Water comes from a number of sources:

- Overspill from L Lake which is limited to wet weather conditions;
- Discharge from Rainworth STW (highly variable, between 0.5 and 4 Ml/day);
- Discharge from Bilsthorpe STW; and
- Flow from Gallowshole Dyke (at SK646649).

There are several problems concerning the site which are the result of fissuring and subsidence caused by coal mining. In the recent past there have been occasions on which no flow has reached Rufford Country Park as fissures have opened up and intercepted the entire flow of Rainworth Water. British Coal accepted responsibility for this in the past and the Coal Authority has undertaken work to put the problems right when they occur.

Similarly, subsidence caused the appearance of a lake on Rainworth Water at Inkersall Farm. The Coal Authority again accepted responsibility and as the landowners wished to keep the lake as a feature they arranged to landscape it into the surrounding land and restored an outflow along Rainworth Water. However, three years later the lake started flooding the surrounding ground due to further subsidence and this has led to a reduction in outflow.

During a site visit with Agency staff on 22 January 1998 it was noticed that there was less flow in Rainworth Water at the confluence with Gallowshole Dyke than there was at L Lake, ~~11 km~~ upstream. This suggests a loss of water along the river either due to continuing mining-related problems or to excessive abstractions.

The Agency has put forward two schemes to be considered:

- Review Licence 70/3 and see if it would be practicable to reinstall a pump set at the existing borehole between L Lake and Rainworth;
- Install a new borehole upstream of L Lake on the northside tributary at SK579583.

Releases of either 1 or 2 Ml/d would be triggered by flows in Rainworth Water upstream of the confluence with Gallowshole Dyke. The two options, each with two sub-options, are summarised in Table 6.1.

Table 6.1 **Low Flow Alleviation Options**

| Option | Description | Improvements |
|---|---|---|
| 1a / 1b | Compensation release of 1 Ml/d (Option 1a) or 2 Ml/d (Option 1b) from a refurbished borehole | Rewater 1.7 km, significantly increased flows in 9 km. |
| 2a / 2b | Compensation release of 1 Ml/d (Option 2a) or 2 Ml/d (Option 2b) from a new borehole upstream of L Lake | Rewater 2.6 km, significantly increased flows in 9 km. |

A copy of the information provided by the Agency is provided in Appendix 6. Very little hydrological information is available. The limited information has been used to derive appropriate factors for the economic benefits of each option for those uses which are frequency and duration dependent. The river has been divided into two reaches for this purpose:

Reach 1 From L Lake (or the augmentation point in the case of Option 2) to the outfall from Rainworth STW at SK 598592 (1.7 km with Option 1 or 2.6 km with Option 2)

Reach 2 From the outfall from Rainworth STW to the confluence with the Gallowshole Dyke (9 km)

Target flows for each reach have been assessed to determine the extent to which the low flow alleviation schemes will improve the situation. Flow improvement factors have been derived from a consideration of both the **proportional flow** improvement from the existing situation at the nominal Q95% level, and the **proportional time** improvement that the target flow is achieved. With the very limited hydrological data available these estimates are only an approximation. Corresponding return periods for very low flows (i.e. about 50% of the target flows) have also been estimated for the before and after situations. The figures which have been derived are summarised in Table 6.2.

Table 6.2 **Summary of Hydrological Assessment for Rainworth Water**

| | **Reach 1** | **Reach 2** |
|---|---|---|
| **Target Flow (Ml/d)** | 1 | 2.5 |
| **% of Time above Target** | | |
| **Before** | approx 25% | approx 40% |
| **After** Option 1a, 2a | 95% | 70% |
| Option 1b, 2b | > 95% | 95% |
| **Flow Improvement Factor** | | |
| Option 1a, 2a | 100% | 40% |
| Option 1b, 2b | 100% | 80% |
| **Return Period (years)** before → after | | |
| Option 1a, 2a | 1 → 5 | 1 → 5 |
| Option 1b, 2b | 1 → 10 | 1 → 10 |

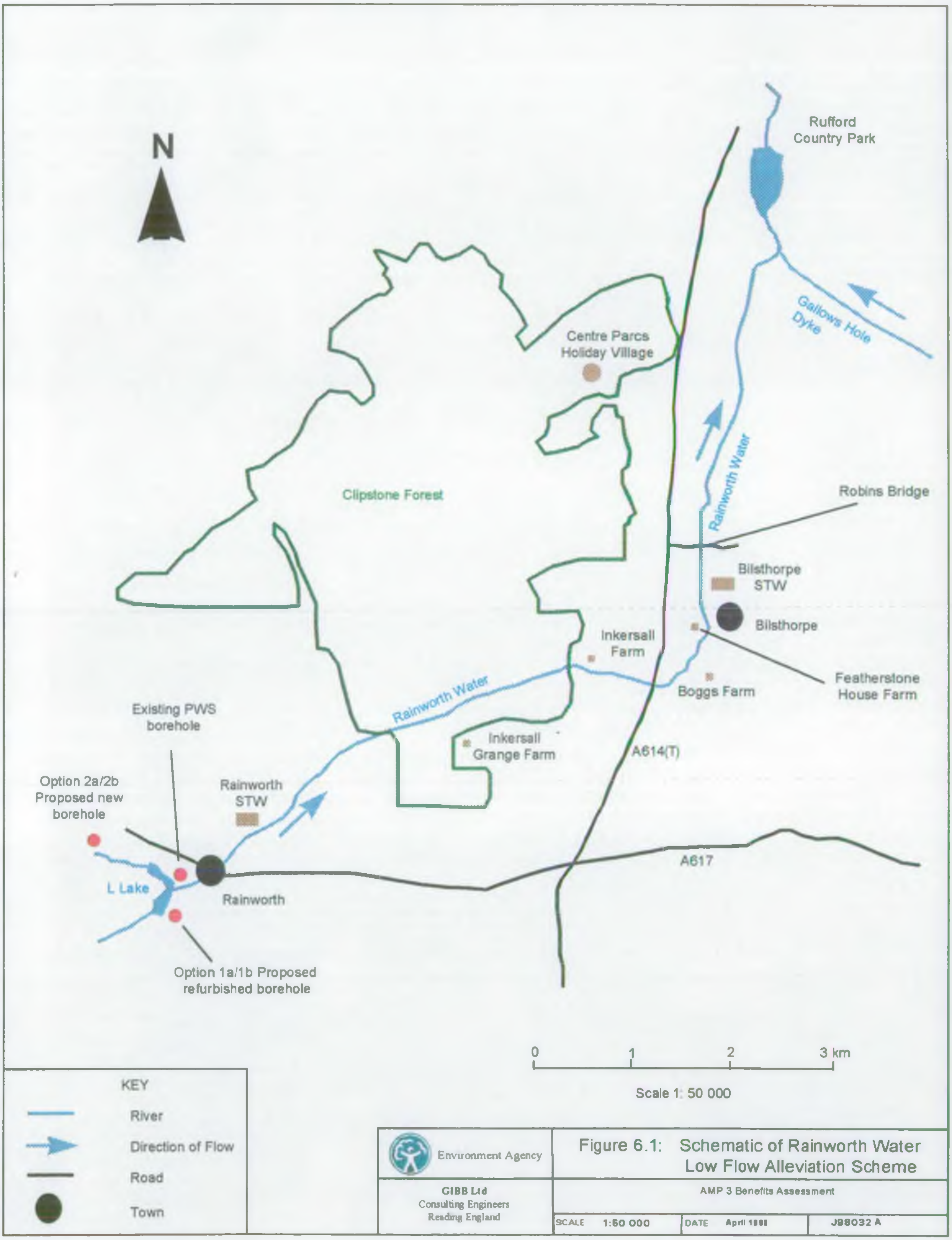



Figure 6.1: Schematic of Rainworth Water Low Flow Alleviation Scheme

In addition to the interim remedial measures indicated above, Water Company groundwater licences in the Nottinghamshire aquifer will reduce by a total of 25 Ml/d as result of existing licence conditions scheduled to take effect before the end of the AMP3 period. The Agency has also advised the Water Company that a further reduction totalling 40 Ml/d will be required over future AMP planning periods to bring groundwater abstractions from this aquifer down to a sustainable level. These proposals result from detailed hydrogeological modelling of the Nottinghamshire aquifer by the Agency. The Water Company has accepted these findings and the proposed cutbacks have been included in the Company's draft water resources plan. These reductions will benefit a wider area of Nottinghamshire, including the priority site on Dover Beck and Oxton Dumble, as well as assisting this local site.

## 6.2 Scope of Study

Table 6.3 has been used as a checklist to focus on those impacts which are likely to be significant and need to be included in the economic appraisal.

**Table 6.3 Summary of Impacts**

| Impact Category | | Comments |
|---|---|---|
| Drinking Water Supply | | Not applicable |
| Industrial Abstraction | | Not applicable |
| Agriculture | Livestock | No |
| | Irrigation | Intensively irrigated carrots, potatoes and sugar beet. Excellent soil for these types of crops. |
| In stream recreation | Boating | No |
| | Bathing | No |
| | Angling | At L Lake |
| Informal recreation | Walking, picnicking, photography | Major honeypot site at Rufford Country Park (Notts CC). Extensive public access to river. Centre Parcs nearby. |
| Amenity /Aesthetics | Property prices | Some properties adjacent to Rainworth Water. |
| Conservation (Non-Use or Passive Use) | Ecology | Yes |
| | Heritage | |
| Other | | |

Restoration of the flow will improve the continuity of the linear wildlife habitat of Rainworth Water, which at present is not complete due to the river periodically suffering extremely low flows.

The categories that have been included in the benefit assessment are:

- informal recreation;
- agriculture;
- angling;
- property; and
- non-use.

## 6.3 Capital and Operating Costs

Severn Trent Water Ltd has provided the Agency with estimates of the capital expenditure (capex) and operating expenditure (opex) necessary to provide for the replacement of 1 or 2 Ml/d of water currently abstracted at the Rainworth groundwater pumping station which, with Option 1, would be diverted to L Lake. In addition it is proposed that a pump should be installed in one of the existing boreholes to effect the flow augmentation. With Option 2 a new borehole would be implemented by the Water Company, typical costs for which have been provided by the Agency. In addition a further groundwater study will be undertaken by the Agency. Details of the costs are summarised in Table 6.4.

**Table 6.4 Summary of Cost Estimates (£ 000 Q4 1997)**

| | Option 1a | Option 1b | Option 2a | Option 2b |
|---|---|---|---|---|
| **Capital expenditure** | | | | |
| Replacement water | 690 | 1379 | 690 | 1379 |
| PWS option | 25 | 50 | | |
| New borehole | | | 120 | 200 |
| Groundwater study | 10 | 10 | 10 | 10 |
| Total | 725 | 1,439 | 820 | 1589 |
| **Operating expenditure (per annum)** | | | | |
| Replacement water | 11 | 23 | 11 | 23 |
| New borehole | | | 9 | 18 |
| Total | 11 | 23 | 20 | 41 |

## 6.4 Estimation of Benefits

### 6.4.1 Informal Recreation

There are a number of sites on Rainworth Water at which informal recreation is a relevant economic factor. These include:

- L Lake;
- The forest tracks and footpaths in Clipstone Forest;
- the picnic site at Robins Bridge; and
- Rufford Country Park.

Furthermore the Centre Parcs Holiday complex is situated in the area and has access to Clipstone Forest. However, as visitors to Centre Parcs are likely to be attracted whatever the state of flow in Rainworth Water, the costs of visiting the holiday village cannot be used as a representation of the economic value of maintaining the flow.

Although Rufford Country Park is just downstream of the confluence with the Gallowshole Dyke, the presence of enhanced low flows in Rainworth Water is considered to be a benefit to a least a proportion of the visitors to Rufford Country Park. Nottinghamshire County Council, the owners of the Park, estimate that there are 700,000 visitors per year.

In the absence of reliable primary sources the estimation of visitor numbers to the rest of Rainworth Water has been based on the indirect approach contained in the Manual. Realistic estimates of the likely number of visits have been derived from previous experience, utilising the GIS data to distribute the numbers between the river reaches.

As the informal recreational activities are unpriced there is no economic rent or profit earned by the activity. The total value of the recreational activity is measured in consumer surplus or the difference between what the consumer pays for the activity (zero) and what they would be willing to pay. The Guidelines recommend the following per visit estimates of the consumer surplus, assuming that 40% of the willingness-to-pay is attributable to the presence of water:

- Upper bound estimate: £1.48 per visitor day;
- Central estimate: £0.60 per visitor day; and
- Lower bound estimate: £0.20 per visitor day.

Combining participation rates and willingness-to-pay with the flow improvement factors from Table 6.2 produces the annual incremental benefits which are presented in Table 6.5.

**Table 6.5 Annual Informal Recreation Benefits**

| | Option | Visitor Numbers by River Reach (000) | | | Factored Benefit by River Reach (£000 Q4 1997) | | | |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | Rufford Water | 1 | 2 | Rufford Water | Total |
| **Upper Bound** | **1a** | 6 | 16 | 700 | 8 | 10 | 10 | 28 |
| | **1b** | 6 | 16 | 700 | 8 | 19 | 21 | 48 |
| | **2a** | 7 | 16 | 700 | 11 | 10 | 10 | 31 |
| | **2b** | 7 | 16 | 700 | 11 | 19 | 21 | 51 |
| **Central Estimate** | **1a** | 4 | 12 | 700 | 3 | 3 | 4 | 10 |
| | **1b** | 4 | 12 | 700 | 3 | 6 | 8 | 17 |
| | **2a** | 6 | 12 | 700 | 3 | 3 | 4 | 11 |
| | **2b** | 6 | 12 | 700 | 3 | 6 | 8 | 18 |
| **Lower Bound** | **1a** | 3 | 10 | 700 | 0.7 | 0.8 | 1.4 | 2.9 |
| | **1b** | 3 | 10 | 700 | 0.7 | 1.6 | 2.8 | 5.0 |
| | **2a** | 5 | 10 | 700 | 0.9 | 0.8 | 1.4 | 3.1 |
| | **2b** | 5 | 10 | 700 | 0.9 | 1.6 | 2.8 | 5.3 |

### 6.4.2 Agriculture

Much of the land in this region is used for intensive agriculture, comprising intensively irrigated high value crops such as carrots, potatoes and sugar beet. The soil is excellent for these types of crops but the crops need to be irrigated as the soil has a low water holding capacity. Hence there are a large number of abstraction licences granted for agricultural purposes.

The licences have volumetric limits beyond which abstractions are not allowed. This causes problems for the agricultural community as the crops rely on a regular source of moisture to maintain their quality and therefore their price. Benefit would accrue to the farming community if they were able to abstract for more days during the drier parts of the year and therefore maintain their crops at optimum condition for longer. The Agency would also benefit as there would be a reduction in illegal abstractions which deplete the river to dangerously low levels.

There are a number of surface water abstraction licences in the 11 km reach of Rainworth Water for spray irrigation. These include:

- Boggs Farm;
- Inkersall Farm;
- Featherstone House Farm; and
- Inkersall Grange Farm (licence holder Robert Thomas Farms).

The impact of alleviating the low flows in Rainworth for each of these abstractions is addressed separately below.

- Boggs Farm has been affected by the low flows and has not been able to abstract from the surface water for irrigation to the optimum effect. In order to overcome this problem which stems from insufficient summer flows the owner intends to apply for permission to construct a winter storage lagoon. The licence allows for 30,000 $m^3$/year to be abstracted and using the approach given in the low flow guidelines would entail a capital cost of £30,000. The options for alleviation of low flows could remove the need for this expenditure which could therefore be included in the economic appraisal as a resource cost saving. However, the abstraction is licenced for 0.8 Ml/d, and if unrestricted, would therefore remove a substantial proportion of the flow during low flow periods, particularly with Options 1a and 2a where the additional compensation release is only 1 Ml/d. It is considered that the reduction in other benefits from this loss of water downstream of Boggs Farm is likely to be greater than the potential resource cost saving. In addition, the provision of winter storage will provide a more secure agricultural supply. It has therefore been assumed that the construction of the winter storage lagoon will proceed.
- **Inkersall Farm** has an abstraction licence for spray irrigation but the owner has not used this for the past five years following the sale of land. It is unlikely that this will be used by the owner in the foreseeable future and consequently there will be no economic benefit to this particular user.
- **Featherstone House Farm** has a licence to abstract from Rainworth Water but has an alternative source which has been used for the past five years. The surface water abstraction has not been required and thus the alleviation of the low flows cannot be considered to generate any economic benefits to this farm.
- Robert Thomas Farms at **Inkersall Grange Farm** has a restricted licence to abstract from the surface water and stores this water in a 45,000 $m^3$ reservoir for spray irrigation in the summer. The licence only allows abstractions when flow in Rainworth Water exceeds the equivalent of 4.87 Ml/d. The low flows have meant that the surface water has become an unreliable source for supplying the reservoir, although relatively few days of irrigation are lost as the cropping regime is based on the amount of water available in storage. The Agency is in the process of granting a groundwater abstraction licence for the farmer to develop an alternative source of supply providing up to 250,000 $m^3$/year or 4.4 Ml/d.

It is therefore concluded that any potential agricultural benefits of the low flow alleviation scheme would be small, and would be more than offset by a reduction in other benefits downstream.

### 6.4.3 Angling

Angling is the only in-stream recreational activity on Rainworth Water and it is limited to L Lake which is run as a privately owned coarse fishery. Fishermen may either purchase day tickets at £5/day or season tickets at £60. Jack Singleton, the bailiff at the lake, estimated there to be around 140 season ticket holders and reported that day ticket sales were very variable, but would not give an estimate of the potential number of anglers visiting the site. The bailiff, who has been at the site for the past 28 years, was of the opinion however that the low river flows had had no impact on the quality of angling and the number of anglers to the site. On the basis of this anecdotal evidence no angling benefits at L Lake are taken as resulting from the alleviation of low flows in Rainworth Water.

There is no fishing in the rest of Rainworth Water as it is too small to support a viable fishery. This situation will not change with the low flow alleviation options currently under consideration.

### 6.4.4 Property

There are a number of properties affected by Rainworth Water, notable amongst which are:

- Lake Farm Road, Rainworth;
- Inkersall Farm;
- Mickledale Lane, Bilsthorpe; and
- A new high value housing development just south of Rufford Country Park.

All of these will be directly affected by low flows, particularly those on Lake Farm Road as Rainworth Water flows through their back gardens.

Newark and Sherwood District Council was contacted to provide Council Tax Bands for the properties identified as adjacent to the watercourses. These are summarised in Table 6.6.

**Table 6.6 Properties Adjacent to Rainworth Water by Council Tax Band**

| Band | 1997 Midpoint | No of properties | | | Economic Value |
|---|---|---|---|---|---|
| | (£ 000) | Reach 1 | Reach 2 | Total | (£ 000 Q4 1997) |
| A | 40 | 5 | 45 | 50 | 2,020 |
| B | 46 | | | | |
| C | 61 | | | | |
| D | 79 | | | | |
| E | 105 | | 1 | 1 | 105 |
| F | 141 | | | | |
| G | 242 | | 2 | 2 | 485 |
| H | 323 | | | | |
| **Total** | | **5** | **48** | **53** | **2,610** |

Source: Newark and Sherwood District Council

By applying the formulae given in the Benefit Assessment Guidelines, using the assumed changes in return periods for the low flows indicated in Table 6.2, the benefit to property owners has been estimated in terms of once-off changes in stock.

**Table 6.7 Amenity and Aesthetic Stock Benefits (£000 Q4 1997)**

| Option | Total Incremental Benefits | | |
|---|---|---|---|
| | Upper Bound | Central Estimate | Lower Bound |
| 1a / 2a | 273 | 182 | 37 |
| 1b / 2b | 391 | 261 | 52 |

### 6.4.5 Non-Use

Non-use (conservation) benefit estimates for Rainworth Water have been derived for:

- local residents within 3 km;
- river users among the general public who do not visit these particular rivers but do hold non-use values towards the alleviation of low flows in rivers; and
- the wider general public who are not river users.

The non-use benefits have been derived using the procedures given in Section 9 of the Benefit Assessment Guidelines.

**Local resident non-use valuation**

It has been assumed that there are some 11,000 households within 3 km of Rainworth Water, distributed between the two river reaches as indicated below, based on population data obtained from the Agency GIS model and assuming 2.7 people/household:

| | |
|---|---|
| Reach I | 6,328 (4,288 with Options 1a and 1b) |
| Reach 2 | 5,093 |

In accordance with the Guidelines, the following values per household per annum are applied where full low flow alleviation is achieved:

| | |
|---|---|
| Upper Bound | £12.00 |
| Central Estimate | £10.00 |
| Lower Bound | £ 7.00 |

**General public non-use valuation**

It is assumed that there are 3.15 million households within Severn Trent Water's area and that 45% of the population are general river users, from which the actual number of local households already included are subtracted. The remaining 55% of the population in the service area are taken as non-users for whom a lower scale of benefits applies. The central estimates are based on the figures of £0.05 and £0.03 per household per km of river per annum for full low flow alleviation in accordance with the Guidelines, with +/- 25% for upper and lower bounds.

The annual non-use (conservation) benefit of each option, applying the flow improvement factors from Table 6.2 for each river reach, are summarised in Table 6.8 in terms of the local resident non-use benefits and the full (local resident plus general public non-use) benefits.

Table 6.8 **Annual Non-Use Benefits (£000 Q4 1997)**

| Option | Extent | Upper | Central | Lower |
|---|---|---|---|---|
| **1a** | Local | 76 | 63 | 44 |
| | Full | 887 | 712 | 531 |
| **1b** | Local | 100 | 84 | 59 |
| | Full | 1,461 | 1,173 | 875 |
| **2a** | Local | 100 | 84 | 59 |
| | Full | 1,048 | 842 | 627 |
| **2b** | Local | 125 | 104 | 73 |
| | Full | 1,623 | 1,302 | 972 |

## 6.5 Assessment of Tangibles (Cost Benefit Analysis)

The costs and the annual benefit streams have been aggregated in terms of present values in accordance with the procedures given in the Benefit Assessment Guidelines. The indicators in terms of net present values (NPV) and benefit cost ratios for the two options are presented in Table 6.9. The results are shown:

- both including and excluding non-use, together with intermediate figures: one including only 50% of the general public (i.e. non-local) non-use and the other including only local non-use;
- for the central estimates, with upper and lower bounds;
- using the different discount rates and time horizons; and
- with and without rolling forward the benefits.

For all combinations of assumptions Option 1 generates a slightly higher benefit cost ratio than Option 2. This result is a combination of two factors: the capital cost of providing a compensation release from a refurbished borehole with Option 1 is less than the estimated cost of developing a new borehole source; however the benefits are marginally greater with Option 2 because of the extra 0.9 km of river affected which includes the SSSI at L Lake.

The overall results are highly sensitive to the assumptions regarding non-use benefits, with benefit cost ratios in the range 6 to over 17 when the full non-use benefits are included. If only the local non-use benefits are included, the benefit cost ratio reduces to the range 0.8 to 1.6 with the central estimates. If no non-use benefits are included the benefit cost ratio reduces to below 0.4. For all cases where a proportion of the non-local non-use benefits are included, Option 2b has the highest net present value.

A summary of the assessment of tangibles (i.e. the quantifiable costs and benefits) for all options is presented in Table 6.10. For this analysis, which has been carried forward to the Summary Business Case, the economic benefit has been determined on the following basis:

- including 50% of the general public (i.e. non-local) non-use benefits
- central estimates without rolling forward of the benefits.

A breakdown of the total present value of the benefits for Option 2b by use category (central estimates, including 50% of the non-local non-use benefits) with the 6% Treasury discount rate with no rolling forward is shown on Figure 6.2, together with a breakdown of the present value of the costs.

**Table 6.9 (Sheet 1)** **Rainworth Water : Summary of Costs and Benefits**

**(£ 000 Q4 1997 expressed as present values)**

| Option | Costs | Benefits | | | | Total NPV | | | | Benefit Cost Ratio | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 7% Discount Rate, 30 year time period | | | | | | | | | | | | |
| | | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use |
| **Upper estimates, no rolling forward** | | | | | | | | | | | | | |
| 1a | 804 | 10,735 | 6,083 | 1,431 | 560 | 9,931 | 5,279 | 628 | -243 | 13.4 | 7.6 | 1.78 | 0.70 |
| 1b | 1,609 | 17,665 | 9,854 | 2,043 | 891 | 16,056 | 8,245 | 434 | -717 | 11.0 | 6.1 | 1.27 | 0.55 |
| 2a | 996 | 12,617 | 7,180 | 1,743 | 591 | 11,621 | 6,184 | 747 | -405 | 12.7 | 7.2 | 1.75 | 0.59 |
| 2b | 1,955 | 19,542 | 10,948 | 2,354 | 922 | 17,587 | 8,993 | 399 | -1,033 | 10.0 | 5.6 | 1.20 | 0.47 |
| **Upper estimates, with rolling forward** | | | | | | | | | | | | | |
| 1a | 804 | 11,311 | 6,404 | 1,498 | 579 | 10,507 | 5,600 | 694 | -225 | 14.1 | 8.0 | 1.86 | 0.72 |
| 1b | 1,609 | 18,616 | 10,377 | 2,138 | 923 | 17,007 | 8,768 | 529 | -686 | 11.6 | 6.5 | 1.33 | 0.57 |
| 2a | 996 | 13,296 | 7,561 | 1,827 | 612 | 12,300 | 6,565 | 831 | -384 | 13.4 | 7.6 | 1.83 | 0.61 |
| 2b | 1,955 | 20,595 | 11,531 | 2,466 | 956 | 18,640 | 9,575 | 511 | -1,000 | 10.5 | 5.9 | 1.26 | 0.49 |
| **Central estimates, no rolling forward** | | | | | | | | | | | | | |
| 1a | 804 | 8,439 | 4,718 | 997 | 271 | 7,635 | 3,914 | 193 | -533 | 10.5 | 5.9 | 1.24 | 0.34 |
| 1b | 1,609 | 13,879 | 7,630 | 1,381 | 422 | 12,270 | 6,022 | -227 | -1,187 | 8.6 | 4.7 | 0.86 | 0.26 |
| 2a | 996 | 9,939 | 5,590 | 1,240 | 280 | 8,944 | 4,594 | 244 | -715 | 10.0 | 5.6 | 1.25 | 0.28 |
| 2b | 1,955 | 15,375 | 8,500 | 1,625 | 431 | 13,420 | 6,545 | -331 | -1,524 | 7.9 | 4.3 | 0.83 | 0.22 |
| **Central estimates, with rolling forward** | | | | | | | | | | | | | |
| 1a | 804 | 8,893 | 4,968 | 1,043 | 278 | 8,090 | 4,165 | 240 | -526 | 11.1 | 6.2 | 1.30 | 0.35 |
| 1b | 1,609 | 14,628 | 8,037 | 1,446 | 434 | 13,019 | 6,428 | -163 | -1,175 | 9.1 | 5.0 | 0.90 | 0.27 |
| 2a | 996 | 10,476 | 5,888 | 1,300 | 288 | 9,480 | 4,892 | 304 | -708 | 10.5 | 5.9 | 1.31 | 0.29 |
| 2b | 1,955 | 16,206 | 8,954 | 1,703 | 444 | 14,250 | 6,999 | -253 | -1,512 | 8.3 | 4.6 | 0.87 | 0.23 |
| **Lower estimates, no rolling forward** | | | | | | | | | | | | | |
| 1a | 804 | 6,155 | 3,364 | 573 | 65 | 5,351 | 2,560 | -231 | -739 | 7.7 | 4.2 | 0.71 | 0.08 |
| 1b | 1,609 | 10,149 | 5,462 | 776 | 104 | 8,540 | 3,854 | -833 | -1,505 | 6.3 | 3.4 | 0.48 | 0.06 |
| 2a | 996 | 7,264 | 4,002 | 739 | 68 | 6,268 | 3,006 | -256 | -928 | 7.3 | 4.0 | 0.74 | 0.07 |
| 2b | 1,955 | 11,255 | 6,098 | 942 | 106 | 9,299 | 4,143 | -1,014 | -1,849 | 5.8 | 3.1 | 0.48 | 0.05 |
| **Lower estimates, with rolling forward** | | | | | | | | | | | | | |
| 1a | 804 | 6,490 | 3,547 | 603 | 67 | 5,687 | 2,743 | -201 | -737 | 8.1 | 4.4 | 0.75 | 0.08 |
| 1b | 1,609 | 10,703 | 5,759 | 816 | 107 | 9,094 | 4,150 | -793 | -1,501 | 6.7 | 3.6 | 0.51 | 0.07 |
| 2a | 996 | 7,660 | 4,219 | 778 | 70 | 6,664 | 3,223 | -218 | -926 | 7.7 | 4.2 | 0.78 | 0.07 |
| 2b | 1,955 | 11,869 | 6,430 | 991 | 110 | 9,913 | 4,475 | -964 | -1,845 | 6.1 | 3.3 | 0.51 | 0.06 |

Table 6.9 (Sheet 2) **Rainworth Water : Summary of Costs and Benefits**
(£ 000 Q4 1997 expressed as present values)

| Option | 6% Discount Rate, 50 year time period | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Costs | Benefits | | | | Total NPV | | | | Benefit Cost Ratio | | | |
| | | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use |
| Upper estimates, no rolling forward | | | | | | | | | | | | | |
| 1a | 847 | 13,798 | 7,791 | 1,783 | 659 | 12,951 | 6,944 | 937 | -188 | 16.3 | 9.2 | 2.11 | 0.78 |
| 1b | 1,698 | 22,720 | 12,633 | 2,545 | 1,058 | 21,022 | 10,934 | 847 | -640 | 13.4 | 7.4 | 1.50 | 0.62 |
| 2a | 1,070 | 16,229 | 9,207 | 2,186 | 698 | 15,159 | 8,137 | 1,116 | -372 | 15.2 | 8.6 | 2.04 | 0.65 |
| 2b | 2,107 | 25,144 | 14,046 | 2,947 | 1,098 | 23,038 | 11,939 | 841 | -1,009 | 11.9 | 6.7 | 1.40 | 0.52 |
| Upper estimates, with rolling forward | | | | | | | | | | | | | |
| 1a | 847 | 14,854 | 8,379 | 1,905 | 692 | 14,007 | 7,532 | 1,058 | -155 | 17.5 | 9.9 | 2.25 | 0.82 |
| 1b | 1,698 | 24,463 | 13,591 | 2,718 | 1,115 | 22,765 | 11,892 | 1,020 | -583 | 14.4 | 8.0 | 1.60 | 0.66 |
| 2a | 1,070 | 17,474 | 9,906 | 2,338 | 735 | 16,404 | 8,836 | 1,268 | -335 | 16.3 | 9.3 | 2.19 | 0.69 |
| 2b | 2,107 | 27,076 | 15,114 | 3,152 | 1,158 | 24,969 | 13,007 | 1,045 | -949 | 12.9 | 7.2 | 1.50 | 0.55 |
| Central estimates, no rolling forward | | | | | | | | | | | | | |
| 1a | 847 | 10,855 | 6,049 | 1,244 | 306 | 10,008 | 5,203 | 397 | -541 | 12.8 | 7.1 | 1.47 | 0.36 |
| 1b | 1,698 | 17,862 | 9,792 | 1,722 | 483 | 16,164 | 8,094 | 23 | -1,216 | 10.5 | 5.8 | 1.01 | 0.28 |
| 2a | 1,070 | 12,793 | 7,175 | 1,558 | 319 | 11,723 | 6,106 | 488 | -751 | 12.0 | 6.7 | 1.46 | 0.30 |
| 2b | 2,107 | 19,794 | 10,915 | 2,036 | 495 | 17,687 | 8,809 | -70 | -1,612 | 9.4 | 5.2 | 0.97 | 0.23 |
| Central estimates, with rolling forward | | | | | | | | | | | | | |
| 1a | 847 | 11,688 | 6,509 | 1,329 | 318 | 10,841 | 5,662 | 482 | -529 | 13.8 | 7.7 | 1.57 | 0.38 |
| 1b | 1,698 | 19,235 | 10,537 | 1,839 | 503 | 17,537 | 8,839 | 141 | -1,195 | 11.3 | 6.2 | 1.08 | 0.30 |
| 2a | 1,070 | 13,776 | 7,722 | 1,668 | 332 | 12,707 | 6,652 | 598 | -738 | 12.9 | 7.2 | 1.56 | 0.31 |
| 2b | 2,107 | 21,318 | 11,748 | 2,178 | 517 | 19,211 | 9,641 | 71 | -1,590 | 10.1 | 5.6 | 1.03 | 0.25 |
| Lower estimates, no rolling forward | | | | | | | | | | | | | |
| 1a | 847 | 7,940 | 4,336 | 731 | 75 | 7,093 | 3,489 | -116 | -772 | 9.4 | 5.1 | 0.86 | 0.09 |
| 1b | 1,698 | 13,094 | 7,042 | 989 | 122 | 11,396 | 5,343 | -709 | -1,577 | 7.7 | 4.1 | 0.58 | 0.07 |
| 2a | 1,070 | 9,372 | 5,159 | 946 | 79 | 8,302 | 4,089 | -124 | -991 | 8.8 | 4.8 | 0.88 | 0.07 |
| 2b | 2,107 | 14,522 | 7,863 | 1,204 | 125 | 12,416 | 5,757 | -903 | -1,982 | 6.9 | 3.7 | 0.57 | 0.06 |
| Lower estimates, with rolling forward | | | | | | | | | | | | | |
| 1a | 847 | 8,556 | 4,671 | 786 | 79 | 7,709 | 3,824 | -61 | -768 | 10.1 | 5.5 | 0.93 | 0.09 |
| 1b | 1,698 | 14,110 | 7,586 | 1,063 | 128 | 12,412 | 5,888 | -636 | -1,571 | 8.3 | 4.5 | 0.63 | 0.08 |
| 2a | 1,070 | 10,099 | 5,558 | 1,017 | 82 | 9,029 | 4,488 | -52 | -988 | 9.4 | 5.2 | 0.95 | 0.08 |
| 2b | 2,107 | 15,649 | 8,472 | 1,294 | 131 | 13,542 | 6,365 | -812 | -1,975 | 7.4 | 4.0 | 0.61 | 0.06 |

Table 6.10 **Assessment of Tangibles (£000 Q4 1997)**

| Option | Agency Costs | Water Co. Costs | Economic Benefit | Net Present Value | Benefit Cost Ratio |
|---|---|---|---|---|---|
| 6% discount rate, 50 year time period | | | | | |
| **Do Nothing** | 0 | 0 | 0 | 0 | 0 |
| **Option 1a** | 9 | 838 | 6,049 | 5,203 | 7.1 |
| **Option 1b** | 9 | 1,689 | 9,792 | 8,094 | 5.8 |
| **Option 2a** | 9 | 1,061 | 7,175 | 6,106 | 6.7 |
| **Option 2b** | 9 | 2,097 | 10,915 | 8,809 | 5.2 |
| 7% discount rate, 30 year time period | | | | | |
| **Do Nothing** | 0 | 0 | 0 | 0 | 0 |
| **Option 1a** | 9 | 794 | 4,718 | 3,914 | 5.9 |
| **Option 1b** | 9 | 1,599 | 7,630 | 6,022 | 4.7 |
| **Option 2a** | 9 | 986 | 5,590 | 4,594 | 5.6 |
| **Option 2b** | 9 | 1,946 | 8,500 | 6,545 | 4.3 |

## 6.6 Assessment of Intangibles

The assessment of intangible benefits (or disbenefits) has been undertaken by a weighting and scoring system and is presented in Table 6.11. The intangibles considered in the table are:

1. Facilitation of Agency meeting objectives
2. Improved public relations and maintenance of credibility of Agency
3. Longer term benefits not quantified in economic analysis

Each of the intangible benefits has been allocated a weighting within the range from 5 to 0 (from most important to least important). Scores reflecting the ability of each option to deliver the intangible benefit have been allocated from 5 to 0 (from greatest ability to least ability).

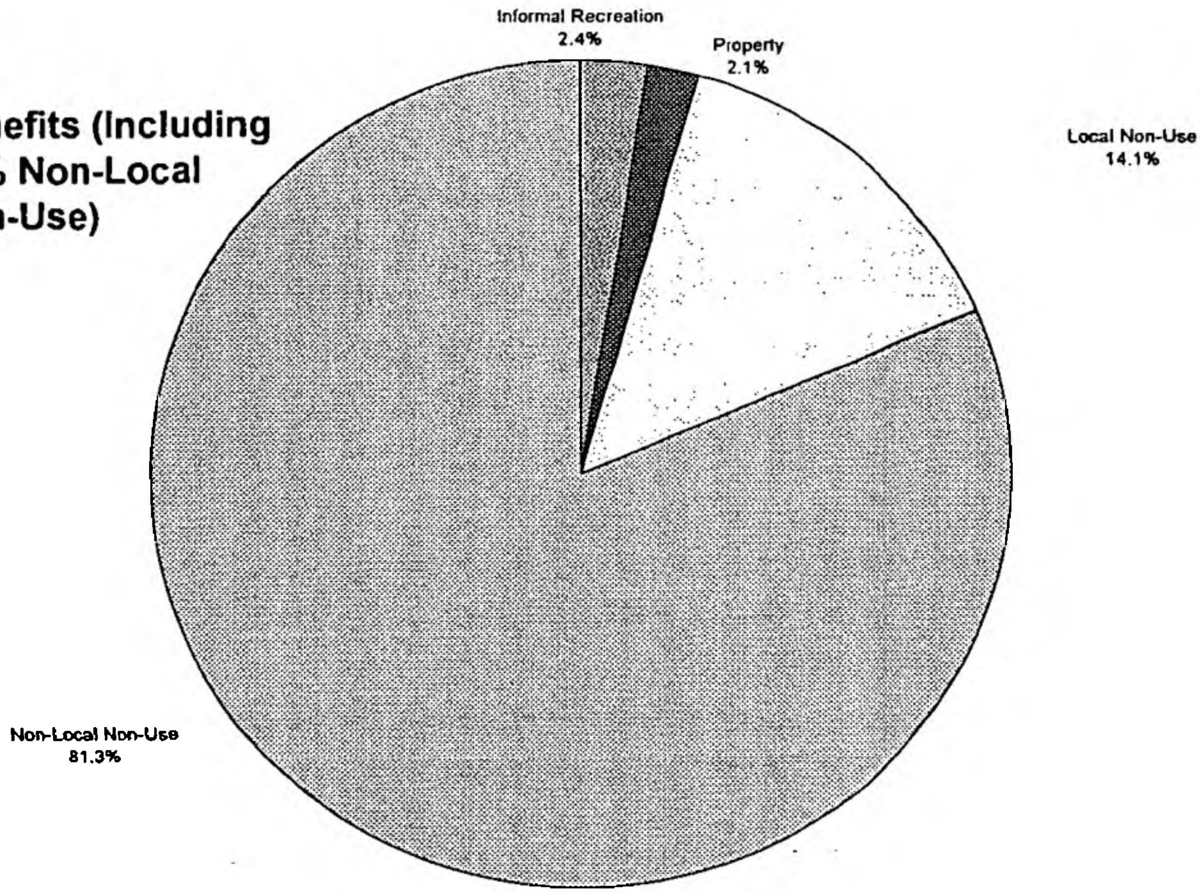
## 6.7 Risk Assessment

A risk assessment of the options carried has been undertaken and the results tabulated in a "Risk Register" (Table 6.12). The risks considered to be relevant in the appraisal are:

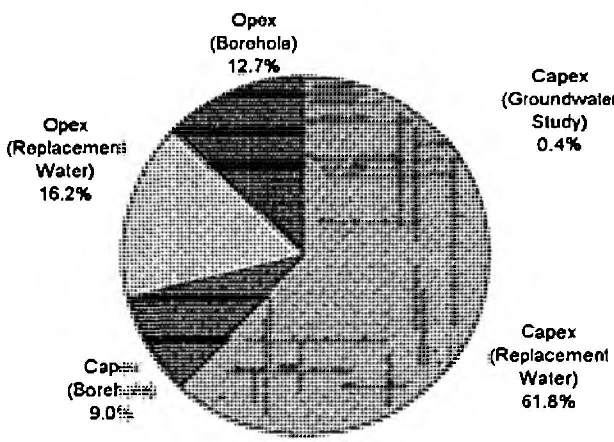
Risk 1 Operational failure of flow alleviation
Risk 2 Failure to provide anticipated benefits
Risk 3 Failure to supply a sustainable solution

Within the Risk Register the likelihood of the risk happening, and the consequent effect on the solution, are classified as "high", "medium" or "low".

**Benefits (Including 50% Non-Local Non-Use)**




**Costs**




Note: The area of the circles is proportional to the present value of the benefits or costs at a 6% discount rate

**Rainworth Water Option 2b**
**Present Value of Costs and Benefits**
**Figure 6.2**

**Table 6.11 Assessment of Intangible Benefits**

| Intangible Benefit | Weighting Factor | Option 1a 1 Ml/d from refurbished borehole | | Option 1b 2 Ml/d from refurbished borehole | | Option 2a 1 Ml/d from new borehole | | Option 2b 2 Ml/d from new borehole | | Comment |
|---|---|---|---|---|---|---|---|---|---|---|
| | | points | weighted points | points | weighted points | points | weighted points | points | weighted points | |
| 1 | 3 | 1 | 3 | 2 | 6 | 3 | 9 | 4 | 12 | Option 2a/2b has greater impact on L Lake |
| 2 | 3 | 3 | 9 | 3 | 9 | 4 | 12 | 4 | 12 | Option 2a/2b has greater impact on L Lake |
| 3 | 3 | 3 | 9 | 4 | 12 | 3 | 9 | 4 | 12 | STW effluent dilution downstream |
| Total weighted score | | | 21 | | 27 | | 30 | | 36 | |

Intangible Benefit 1: Facilitation of Agency meeting objectives
Intangible Benefit 2: Improved public relations and maintenance of credibility of Agency
Intangible Benefit 3: Longer term benefits not quantified in economic analysis

**Table 6.12 Risk Register**

| Identified Risk | Option 1a 1 Ml/d from refurbished borehole | | Option 1b 2 Ml/d from refurbished borehole | | Option 2a 1 Ml/d from new borehole | | Option 2b 2 Ml/d from new borehole | | Comment |
|---|---|---|---|---|---|---|---|---|---|
| | Likelihood | Effect | Likelihood | Effect | Likelihood | Effect | Likelihood | Effect | |
| Operational failure of flow alleviation | L | L | L | L | L | L | L | L | |
| Failure to provide anticipated benefits | M | M | M | M | M | M | M | M | Bed lining may be required to seal fissures |
| Failure to supply a sustainable solution | L | M | M | M | L | M | M | M | In the long term, reductions in groundwater abstractions will provide a sustainable solution |

Relative risks: H high M medium L low

## 6.8 Selection of Preferred Option

From the assessment of tangibles presented in Table 6.10 it can be seen that Option 2b represents the most cost effective solution in terms of maximum net present value (NPV). This conclusion is supported by the assessment of intangibles in Table 6.11, particularly in terms of the greatest impact on the SSSI at L Lake.

Although the risk register presented in Table 6.12 suggests that Options 1b/2b may have slightly higher risk than Options 1a/2a of not providing a sustainable solution, this risk will be mitigated by the long term overall reduction in abstractions from the Nottinghamshire aquifer.

**It is therefore concluded that Option 2b, a compensation release of 2 Ml/d from a new borehole upstream of L Lake, should be selected as the preferred option.**

Further investigations will be undertaken before implementation, including a study of the groundwater regime below the SSSI at L Lake being undertaken during 1998/99 to confirm whether the lake is situated on a perched water table or not. If these investigations confirm the requirement for extra water, the chosen option will be implemented together with monitoring along Rainworth Water. Measurement of flows along the watercourse will be required to monitor the performance of the scheme and identify reaches where water may be lost through the stream bed.

The proposed remedial measures will re-water 2.6 km of watercourse and significantly improve the flow in a further 9 km. In the longer term, with reduced groundwater abstractions, rising groundwater levels could restore some baseflows to the river, with a subsequent reduction in the requirements for compensation releases.

The re-instatement and increase of flows in Rainworth Water should improve the continuity of the linear wildlife habitat which is currently incomplete due to the negligible flows within the river for several months of the year.

The assessed economic benefit takes account of these ecological improvements in addition to the increase in the amenity and recreational value of the area surrounding the watercourses.

The increase in flows could also provide some improvement in water quality as a result of better dilution of the effluent from the Rainworth and Bilsthorpe sewage treatment works.

## 6.9 Tasks and Dependencies

| | |
|---|---|
| Investigations: | Agency Midlands Region, Regional Office |
| Design and implementation: | Agency Midlands Region, Regional Office<br>Agency Midlands Region, Lower Trent Area |

**Programme for implementation of preferred option:**

| | |
|---|---|
| 1998 | Submission of Business Plan |
| 1999 | Groundwater Investigation |
| 2000 | Investigation and Design<br>Planning and Consents |
| 2001 | Construction |

## 6.10 Cost of Preferred Option

The estimated capital and operating costs of the preferred option are given in Table 6.13. The estimates of likely future capital costs are based on the assumption that the Construction Output Index (COPI) will rise by 4 per cent per annum. In the estimation of operating costs an annual increase of 2.5 per cent per annum in the Retail Price Index (RPI) has been assumed.

**Table 6.13 Estimated Costs of the Preferred Option (£ 000)**

| **Year** | **Water Company** | | **Agency** | |
|---|---|---|---|---|
| ending 31/03 | Capex | Opex | Capex | Opex |
| 1999 | 0 | 0 | 4[1] | 0 |
| 2000 | 0 | 0 | 11 | 0 |
| 2001 | 0 | 0 | 0 | 0 |
| 2002 | 1,847 | 45 | 0 | 0 |
| 2003 | 0 | 46 | 0 | 0 |

[1] comprises submission of business plan, the cost of which has not been included in the assessment of tangibles

# 7 BATTLEFIELD BROOK

## 7.1 Scheme Objectives

Low flows in the Battlefield Brook catchment in the 1980s as a result of over-abstraction of groundwater in the Bromsgrove area led to the installation by the National Rivers Authority in 1992 of a new borehole in Sanders Park, Bromsgrove, together with an associated gauging station for monitoring purposes. This borehole has been largely successful in ensuring that a reasonable baseflow is achieved between the borehole and the confluence with the Spadesbourne Brook.

This scheme did not address the low flow problems upstream of Sanders Park to Catshill, or the Catshill Brook itself. The next low flow alleviation scheme is to be undertaken for the Battlefield Brook, but at present this has not been developed to include the Catshill Brook.

The current proposals target the main stream of the Battlefield Brook for the further alleviation of low flows as summarised in Table 7.1. All options involve a reduction in the abstraction for public water supply at the existing public water supply boreholes and augmentation of the river system from groundwater. In the longer term it is intended to reduce the total groundwater abstractions to a sustainable level which should result in rising groundwater levels re-watering the brook and its tributaries, with a subsequent reduction in the requirements for compensation releases.

The overall river system and the proposed augmentation points are shown on Figure 7.1.

**Table 7.1 Low Flow Alleviation Options**

| Option | Description | Improvements |
|---|---|---|
| 1 | Output from the Wildmoor Borehole to the Battlefield Brook. Compensation release of 1 Ml/day. | Rewater 6.1 km, significantly increased flows 3.8 km |
| 2 | Output from the Washingstocks Borehole to the Battlefield Brook. Compensation release of 1 Ml/day. | Rewater 3.7 km, significantly increased flows 3.8 km |
| 3 | Options 1 and 2 combined. Total compensation release of 2 Ml/day. | Rewater 6.1 km, significantly increased flows 3.8 km; with greater increase in flows |

In all cases the compensation flow would be triggered when the Agency gauging station at Sanders Park is at Q20% (3.6 Ml/d) or below.

Flow duration/frequency curves were provided by the Agency to define the impact of the alleviation options and these are included in Appendix 7. The data relates to the gauging station at Sanders Park.

The available information has been used to derive appropriate factors for the economic benefits of each option for those uses which are frequency and duration dependent. The river has been divided into three reaches for this purpose:

| | |
|---|---|
| Reach 1 | Wildmoor borehole to Washingstocks borehole (2.4 km) |
| Reach 2 | Washingstocks borehole to Sanders Park borehole (3.7 km) |
| Reach 3 | Sanders Park borehole to the outfall from Bromsgrove STW on Sugar Brook (3.8 km) |

Target flows for each reach have been assessed to determine the extent to which the low flow alleviation schemes will improve the situation. Flow improvement factors have been derived from a consideration of both the **proportional flow** improvement from the existing situation at the Q95% level, and the **proportional time** improvement that the target flow is achieved. Corresponding return periods for very low flows (i.e. about 50% of the target flows) have also been assessed for the before and after situations. The figures which have been derived are summarised in Table 7.2.

**Table 7.2 Summary of Hydrological Assessment for Battlefield Brook**

| | | Reach 1 | Reach 2 | Reach 3 |
|---|---|---|---|---|
| **Target Flow (Ml/d)** | | 1 | 1.5 | 2 |
| **% of Time above Target** | | | | |
| **Before** | | 25% | 25% | 25% |
| **After** | Option 1 | 100% | 90% | 80% |
| | Option 2 | 25% | 90% | 80% |
| | Option 3 (1 + 2) | 100% | 100% | 100% |
| **Flow Improvement Factor** | | | | |
| | Option 1 | 100% | 80% | 65% |
| | Option 2 | 0% | 80% | 65% |
| | Option 3 (1 + 2) | 100% | 100% | 95% |
| **Return Period (years)** before → after | | | | |
| | Option 1 | 1 → 10 | 1 → 5 | 1 → 5 |
| | Option 2 | 1 → 1 | 1 → 5 | 1 → 5 |
| | Option 3 (1 + 2) | 1 → >10 | 1 → 10 | 1 → 10 |

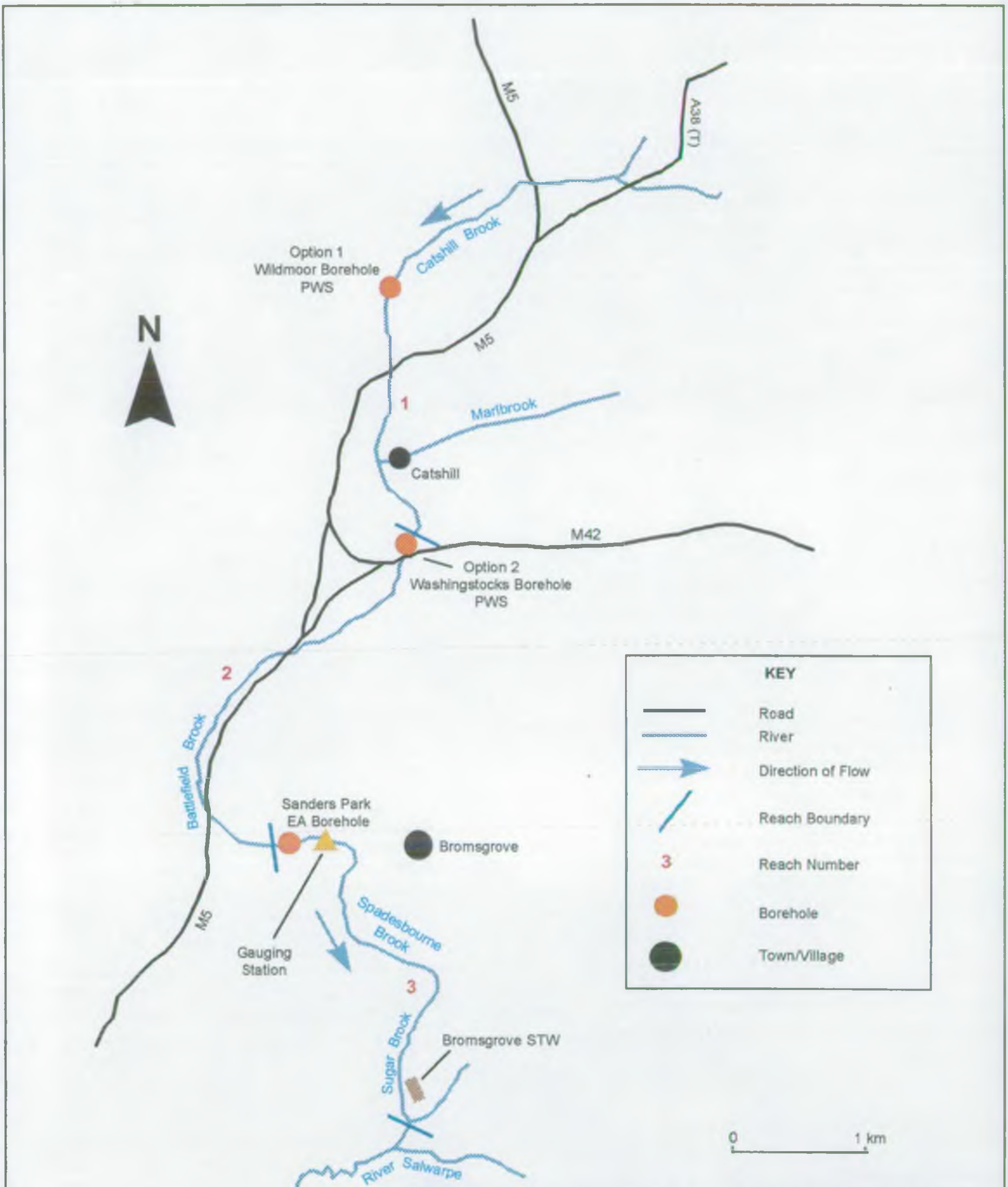
In the longer term it is intended to reduce the total groundwater abstraction from the Bromsgrove aquifer to a sustainable level. Of the overall reduction, 2 Ml/d has been attributed to the scheme to alleviate low flow problems on this local watercourse.

## 7.2 Scope of Study

Table 7.3 has been used as a checklist to focus on those impacts which are likely to be significant and need to be included in the economic appraisal.

There are five surface water abstraction licences granted on the Battlefield Brook, of which only two are situated below the proposed augmentation points.

Restoration of the flow will improve the continuity of the river's linear wildlife habitat, which at present is not complete due to the river periodically suffering extremely low flows.




Environment Agency

Figure 7.1: Schematic of Battlefield Brook Low Flow Alleviation Scheme

GIBB Ltd
Consulting Engineers
Reading England

AMP 3 Benefits Assessment

DATE April 1998

J98032A

**Table 7.3 Summary of Impacts**

| Impact Category | | Comments |
|---|---|---|
| Drinking Water Supply | | Increased flow available for PWS abstraction downstream. |
| Industrial Abstraction | | Not applicable |
| Agriculture | Livestock | Riparian use |
| | Irrigation | Important agricultural area. Arable production of high value crops. |
| In-stream Recreation | Boating | Not applicable |
| | Bathing | Not applicable |
| | Angling | Not applicable |
| Informal recreation | Walking, picnicking, photography | Limited. Urban park environment at Sanders Park |
| Amenity /Aesthetics | Property prices | A number of properties overlooking the river. |
| Conservation (Non-Use or Passive Use) | Ecology | Yes |
| | Heritage | Not applicable |
| Other | | None |

The categories that have been included in the benefit assessment are:

- informal recreation;
- agriculture
- property;
- drinking water supply resource cost savings; and
- non-use.

Although the additional flow will provide some additional dilution to the discharge from the existing STW at Bromsgrove, the proportional increase will be relatively small. It has therefore been agreed with the Agency that no additional economic benefits due to water quality improvements can be identified at this stage.

## 7.3 Capital and Operating Costs

Severn Trent Water Ltd has provided the Agency with estimates of the capital expenditure (capex) and operating expenditure (opex) necessary to provide for the replacement of the water currently abstracted at the various boreholes which could be diverted to alleviate low flows in the Battlefield Brook. In addition to the costs of providing replacement water, some minor works will be required in the vicinity of the boreholes to effect the flow augmentation. Details of the costs are included in Appendix C and summarised in Table 7.4.

**Table 7.4 Summary of Cost Estimates (£ 000 Q4 1997)**

| | Option 1 | Option 2 |
|---|---|---|
| **Capital expenditure** | | |
| Replacement water | 690 | 690 |
| PWS option | 10 | 10 |
| Total | 700 | 700 |
| **Operating expenditure (per annum)** | | |
| Replacement water | 11 | 11 |
| PWS Option | 6 | 6 |
| Total | 17 | 17 |

## 7.4 Estimation of Benefits

### 7.4.1 Informal Recreation

In the absence of reliable primary sources the estimation of visitor numbers to the sites has been based on the indirect approach outlined in the Agency Guidelines, related to the population within 0.8 km of the river, obtained from the Agency's GIS system. Taking account of the facilities at Sanders Park which qualifies as a 'honeypot' site and with other local amenity areas in the vicinity of the river, realistic estimates of the likely number of visits have been derived from previous experience, utilising the GIS data to distribute the numbers between the river reaches.

As the informal recreational activities are unpriced there is no economic rent or profit earned by the activity. The total value of the recreational activity is measured in consumer surplus or the difference between what the consumer pays for the activity (zero) and what they would be willing to pay. The Guidelines recommend the following per visit estimates of the consumer surplus, assuming 40% of the willingness-to-pay is attributable to the presence of water:

- Upper bound estimate: £1.48 per visitor day;
- Central estimate: £0.60 per visitor day; and
- Lower bound estimate: £0.20 per visitor day.

Combining participation rates and willingness-to-pay with the flow improvement factors from Table 7.2 produces the annual incremental benefits which are presented in Table 7.5.

### 7.4.2 Angling

Discussions with Agency staff revealed that there are no angling interests on the Battlefield Brook.

Table 7.5 **Annual Informal Recreation Benefits**

| | Option | Visitor Numbers by River Reach (000) | | | Factored Benefit by River Reach (£000 Q4 1997) | | | |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 1 | 2 | 3 | Total |
| **Upper Bound** | 1 | 9 | 12 | 23 | 14 | 15 | 22 | 50 |
| | 2 | 9 | 12 | 23 | 0 | 15 | 22 | 36 |
| | 3 | 9 | 12 | 23 | 14 | 18 | 32 | 64 |
| **Central Estimate** | 1 | 7 | 9 | 17 | 4 | 5 | 7 | 16 |
| | 2 | 7 | 9 | 17 | 0 | 5 | 7 | 11 |
| | 3 | 7 | 9 | 17 | 4 | 6 | 10 | 20 |
| **Lower Bound** | 1 | 6 | 8 | 14 | 1 | 1 | 2 | 4 |
| | 2 | 6 | 8 | 14 | 0 | 1 | 2 | 3 |
| | 3 | 6 | 8 | 14 | 1 | 2 | 3 | 5 |

### 7.4.3 Agriculture

Of the five surface water abstraction licences granted on the Battlefield Brook, it is only the two located below the augmentation points which may accrue agricultural benefits. At the Malthouse, a short distance downstream of the flow augmentation point with Option 1 there is a spray irrigation licence (No. 18/54/7/57) for a maximum abstraction equivalent to about 0.2 Ml/d. Further downstream at Grove Farm, below the flow augmentation point with Option 2, there is a spray irrigation licence (No. 18/54/7/130) for a maximum abstraction equivalent to about 0.7 Ml/d.

It has not been possible within the tight timescale for the original analysis to obtain sufficient detail of potential future abstractions by these two licence holders in the event of implementation of a low flow alleviation scheme. However, any benefits to agriculture would be at the expense of benefits identified downstream since abstractions could effectively reduce flows to almost zero again with Options 1 or 2. It may be noted that non-use benefits downstream will be impacted most severely.

### 7.4.4 Property

Bromsgrove District Council was contacted to provide Council Tax Bands for the properties identified as adjacent to the watercourses. Virtually all the properties are in Catshill village, in Reach 1. Although Reach 3 passes through a relatively densely populated area to the south of Bromsgrove town centre, virtually no residential properties actually border the brook and it is considered that the commercial and industrial properties which do will not realise any property benefits. The property details on which the benefits are based are summarised in Table 7.6.

**Table 7.6 Properties Adjacent to Battlefield Brook by Council Tax Band**

| Band | 1997 Midpoint (£ 000) | No of properties | | | | Economic Value (£ 000 Q4 1997) |
|---|---|---|---|---|---|---|
| | | Reach 1 | Reach 2 | Reach 3 | Total | |
| A | 40 | 0 | | | 0 | |
| B | 46 | 5 | | | 5 | 232 |
| C | 61 | 12 | | | 12 | 727 |
| D | 79 | 8 | | | 8 | 630 |
| E | 105 | 0 | | | 0 | 0 |
| F | 141 | 0 | | | 0 | 0 |
| G | 242 | 1 | | | 1 | 242 |
| H | 323 | 4 | 1 | | 5 | 1615 |
| **Total** | | **30** | **1** | | **31** | **3447** |

Source: Bromsgrove District Council

By applying the formulae given in the Benefit Assessment Guidelines, using the assumed changes in return periods for the low flows indicated in Table 7.2, the benefit to property owners has been estimated in terms of once-off changes in stock.

**Table 7.7 Amenity and Aesthetic Stock Benefits (£000 Q4 1997)**

| Option | Total Incremental Benefits | | |
|---|---|---|---|
| | Upper Bound | Central Estimate | Lower Bound |
| 1 | 502 | 334 | 67 |
| 2 | 34 | 23 | 5 |
| 3 | 517 | 345 | 69 |

### 7.4.5 Resource Cost Savings

With a quantity of water being added to the Battlefield Brook there will be a higher discharge to the Severn which could be available for abstraction for public water supply downstream in preference to pumping from the Shropshire Groundwater Scheme. An earlier assessment by the Agency for the River Worfe indicated that this benefit might be realised on average for some 75 days per year at an estimated value of £19 per Ml. This gives the following annual benefits in terms of resource cost savings:

| | | |
|---|---|---|
| Options 1 and 2 | 1 Ml/d | £ 1425 |
| Option 3 | 2 Ml/d | £ 2850 |

### 7.4.6 Non-Use

Non-use (conservation) benefit estimates for the Battlefield Brook have been derived for:

- local residents within 3 km;
- river users among the general public who do not visit this particular river and its tributaries but do hold non-use values towards the alleviation of low flows in rivers;
- the wider general public who are not river users.

The non-use benefits have been derived using the procedures given in Section 9 of the Benefit Assessment Guidelines.

**Local resident non-use valuation**

It has been assumed that there are some 17,000 households within 3 km of the Battlefield Brook, distributed between the three river reaches as indicated below, based on population data obtained from the Agency GIS model and assuming 2.7 people/household:

| | |
|---|---|
| Reach I | 6,939 |
| Reach 2 | 3,479 |
| Reach 3 | 6,386 |

In accordance with the Guidelines, the following values per household per annum are applied where full low flow alleviation is achieved:

| | |
|---|---|
| Upper Bound | £12.00 |
| Central Estimate | £10.00 |
| Lower Bound | £ 7.00 |

**General public non-use valuation**

It is assumed that there are 3.15 million households within Severn Trent Water's area and that 45% of the population are general river users, from which the actual number of local households already included are subtracted. The remaining 55% of the population in the service area are taken as non-users for whom a lower scale of benefits applies. The central estimates are based on the figures of £0.05 and £0.03 per household per km of river per annum for full low flow alleviation in accordance with the Guidelines, with +/- 25% for upper and lower bounds.

The annual non-use (conservation) benefit of each option, applying the flow improvement factors from Table 7.2 for each river reach, are summarised in Table 7.8 in terms of the local resident non-use benefits and the full (local resident plus general public non-use) benefits.

**Table 7.8 Annual Non-Use Benefits (£000 Q4 1997)**

| Option | Extent | Upper | Central | Lower |
|---|---|---|---|---|
| 1 | Local | 166 | 139 | 97 |
| | Full | 1,361 | 1,094 | 814 |
| 2 | Local | 83 | 69 | 49 |
| | Full | 911 | 732 | 545 |
| 3 | Local | 198 | 165 | 115 |
| | Full | 1,679 | 1,350 | 1,004 |

## 7.5 Assessment of Tangibles (Cost Benefit Analysis)

The costs and the annual benefit streams have been aggregated in terms of present values in accordance with the procedures given in the Benefit Assessment Guidelines. The indicators in terms of net present values (NPV) and benefit cost ratios for the various options are presented in Table 7.9. The results are shown:

- both including and excluding non-use, together with two intermediate figures: one including only 50% of the general public (i.e. non-local) non-use and the other including only local non-use;
- for the central estimates, with upper and lower bounds;
- using the different discount rates and time horizons; and
- with and without rolling forward the benefits.

Option 1 has a consistently higher benefit cost ratio than Option 2 which is a result of a greater length of watercourse being impacted. However, Option 3 has the highest net present value when any proportion of the non-local non-use benefits is included. It can therefore be concluded that the incremental benefits of providing the 1 Ml/d from the borehole at Washingstocks with Option 2 will probably justify the extra costs in addition to Option 1.

The overall results are highly sensitive to the assumptions regarding non-use benefits, with benefit cost ratios in the range 7 to 25 when the full non-use benefits are included. If only the local non-use benefits are included, the benefit cost ratio reduces to the range 1.1 to 3.1 with the central estimates. If no non-use benefits are included the NPV becomes negative in all cases considered except Option 1 with the upper bound estimates.

A summary of the assessment of tangibles (i.e. the quantifiable costs and benefits) for all options is presented in Table 7.10. For this analysis, which has been carried forward to the Summary Business Case, the economic benefit has been determined on the following basis:

- including 50% of the general public (i.e. non-local) non-use benefits
- central estimates without rolling forward of the benefits.

A breakdown of the total present value of the benefits by use category for Option 3 (central estimates, including 50% of the non-local non-use benefits) with the 6% Treasury discount rate, with no rolling forward, is shown on Figure 7.2, together with a breakdown of the present value of the costs.

Table 7.9 (Sheet 1) **Battlefield Brook : Summary of Costs and Benefits**

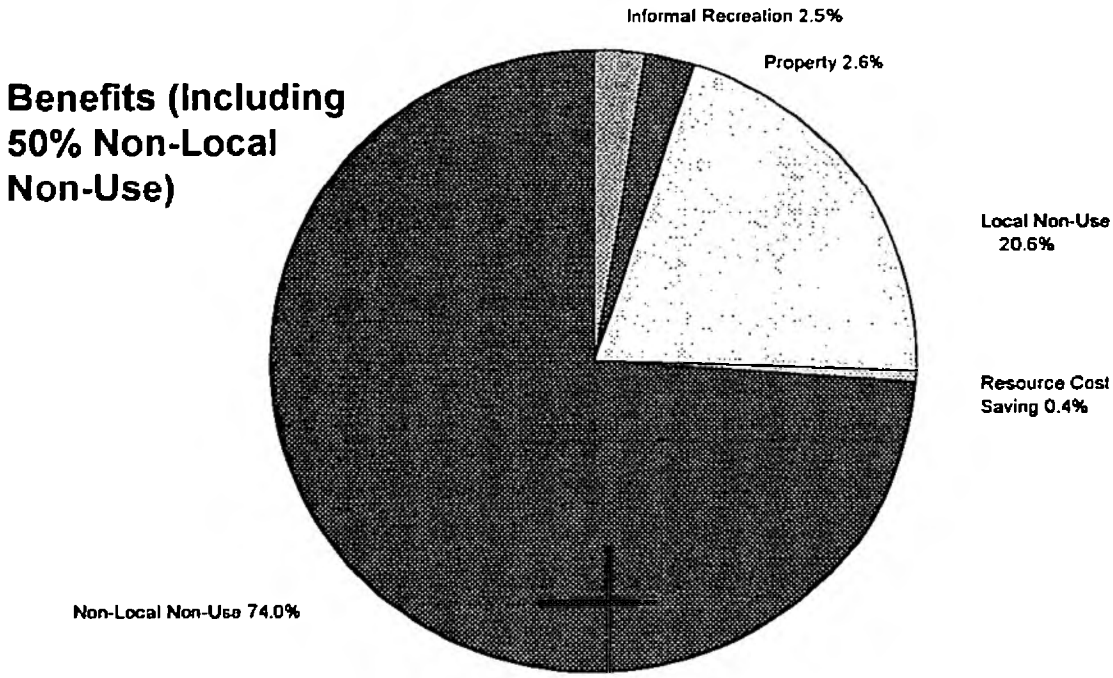
(£ 000 Q4 1997 expressed as present values)

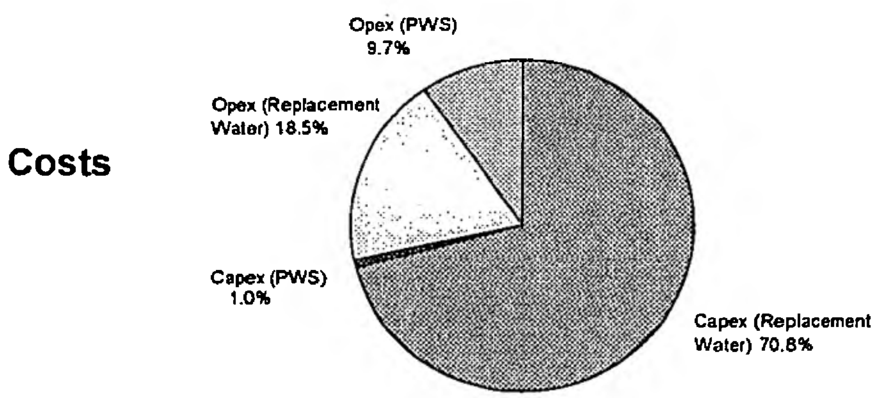
| Option | Costs | 7% Discount Rate, 30 year time period | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Benefits | | | | Total NPV | | | | Benefit Cost Ratio | | | |
| | | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use |
| Upper estimates, no rolling forward | | | | | | | | | | | | | |
| 1 | 849 | 16,643 | 9,792 | 2,941 | 1,030 | 15,794 | 8,943 | 2,091 | 181 | 19.6 | 11.5 | 3.46 | 1.21 |
| 2 | 849 | 10,906 | 6,154 | 1,403 | 448 | 10,056 | 5,305 | 554 | -401 | 12.8 | 7.2 | 1.65 | 0.53 |
| 3 | 1,710 | 20,449 | 11,953 | 3,457 | 1,187 | 18,739 | 10,243 | 1,747 | -523 | 12.0 | 7.0 | 2.02 | 0.69 |
| Upper estimates, with rolling forward | | | | | | | | | | | | | |
| 1 | 849 | 17,533 | 10,306 | 3,080 | 1,065 | 16,683 | 9,457 | 2,231 | 216 | 20.6 | 12.1 | 3.63 | 1.25 |
| 2 | 849 | 11,501 | 6,490 | 1,478 | 471 | 10,652 | 5,641 | 629 | -378 | 13.5 | 7.6 | 1.74 | 0.55 |
| 3 | 1,710 | 21,546 | 12,585 | 3,623 | 1,229 | 19,836 | 10,875 | 1,913 | -481 | 12.6 | 7.4 | 2.12 | 0.72 |
| Central estimates, no rolling forward | | | | | | | | | | | | | |
| 1 | 849 | 13,043 | 7,562 | 2,081 | 489 | 12,193 | 6,712 | 1,231 | -360 | 15.4 | 8.9 | 2.45 | 0.58 |
| 2 | 849 | 8,549 | 4,748 | 947 | 152 | 7,700 | 3,899 | 98 | -698 | 10.1 | 5.6 | 1.12 | 0.18 |
| 3 | 1,710 | 16,018 | 9,221 | 2,424 | 533 | 14,308 | 7,511 | 714 | -1,177 | 9.4 | 5.4 | 1.42 | 0.31 |
| Central estimates, with rolling forward | | | | | | | | | | | | | |
| 1 | 849 | 13,742 | 7,961 | 2,180 | 501 | 12,893 | 7,112 | 1,331 | -348 | 16.2 | 9.4 | 2.57 | 0.59 |
| 2 | 849 | 9,016 | 5,007 | 998 | 159 | 8,167 | 4,158 | 149 | -690 | 10.6 | 5.9 | 1.18 | 0.19 |
| 3 | 1,710 | 16,880 | 9,711 | 2,542 | 547 | 15,170 | 8,001 | 832 | -1,163 | 9.9 | 5.7 | 1.49 | 0.32 |
| Lower estimates, no rolling forward | | | | | | | | | | | | | |
| 1 | 849 | 9,459 | 5,348 | 1,237 | 123 | 8,610 | 4,499 | 388 | -726 | 11.1 | 6.3 | 1.46 | 0.15 |
| 2 | 849 | 6,299 | 3,448 | 597 | 40 | 5,449 | 2,599 | -252 | -809 | 7.4 | 4.1 | 0.70 | 0.05 |
| 3 | 1,710 | 11,644 | 6,546 | 1,448 | 124 | 9,934 | 4,836 | -262 | -1,586 | 6.8 | 3.8 | 0.85 | 0.07 |
| Lower estimates, with rolling forward | | | | | | | | | | | | | |
| 1 | 849 | 9,974 | 5,638 | 1,302 | 127 | 9,125 | 4,789 | 453 | -722 | 11.7 | 6.6 | 1.53 | 0.15 |
| 2 | 849 | 6,643 | 3,636 | 630 | 42 | 5,794 | 2,787 | -220 | -807 | 7.8 | 4.3 | 0.74 | 0.05 |
| 3 | 1,710 | 12,278 | 6,901 | 1,524 | 128 | 10,568 | 5,191 | -186 | -1,582 | 7.2 | 4.0 | 0.89 | 0.07 |

Table 7.9 (Sheet 2) **Battlefield Brook : Summary of Costs and Benefits**

(£ 000 Q4 1997 expressed as present values)

| Option | Costs | Benefits | | | | Total NPV | | | | Benefit Cost Ratio | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 6% Discount Rate, 50 year time period | | | | | | | | | | | | |
| | | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use |
| Upper estimates, no rolling forward | | | | | | | | | | | | | |
| 1 | 912 | 21,374 | 12,526 | 3,678 | 1,211 | 20,462 | 11,614 | 2,766 | 299 | 23.4 | 13.7 | 4.03 | 1.33 |
| 2 | 912 | 14,075 | 7,939 | 1,804 | 570 | 13,163 | 7,027 | 891 | -342 | 15.4 | 8.7 | 1.98 | 0.63 |
| 3 | 1,839 | 26,285 | 15,313 | 4,340 | 1,409 | 24,446 | 13,473 | 2,501 | -430 | 14.3 | 8.3 | 2.36 | 0.77 |
| Upper estimates, with rolling forward | | | | | | | | | | | | | |
| 1 | 912 | 23,005 | 13,468 | 3,932 | 1,273 | 22,093 | 12,556 | 3,020 | 361 | 25.2 | 14.8 | 4.31 | 1.40 |
| 2 | 912 | 15,169 | 8,555 | 1,942 | 613 | 14,256 | 7,643 | 1,029 | -300 | 16.6 | 9.4 | 2.13 | 0.67 |
| 3 | 1,839 | 28,297 | 16,471 | 4,644 | 1,485 | 26,458 | 14,631 | 2,805 | -355 | 15.4 | 9.0 | 2.52 | 0.81 |
| Central estimates, no rolling forward | | | | | | | | | | | | | |
| 1 | 912 | 16,764 | 9,686 | 2,607 | 552 | 15,852 | 8,773 | 1,695 | -361 | 18.4 | 10.6 | 2.86 | 0.60 |
| 2 | 912 | 11,035 | 6,126 | 1,218 | 190 | 10,123 | 5,214 | 305 | -722 | 12.1 | 6.7 | 1.33 | 0.21 |
| 3 | 1,839 | 20,604 | 11,826 | 3,048 | 605 | 18,764 | 9,987 | 1,209 | -1,234 | 11.2 | 6.4 | 1.66 | 0.33 |
| Central estimates, with rolling forward | | | | | | | | | | | | | |
| 1 | 912 | 18,047 | 10,418 | 2,789 | 573 | 17,135 | 9,506 | 1,876 | -339 | 19.8 | 11.4 | 3.06 | 0.63 |
| 2 | 912 | 11,892 | 6,602 | 1,311 | 203 | 10,980 | 5,689 | 399 | -709 | 13.0 | 7.2 | 1.44 | 0.22 |
| 3 | 1,839 | 22,185 | 12,724 | 3,263 | 630 | 20,345 | 10,884 | 1,423 | -1,210 | 12.1 | 6.9 | 1.77 | 0.34 |
| Lower estimates, no rolling forward | | | | | | | | | | | | | |
| 1 | 912 | 12,200 | 6,891 | 1,582 | 143 | 11,287 | 5,979 | 670 | -769 | 13.4 | 7.6 | 1.73 | 0.16 |
| 2 | 912 | 8,133 | 4,451 | 770 | 50 | 7,221 | 3,539 | -143 | -862 | 8.9 | 4.9 | 0.84 | 0.06 |
| 3 | 1,839 | 15,020 | 8,437 | 1,853 | 143 | 13,181 | 6,597 | 14 | -1,696 | 8.2 | 4.6 | 1.01 | 0.08 |
| Lower estimates, with rolling forward | | | | | | | | | | | | | |
| 1 | 912 | 13,145 | 7,423 | 1,701 | 150 | 12,232 | 6,511 | 789 | -762 | 14.4 | 8.1 | 1.86 | 0.16 |
| 2 | 912 | 8,765 | 4,797 | 829 | 54 | 7,853 | 3,885 | -83 | -858 | 9.6 | 5.3 | 0.91 | 0.06 |
| 3 | 1,839 | 16,184 | 9,089 | 1,993 | 150 | 14,345 | 7,249 | 153 | -1,690 | 8.8 | 4.9 | 1.08 | 0.08 |




Note: The area of the circles is proportional to the present value of the benefits or costs at a 6% discount rate

**Battlefield Brook Option 3**
**Present Value of Benefits and Costs**
**Figure 7.2**

Table 7.10 **Assessment of Tangibles (£000 Q4 1997)**

| Option | Agency Costs | Water Co. Costs | Economic Benefit | Net Present Value | Benefit Cost Ratio |
|---|---|---|---|---|---|
| 6% discount rate, 50 year time period | | | | | |
| **Do Nothing** | 0 | 0 | 0 | 0 | 0 |
| **Option 1** | 0 | 912 | 9,686 | 8,773 | 10.6 |
| **Option 2** | 0 | 912 | 6,126 | 5,214 | 6.7 |
| **Option 3** | 0 | 1,839 | 11,826 | 9,987 | 6.4 |
| 7% discount rate, 30 year time period | | | | | |
| **Do Nothing** | 0 | 0 | 0 | 0 | 0 |
| **Option 1** | 0 | 849 | 7,562 | 6,712 | 8.9 |
| **Option 2** | 0 | 849 | 4,748 | 3,899 | 5.6 |
| **Option 3** | 0 | 1,710 | 9,221 | 7,511 | 9.4 |

## 7.6 Assessment of Intangibles

The assessment of intangible benefits (or disbenefits) has been undertaken by a weighting and scoring system and is presented in Table 7.11. The intangibles considered in the table are:

1. Facilitation of Agency meeting objectives
2. Improved public relations and maintenance of credibility of Agency
3. Longer term benefits not quantified in economic analysis

Each of the intangible benefits has been allocated a weighting within the range from 5 to 0 (from most important to least important). Scores reflecting the ability of each option to deliver the intangible benefit have been allocated from 5 to 0 (from greatest ability to least ability).

## 7.7 Risk Assessment

A risk assessment of the options has been undertaken and the results tabulated in a "Risk Register" (Table 7.12). The risks considered to be relevant in the appraisal are:

Risk 1 Operational failure of flow alleviation
Risk 2 Failure to provide anticipated benefits
Risk 3 Failure to supply a sustainable solution

Within the Risk Register the likelihood of the risk happening, and the consequent effect on the solution, are classified as "high", "medium" or "low".

**Table 7.11** **Assessment of Intangible Benefits**

| Intangible Benefit | Weighting Factor | Option 1<br>1 Ml/d release from Wildmoor | | Option 2<br>1 Ml/d release from Washingstocks | | Option 3<br>2 Ml/d release Options 1 + 2 | | Comment |
|---|---|---|---|---|---|---|---|---|
| | | points | weighted points | points | weighted points | points | weighted points | |
| 1 | 3 | 3 | 9 | 2 | 6 | 4 | 12 | |
| 2 | 3 | 3 | 9 | 2 | 6 | 3 | 9 | |
| 3 | 3 | 3 | 9 | 3 | 9 | 4 | 12 | STW effluent dilution downstream |
| Total weighted score | | | 27 | | 21 | | 33 | |

Intangible Benefit 1: Facilitation of Agency meeting objectives
Intangible Benefit 2: Improved public relations and maintenance of credibility of Agency
Intangible Benefit 3: Longer term benefits not quantified in economic analysis

**Table 7.12** **Risk Register**

| Identified Risk | Option 1<br>1 Ml/d release from Wildmoor | | Option 2<br>1 Ml/d release from Washingstocks | | Option 3<br>2 Ml/d release Options 1 + 2 | | Comment |
|---|---|---|---|---|---|---|---|
| | Likeli-hood | Effect | Likeli-hood | Effect | Likeli-hood | Effect | |
| Operational failure of flow alleviation | L | L | L | L | L | L | |
| Failure to provide anticipated benefits | M | M | M | M | M | M | Lining may be required to seal the bed |
| Failure to supply a sustainable solution | M | M | M | M | M | M | In the long term, reductions in groundwater abstractions will provide a sustainable solution |

Relative risks: H high M medium L low

## 7.8 Selection of Preferred Option

From the assessment of tangibles presented in Table 7.10 it can be seen that Option 3 represents the most cost effective solution in terms of maximum net present value (NPV). This conclusion is supported by the assessment of intangibles in Table 7.11. The risk register presented in Table 7.12 does not suggest any adverse risk with this option.

**It is therefore concluded that Option 3, comprising compensation releases of 1 Ml/d from each of the existing boreholes at Wiidmoor and Washingstocks, should be selected as the preferred option.**

The proposed interim remedial measures will re-water 6 km of watercourse upstream of Sanders Park. In addition, some 3.8 km down to the sewage treatment works will benefit from significantly increased flows.

In the longer term, with reduced groundwater abstractions, rising groundwater levels should restore some baseflow to this watercourse and its tributaries, with a subsequent reduction in the requirements for compensation releases.

There will also be some increase in flows in the River Salwarpe which would provide some improvement in water quality as a result of better dilution of the effluent from the sewage treatment works, as well as making more water available for public water supply abstraction from the River Severn. Of these effects, only the benefit of resource cost savings due to the greater availability of water downstream has been included in the economic assessment.

The restoration of flow will improve the continuity of the brook's linear wildlife habitat, which at present is not complete due to the extremely low flows periodically experienced.

The assessed economic benefit takes account of these ecological improvements in addition to the increase in the amenity and recreational value of the area surrounding the watercourses.

## 7.9 Tasks and Dependencies

| | |
|---|---|
| Investigations: | Agency Midlands Region, Upper Severn Area |
| Design and implementation: | Severn Trent Water Ltd. |

**Programme for implementation of the preferred option:**

| | |
|---|---|
| 1998 | Submission of Business Plan |
| 1999 | Investigation and Design<br>Planning and Consents |
| 2000 | Construction of Wildmoor Borehole compensation release (Option 1)<br>Investigation |
| 2001 | Construction (if required) of Washingstocks Borehole compensation release (Option 2) |

## 7.10 Cost of Preferred Option

The estimated capital and operating costs of the preferred option are given in Table 7.13. The estimates of likely future capital costs are based on the assumption that the Construction Output Index (COPI) will rise by 4 per cent per annum. In the estimation of operating costs an annual increase of 2.5 per cent per annum in the Retail Price Index (RPI) has been assumed.

**Table 7.13 Estimated Costs of the Preferred Option (£ 000)**

| Year ending 31/03 | Water Company | | Agency | |
|---|---|---|---|---|
| | Capex | Opex | Capex | Opex |
| 1999 | 0 | 0 | 4[1] | 0 |
| 2000 | 0 | 0 | 0 | 0 |
| 2001 | 787 | 18 | 0 | 0 |
| 2002 | 819 | 39 | 0 | 0 |
| 2003 | 0 | 41 | 0 | 0 |

[1] comprises submission of business plan, the cost of which has not been included in the assessment of tangibles

# 8 BLAKEDOWN BROOK

## 8.1 Scheme Objectives

Over-abstraction of groundwater in the Kidderminster area has resulted in low flow problems on the Blakedown Brook which flows through two SSSIs. For some time the Agency has been involved in trying to alleviate these problems. The Blakedown Brook and its tributaries, which include a large number of pools retained by old dams and weirs, are shown in Figure 8.1. Schemes have already been commissioned on two of the tributaries:

- a borehole to supplement flows into and maintain levels in the Ladies, Forge and Swan Pools;
- a borehole to supplement flow into and maintain levels in the Coopers, Harborough and Pavilion Pools.

The two boreholes are operated by the Agency and are triggered by pool levels, but will not provide inflow to the main stream of the Blakedown Brook, which has the two SSSIs in the lower reaches at Podmore and Hurcott Pools. There is a requirement to provide an inflow to these pools to maintain the SSSIs, but at present it is not known how much of the new compensation releases will reach them. It has been decided that a trial flow will be implemented before the year 2000 to see what improvements can be achieved.

A large proportion of the flow in the upper reaches is derived from the existing Hagley wastewater treatment works (WTW) operated by Severn Trent Water Ltd. There has been a proposal to close this which will involve the effluent being transferred out of the catchment. After discussion with Severn Trent Water Ltd it has been agreed that:

- the Hagley effluent will be transferred to Roundhill WTW for treatment and then returned to the Blakedown Brook; and that
- the Blakedown WTW will be upgraded.

The pipeline from Roundhill WTW to the Blakedown Brook will have a capacity of 3.0 Ml/d, sufficient to return a flow equivalent to the Hagley effluent (1.5 Ml/d) as well as provide an additional capacity of 1.5 Ml/d which will be available to supplement the inflow to Blakedown Brook if desired.

The schemes considered for the alleviation of low flows in the Blakedown Brook are summarised in Table 8.1 and the augmentation points are shown on Figure 8.1. Option 1 is the scheme mentioned above, using the full capacity of the new pipeline from Roundhill WTW. Option 2 involves augmentation using a groundwater source, either by using an existing public water supply borehole at Churchill or a new borehole there. Option 3 is essentially an independent scheme for the re-watering of Windmill Pool, the one remaining major pool not yet improved, which is situated on a tributary of the Blakedown Brook upstream of Pavilion Pool. Options 4 and 5 are combinations of the first three options.

The Agency has advised that for the purpose of this assessment it should be assumed that Option 1 would be in operation all year round, and Options 2 and 3 for 80% of the time.

Although no flow duration/frequency curves were available for the Blakedown Brook, details of spot gauging were provided by the Agency to assist in defining the impact of the alleviation options and these are included in Appendix 8.

**Table 8.1 Low Flow Alleviation Options**

| Option | Description | Improvements |
|---|---|---|
| 1 | Compensation release of 3 Ml/day from the return effluent pipeline from Roundhill WTW | Replace WTW effluent over 4 km, significantly increased flows over 3.5 km, including SSSIs |
| 2a | Compensation release of 2 Ml/day from the existing South Staffordshire Water Ltd Churchill Pumping Station | Significantly increased flows over 5.5 km, including SSSIs |
| 2b | Compensation release of 2 Ml/day from a proposed new borehole at Churchill | Significantly increased flows over 5.5 km, including SSSIs |
| 3 | Compensation release of 1 Ml/day from a proposed new borehole to the Windmill Pool. | Maintain levels in Windmill Pool |
| 4 | A combination of Options 1+2 | Replace WTW effluent over 4 km, significantly increased flows over 3.5 km, including SSSIs, with higher flows |
| 5 | A combination of Options 1+2+3 | As Option 4, with levels maintained in Windmill Pool |

The available information has been used to derive appropriate factors for the economic benefits of each option for those uses which are frequency and duration dependent. The river has been divided into three reaches for this purpose:

| | |
|---|---|
| Reach 1 | Above Option 2 augmentation point at Churchill (2 km) |
| Reach 2 | Churchill to Blakedown WTW outfall (2 km) |
| Reach 3 | Blakedown WTW outfall to Broadwaters, downstream of Podmore Pool (3.5 km) |

Target flows for each reach have been assessed to determine the extent to which the low flow alleviation schemes will improve the situation. Flow improvement factors have been derived from a consideration of the **proportional flow** improvement from the existing situation. In the absence of flow duration data it was not possible to estimate the **proportional time** improvement that the target flow is achieved. Corresponding return periods for very low flows (i.e. about 50% of the target flows) have also been estimated for the before and after situations. The figures which have been derived are summarised in Table 8.2.

In the longer term it is proposed to reduce the total groundwater abstractions by around 10 Ml/d to a level which is sustainable which will be confirmed by a hydrogeological model currently being developed. The two water companies involved have both made some allowance for these reductions in their draft water resources plans submitted to the Agency. With reduced abstractions, rising groundwater levels should restore baseflows to the brook and its tributaries, with a subsequent reduction in the requirements for compensation releases.

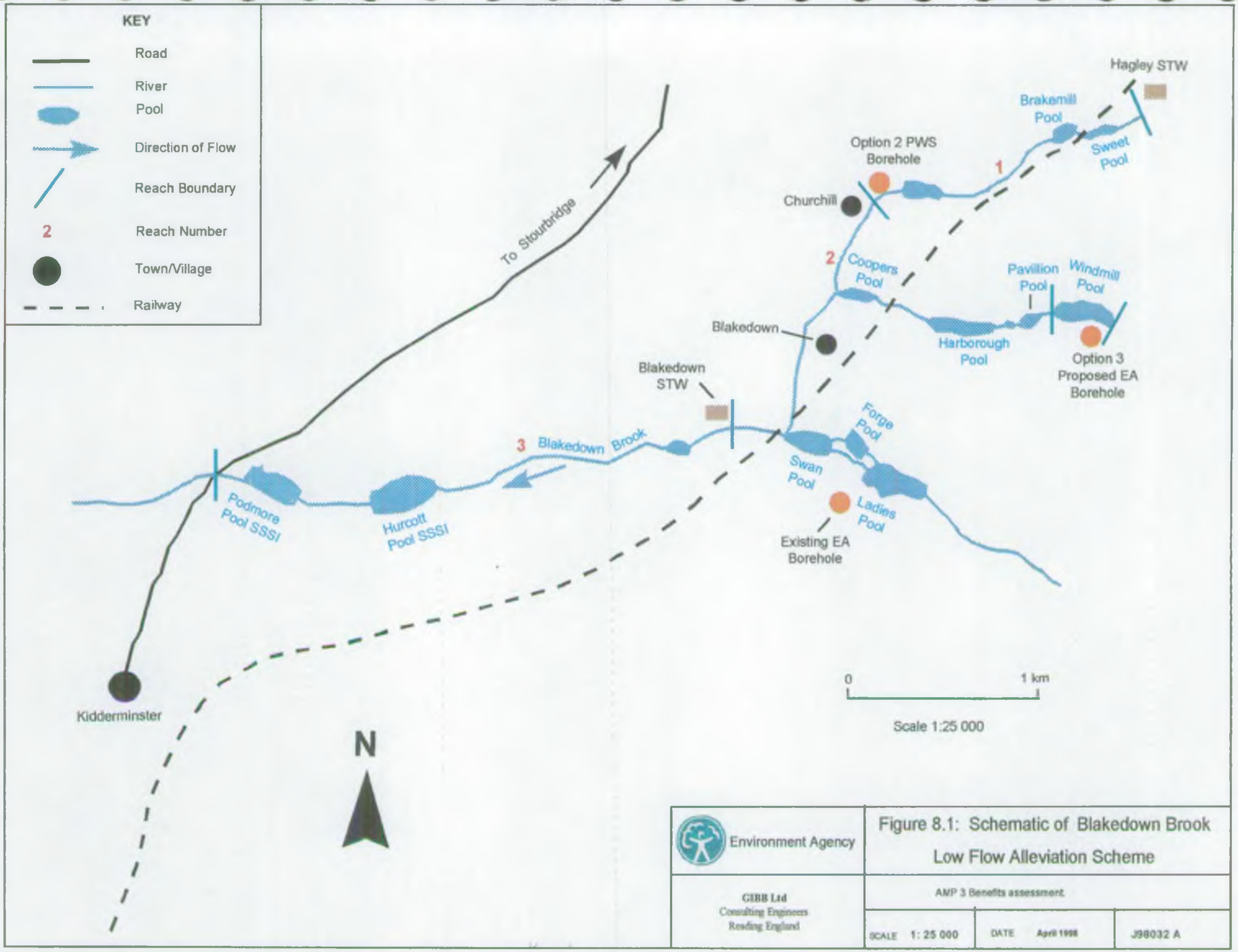


Figure 8.1: Schematic of Blakedown Brook Low Flow Alleviation Scheme

**Table 8.2 Summary of Hydrological Assessment for Blakedown Brook**

| | Reach 1 | Reach 2 | Reach 3 |
|---|---|---|---|
| **Target Flow (Ml/d)** | 3 | 5 | 5 |
| **Flow Improvement Factor** | | | |
| Option 1 | 100% | 60% | 60% |
| Option 2a/2b | 0% | 40% | 40% |
| Option 3 | pool only | | |
| Option 4 (1 + 2) | 100% | 100% | 100% |
| Option 5 (1 + 2 + 3) | 100% | 100% | 100% |
| **Return Period (years)** before → after | | | |
| Option 1 | 1 → 10 | 1 → 5 | 1 → 3 |
| Option 2a/2b | 1 → 1 | 1 → 2 | 1 → 2 |
| Option 3 | pool only | | |
| Option 4 (1 + 2) | 1 → 10 | 1 → 10 | 1 → 5 |
| Option 5 (1 + 2 + 3) | 1 → 10 | 1 → 10 | 1 → 5 |

## 8.2 Scope of Study

Table 8.3 has been used as a checklist to focus on those impacts which are likely to be significant and need to be included in the economic appraisal.

**Table 8.3 Summary of Impacts**

| Impact Category | | Comments |
|---|---|---|
| Drinking Water Supply | | Not applicable |
| Industrial Abstraction | | Not applicable |
| Agriculture | Livestock | Riparian owner |
| | Irrigation | Not applicable |
| In-stream Recreation | Boating | Not applicable |
| | Bathing | Not applicable |
| | Angling | Yes |
| Informal recreation | Walking, picnicking, photography | Yes |
| Amenity /Aesthetics | Property prices | A number of properties overlooking the river. |
| Conservation (Non-Use or Passive Use) | Ecology | Yes |
| | Heritage | Not applicable |
| Other | | None |

Restoration of the flow will improve the continuity of the brook's linear wildlife habitat, which at present is not complete due to the brook periodically suffering extremely low flows.

The categories that have been included in the benefit assessment are:

- informal recreation
- angling;
- property; and
- non-use.

## 8.3 Capital and Operating Costs

Severn Trent Water Ltd and South Staffordshire Water Ltd have provided the Agency with estimates of the capital expenditure (capex) and operating expenditure (opex) necessary to implement the return effluent pipeline from Roundhill WTW and to provide for the replacement of the water currently abstracted which could be diverted to alleviate low flows in the Blakedown Brook. In addition to the costs of providing replacement water, a new pipeline some 2.5 km long will be required with Option 2a to effect the flow augmentation. For Options 2b and 3, new boreholes would be installed near the watercourses by SSWC and the Agency respectively. Details of the costs are summarised in Table 8.4.

**Table 8.4 Summary of Cost Estimates (£ 000 Q4 1997)**

| | Option 1 | Option 2a | Option 2b | Option 3 |
|---|---|---|---|---|
| **Capital expenditure** | | | | |
| Effluent pipeline | 1000[2] | | | |
| Replacement water | | 500[1] | 500[1] | 690[2] |
| PWS option | | 200[1] | | |
| New SSWC borehole | | | 200[3] | |
| New Agency borehole | | | | 120[3,4] |
| Total | 1000 | 700 | 700 | 810 |
| **Operating expenditure (per annum)** | | | | |
| Effluent pipeline | 30[2] | | | |
| Replacement water | | insignificant[1] | insignificant[1] | 11[2] |
| PWS Option | | 5[1] | | |
| New SSWC borehole | | | 5[3] | |
| New Agency borehole | | | | 5[3,4] |
| Total | 30 | 5 | 5 | 16 |

Notes: [1] Costs from SSWC Ltd [2] Costs from STW Ltd [3] Agency estimates
[4] Agency costs to be recharged to STW Ltd under AMP3

As the costs of Option 2b are the same as those for Option 2a and both give rise to the same benefits, Option 2a/2b has been treated as a single option in the cost benefit analysis. With Option 2b there is more flexibility in the location of the release point which is taken into account in the selection of the preferred option in Section 8.8.

## 8.4 Estimation of Benefits

### 8.4.1 Informal Recreation

In the absence of reliable primary sources the estimation of visitor numbers to the sites has been based on the indirect approach outlined in the Agency Guidelines, related to the population within 0.8 km of the river, obtained from the Agency's GIS system. Taking account of visits to sites such as Churchill Forge Mill and other local amenity areas in the vicinity of the river, realistic estimates of the likely number of visits have been derived from previous experience, utilising the GIS data to distribute the numbers between the river reaches.

As the informal recreational activities are unpriced there is no economic rent or profit earned by the activity. The total value of the recreational activity is measured in consumer surplus or the difference between what the consumer pays for the activity (zero) and what they would be willing to pay. The Guidelines recommend the following per visit estimates of the consumer surplus, assuming 40% of the willingness-to-pay is attributable to the presence of water:

- Upper bound estimate: £1.48 per visitor day;
- Central estimate: £0.60 per visitor day; and
- Lower bound estimate: £0.20 per visitor day.

Combining participation rates and willingness-to-pay with the flow improvement factors from Table 8.2 produces the annual incremental benefits which are presented in Table 8.5.

**Table 8.5 Annual Informal Recreation Benefits**

| | Option | Visitor Numbers by River Reach (000) | | | Factored Benefit by River Reach (£000 Q4 1997) | | | |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 1 | 2 | 3 | Total |
| **Upper Bound** | **1** | 6 | 14 | 14 | 10 | 13 | 13 | 35 |
| | **2a/2b** | | 16 | 14 | | 9 | 8 | 18 |
| | **3** | 3 | | | 4 | | | 4 |
| | **4** | 6 | 14 | 14 | 10 | 21 | 21 | 52 |
| | **5** | 7 | 14 | 14 | 10 | 21 | 21 | 52 |
| **Central Estimate** | **1** | 5 | 11 | 11 | 3 | 4 | 4 | 11 |
| | **2a/2b** | | 12 | 11 | | 3 | 3 | 6 |
| | **3** | 2 | | | 1 | | | 1 |
| | **4** | 5 | 11 | 11 | 3 | 7 | 7 | 16 |
| | **5** | 5 | 11 | 11 | 3 | 7 | 7 | 16 |
| **Lower Bound** | **1** | 4 | 9 | 9 | 1 | 1 | 1 | 3 |
| | **2a/2b** | | 10 | 9 | | 1 | 1 | 1 |
| | **3** | 0 | | | 0 | | | 0 |
| | **4** | 4 | 9 | 9 | 1 | 2 | 2 | 4 |
| | **5** | 4 | 9 | 9 | 1 | 2 | 2 | 4 |

### 8.4.2 Angling

Through discussions with the Agency it is understood that a number of the pools in the Blakedown Brook catchment support, or could support, angling as indicated in Table 8.6.

**Table 8.6 Pools within the Blakedown Brook that support Angling**

| Pool Name | Contact | No. of Pegs | Comments |
|---|---|---|---|
| **Brakemill Pool** | Mal Storey Angling<br>Mr Mal Storey | 48 | • coarse fishery<br>• day ticket only<br>• good supply of water at present<br>• does not foresee extra water a benefit to his fishery |
| **Hurcott Pool** | Hurcott Carp Fishery<br>Mr Paul Wilcox | 25-30 | • stated that an increase in flow would not benefit the angling at Hurcott Pool |
| **Ladies Pool** | | | • on tributary not affected by current proposals |
| **Podmore Pool** | | | • possible improved coarse fishery |
| **Swan Pool** | | | • on tributary not affected by current proposals |
| **Windmill Pool** | | | • possible new coarse fishery |

It is understood that Mal Storey Angling Club leases Brakemill Pool from Lord Cobham. Following telephone conversations with Mr Mal Storey of Mal Storey Angling, it is understood that over the past 12 months Brakemill Pool has had an extremely good supply of water, and he recalls no specific time that the water level has significantly dropped. Mr Storey also stated that any further addition to the volume of water in Brakemill Pool could result in flooding downstream of the dam, at times of heavy rain, and that he does not believe that it would increase the benefits to his fishing club.

Due to time constraints comments from the land owner were not available at the time of reporting.

Through telephone conversations with Mr P Wilcox, Hurcott Carp Fishery, it is understood that Hurcott Pool does not suffer from significant falls in water levels during the summer months and an increase in flow into Hurcott Pool would not increase the benefits to angling on the pool. Mr Wilcox stated that the pool banks cannot hold any futher increase in fisherman numbers.

In the absence of further information it has been assumed that the re-watering of Windmill Pool will create a new coarse fishery similar to that at Brakemill Pool. Based on experience there and at Hurcott it would be reasonable to assume that the pool would sustain at least a moderate day fishery with 40 pegs, with some 60 visits per peg per annum. Similar figures could be expected at Podmore Pool with a substantial improvement in water levels.

The Low Flow Benefit Assessment Guidelines suggest anglers willingness-to-pay values for the introduction of a new coarse fishery as follows:

- poor £3.86 per person per trip (lower bound)
- moderate £4.07 per person per trip (central estimate)
- good £6.21 per person per trip (upper bound)

Combining these with the total number of anglers allows the total benefits of creating a new fishery to be calculated. These are then applied as appropriate to each option giving the annual values summarised in Table 8.7, after deducting the estimated value of the existing poor fishery at Podmore Pool.

**Table 8.7 Annual Angling Benefits for Blakedown Brook Flow Improvement (£000)**

| Option | Upper Bound | Central Estimate | Lower Bound |
|---|---|---|---|
| 1 | 18 | 7 | 4 |
| 2a/2b | 18 | 7 | 4 |
| 3 | 20 | 10 | 6 |
| 4 | 18 | 7 | 4 |
| 5 | 37 | 17 | 10 |

### 8.4.3 Agriculture

There are no abstractions from the surface water for agricultural purposes and therefore no benefit to be gained by this sector.

### 8.4.4 Property

Wyre Forest District Council was contacted to provide Council Tax Bands for the properties identified as adjacent to the watercourses. These are summarised in Table 8.8.

**Table 8.8 Properties Adjacent to Blakedown Brook by Council Tax Band**

| Band | 1997 Midpoint (£ 000) | No of properties | | | | Economic Value (£ 000 Q4 1997) |
|---|---|---|---|---|---|---|
| | | Reach 1 | Reach 2 | Reach 3 | Total | |
| A | 40 | | | | | |
| B | 46 | | | | | |
| C | 61 | | 1 | | 1 | 61 |
| D | 79 | | 3 | 8 | 11 | 866 |
| E | 105 | | 1 | 8 | 9 | 945 |
| F | 141 | | 19 | 5 | 24 | 3,393 |
| G | 242 | 2 | 15 | 2 | 19 | 4,605 |
| H | 323 | | 3 | | 3 | 969 |
| **Total** | | **2** | **42** | **23** | **67** | **10,839** |

Source: Wyre Forest District Council

By applying the formulae given in the Benefit Assessment Guidelines, using the assumed changes in return periods for the low flows indicated in Table 8.2, the benefit to property owners has been estimated in terms of once-off changes in stock.

**Table 8.9 Amenity and Aesthetic Stock Benefits (£000 Q4 1997)**

| Option | Total Incremental Benefits | | |
|---|---|---|---|
| | Upper Bound | Central Estimate | Lower Bound |
| 1 | 1,069 | 713 | 143 |
| 2a/2b | 467 | 311 | 62 |
| 3 | 0 | 0 | 0 |
| 4 | 1,505 | 1,003 | 201 |
| 5 | 1,505 | 1,003 | 201 |

### 8.4.5 Non-Use

Non-use (conservation) benefit estimates for the Blakedown Brook have been derived for:

- local residents within 3 km;
- river users among the general public who do not visit this particular river and its tributaries but do hold non-use values towards the alleviation of low flows in rivers;
- the wider general public who are not river users.

The non-use benefits have been derived using the procedures given in Section 9 of the Benefit Assessment Guidelines.

**Local resident non-use valuation**

It has been assumed that there are almost 20,000 households within 3 km of the Blakedown Brook, distributed between the three river reaches as indicated below, based on population data obtained from the Agency GIS model and assuming 2.7 people/household:

| | |
|---|---|
| Reach I | 5,000 |
| Reach 2 | 7,000 |
| Reach 3 | 7,000 |

In accordance with the Guidelines, the following values per household per annum are applied where full low flow alleviation is achieved:

| | |
|---|---|
| Upper Bound | £12.00 |
| Central Estimate | £10.00 |
| Lower Bound | £ 7.00 |

**General public non-use valuation**

It is assumed that there are 3.15 million households within Severn Trent Water's area and that 45% of the population are general river users, from which the actual number of local households already included are subtracted. The remaining 55% of the population in the service area are taken as non-users for whom a lower scale of benefits applies. The central estimates are based on the figures of £0.05 and £0.03 per household per km of river per annum for full low flow alleviation in accordance with the Guidelines, with +/- 25% for upper and lower bounds. The Windmill Pool has been treated as equivalent to a river length of 2 km for this purpose.

The annual non-use (conservation) benefit of each option, applying the flow improvement factors from Table 8.2 for each river reach, are summarised in Table 8.10 in terms of the local resident non-use benefits and the full (local resident plus general public non-use) benefits.

**Table 8.10 Annual Non-Use Benefits (£000 Q4 1997)**

| Option | Extent | Upper | Central | Lower |
|---|---|---|---|---|
| **1** | Local | 165 | 137 | 96 |
| | Full | 972 | 783 | 581 |
| **2a/2b** | Local | 83 | 69 | 48 |
| | Full | 418 | 337 | 250 |
| **3** | Local | 62 | 51 | 36 |
| | Full | 215 | 174 | 128 |
| **4** | Local | 234 | 195 | 137 |
| | Full | 1,377 | 1,109 | 822 |
| **5** | Local | 239 | 199 | 139 |
| | Full | 1,533 | 1,235 | 916 |

## 8.5 Assessment of Tangibles (Cost Benefit Analysis)

The costs and the annual benefit streams have been aggregated in terms of present values in accordance with the procedures given in the Benefit Assessment Guidelines. The indicators in terms of net present values (NPV) and benefit cost ratios for the various options are presented in Table 8.11. The results are shown:

- both including and excluding non-use, together with two intermediate figures: one including only 50% of the general public (i.e. non-local) non-use and the other including only local non-use;
- for the central estimates, with upper and lower bounds;
- using the different discount rates and time horizons; and
- with and without rolling forward the benefits.

In addition, a variant on Option 5 is also shown which has the same benefits as Option 5, but allows for phasing of the capital costs over the implementation period and includes the additional costs of the replacement water which is expected to be required in order to provide a long term sustainable solution to the problem of over-abstraction. This variant also includes additional Agency costs for the installation of monitoring equipment. The total amount of replacement water (all values in Ml/d) allowed for with Option 5 (long term) is made up as follows:

| | | STW Ltd | SSWC Ltd |
|---|---|---|---|
| Interim | Option 1 | 0 | 0 |
| | Option 2b | 0 | 2 |
| | Option 3 | 1 | 0 |
| Long Term | | 4 | 3 |
| Total | | 5 | 5 |

**Table 8.11 (Sheet 1)** **Blakedown Brook : Summary of Costs and Benefits**

**(£ 000 Q4 1997 expressed as present values)**

| Option | 7% Discount Rate, 30 year time period | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Costs | Benefits | | | | Total NPV | | | | Benefit Cost Ratio | | | |
| | | incl full non-use | incl local and 60% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 60% non-local non-use | incl local non-use | excl non-use |
| **Upper estimates, no rolling forward** | | | | | | | | | | | | | |
| 1 | 1,279 | 12,692 | 8,059 | 3,427 | 1,537 | 11,413 | 6,781 | 2,148 | 258 | 9.9 | 6.3 | 2.68 | 1.20 |
| 2a/2b | 712 | 5,613 | 3,688 | 1,764 | 813 | 4,901 | 2,977 | 1,052 | 102 | 7.9 | 5.2 | 2.48 | 1.14 |
| 3 | 941 | 2,740 | 1,861 | 981 | 273 | 1,799 | 920 | 41 | -668 | 2.9 | 2.0 | 1.04 | 0.29 |
| 4 | 1,990 | 17,910 | 11,355 | 4,800 | 2,111 | 15,920 | 9,365 | 2,810 | 121 | 9.0 | 5.7 | 2.41 | 1.06 |
| 5 | 2,931 | 19,940 | 12,512 | 5,084 | 2,344 | 17,009 | 9,581 | 2,153 | -587 | 6.8 | 4.3 | 1.73 | 0.80 |
| 5 (long term) | 6,377 | 19,940 | 12,512 | 5,084 | 2,344 | 19,940 | 6,135 | 5,084 | 2,344 | 3.1 | 2.0 | 0.80 | 0.37 |
| **Upper estimates, with rolling forward** | | | | | | | | | | | | | |
| 1 | 1,279 | 13,340 | 8,454 | 3,568 | 1,574 | 12,061 | 7,175 | 2,290 | 295 | 10.4 | 6.6 | 2.79 | 1.23 |
| 2a/2b | 712 | 5,900 | 3,870 | 1,840 | 838 | 5,188 | 3,158 | 1,128 | 126 | 8.3 | 5.4 | 2.59 | 1.18 |
| 3 | 941 | 2,890 | 1,962 | 1,035 | 287 | 1,949 | 1,022 | 95 | -653 | 3.1 | 2.1 | 1.10 | 0.31 |
| 4 | 1,990 | 18,826 | 11,912 | 4,997 | 2,162 | 16,835 | 9,921 | 3,007 | 171 | 9.5 | 6.0 | 2.51 | 1.09 |
| 5 | 2,931 | 20,966 | 13,131 | 5,297 | 2,407 | 18,035 | 10,200 | 2,366 | -524 | 7.2 | 4.5 | 1.81 | 0.82 |
| 5 (long term) | 6,377 | 20,966 | 20,966 | 20,966 | 2,407 | 14,590 | 14,590 | 14,590 | -3,969 | 3.3 | 3.3 | 3.29 | 0.38 |
| **Central estimates, no rolling forward** | | | | | | | | | | | | | |
| 1 | 1,279 | 9,821 | 6,115 | 2,409 | 834 | 8,542 | 4,836 | 1,130 | -445 | 7.7 | 4.8 | 1.88 | 0.65 |
| 2a/2b | 712 | 4,293 | 2,753 | 1,213 | 421 | 3,581 | 2,041 | 502 | -290 | 6.0 | 3.9 | 1.70 | 0.59 |
| 3 | 941 | 2,123 | 1,420 | 717 | 126 | 1,183 | 479 | -224 | -815 | 2.3 | 1.5 | 0.76 | 0.13 |
| 4 | 1,990 | 13,877 | 8,633 | 3,388 | 1,148 | 11,886 | 6,642 | 1,398 | -842 | 7.0 | 4.3 | 1.70 | 0.58 |
| 5 | 2,931 | 15,429 | 9,487 | 3,545 | 1,262 | 12,498 | 6,556 | 614 | -1,669 | 5.3 | 3.2 | 1.21 | 0.43 |
| 5 (long term) | 6,377 | 15,429 | 9,487 | 3,545 | 1,262 | 15,429 | 3,110 | 3,545 | 1,262 | 2.4 | 1.5 | 0.56 | 0.20 |
| **Central estimates, with rolling forward** | | | | | | | | | | | | | |
| 1 | 1,279 | 10,328 | 6,419 | 2,510 | 848 | 9,049 | 5,140 | 1,231 | -431 | 8.1 | 5.0 | 1.96 | 0.66 |
| 2a/2b | 712 | 4,514 | 2,890 | 1,266 | 431 | 3,803 | 2,179 | 555 | -281 | 6.3 | 4.1 | 1.78 | 0.61 |
| 3 | 941 | 2,240 | 1,498 | 756 | 133 | 1,299 | 557 | -185 | -808 | 2.4 | 1.6 | 0.80 | 0.14 |
| 4 | 1,990 | 14,593 | 9,062 | 3,530 | 1,167 | 12,603 | 7,071 | 1,540 | -823 | 7.3 | 4.6 | 1.77 | 0.59 |
| 5 | 2,931 | 16,231 | 9,963 | 3,695 | 1,287 | 13,300 | 7,032 | 764 | -1,644 | 5.5 | 3.4 | 1.26 | 0.44 |
| 5 (long term) | 6,377 | 16,231 | 9,963 | 3,695 | 1,287 | 9,854 | 3,586 | -2,682 | -5,089 | 2.5 | 1.6 | 0.58 | 0.20 |
| **Lower estimates, no rolling forward** | | | | | | | | | | | | | |
| 1 | 1,279 | 6,864 | 4,085 | 1,306 | 203 | 5,585 | 2,806 | 27 | -1,076 | 5.4 | 3.2 | 1.02 | 0.16 |
| 2a/2b | 712 | 2,980 | 1,825 | 670 | 116 | 2,268 | 1,113 | -41 | -596 | 4.2 | 2.6 | 0.94 | 0.16 |
| 3 | 941 | 1,543 | 1,016 | 488 | 75 | 602 | 75 | -453 | -866 | 1.6 | 1.1 | 0.52 | 0.08 |
| 4 | 1,990 | 9,704 | 5,771 | 1,838 | 270 | 7,714 | 3,781 | -152 | -1,721 | 4.9 | 2.9 | 0.92 | 0.14 |
| 5 | 2,931 | 10,853 | 6,396 | 1,939 | 341 | 7,922 | 3,465 | -992 | -2,590 | 3.7 | 2.2 | 0.66 | 0.12 |
| 5 (long term) | 6,377 | 10,853 | 6,396 | 1,939 | 341 | 4,476 | 19 | -4,437 | -6,035 | 1.7 | 1.0 | 0.30 | 0.05 |
| **Lower estimates, with rolling forward** | | | | | | | | | | | | | |
| 1 | 1,279 | 7,234 | 4,302 | 1,371 | 208 | 5,955 | 3,024 | 92 | -1,071 | 5.7 | 3.4 | 1.07 | 0.16 |
| 2a/2b | 712 | 3,140 | 1,922 | 704 | 120 | 2,429 | 1,211 | -7 | -592 | 4.4 | 2.7 | 0.99 | 0.17 |
| 3 | 941 | 1,628 | 1,071 | 515 | 79 | 687 | 131 | -426 | -862 | 1.7 | 1.1 | 0.55 | 0.08 |
| 4 | 1,990 | 10,227 | 6,078 | 1,930 | 276 | 8,237 | 4,088 | -60 | -1,715 | 5.1 | 3.1 | 0.97 | 0.14 |
| 5 | 2,931 | 11,438 | 6,737 | 2,037 | 351 | 8,507 | 3,806 | -894 | -2,580 | 3.9 | 2.3 | 0.69 | 0.12 |
| 5 (long term) | 6,377 | 11,438 | 6,737 | 2,037 | 351 | 5,062 | 361 | -4,340 | -6,026 | 1.8 | 1.1 | 0.32 | 0.06 |

**Table 8.11 (Sheet 2)** **Blakedown Brook : Summary of Costs and Benefits**

**(£ 000 Q4 1997 expressed as present values)**

| Option | Costs | Benefits | | | | Total NPV | | | | Benefit Cost Ratio | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 6% Discount Rate, 50 year time period | | | | | | | | | | | | |
| | | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use |
| **Upper estimates, no rolling forward** | | | | | | | | | | | | | |
| 1 | 1,388 | 16,136 | 10,154 | 4,171 | 1,730 | 14,748 | 8,766 | 2,784 | 342 | 11.6 | 7.3 | 3.01 | 1.25 |
| 2a/2b | 734 | 7,137 | 4,652 | 2,166 | 939 | 6,403 | 3,917 | 1,432 | 205 | 9.7 | 6.3 | 2.95 | 1.28 |
| 3 | 1,001 | 3,538 | 2,403 | 1,267 | 352 | 2,537 | 1,402 | 266 | -649 | 3.5 | 2.4 | 1.27 | 0.35 |
| 4 | 2,122 | 22,772 | 14,306 | 5,841 | 2,369 | 20,649 | 12,184 | 3,718 | 246 | 10.7 | 6.7 | 2.75 | 1.12 |
| 5 | 3,124 | 25,393 | 15,800 | 6,207 | 2,669 | 22,269 | 12,676 | 3,083 | -454 | 8.1 | 5.1 | 1.99 | 0.85 |
| 5 (long term) | 6,855 | 25,393 | 15,800 | 6,207 | 2,669 | 18,538 | 8,945 | -648 | -4,186 | 3.7 | 2.3 | 0.91 | 0.39 |
| **Upper estimates, with rolling forward** | | | | | | | | | | | | | |
| 1 | 1,388 | 17,323 | 10,875 | 4,427 | 1,795 | 15,935 | 9,487 | 3,039 | 407 | 12.5 | 7.8 | 3.19 | 1.29 |
| 2a/2b | 734 | 7,663 | 4,984 | 2,305 | 982 | 6,928 | 4,249 | 1,570 | 247 | 10.4 | 6.8 | 3.14 | 1.34 |
| 3 | 1,001 | 3,814 | 2,590 | 1,366 | 379 | 2,812 | 1,589 | 365 | -622 | 3.8 | 2.6 | 1.36 | 0.38 |
| 4 | 2,122 | 24,447 | 15,322 | 6,198 | 2,456 | 22,324 | 13,200 | 4,075 | 333 | 11.5 | 7.2 | 2.92 | 1.16 |
| 5 | 3,124 | 27,272 | 16,932 | 6,593 | 2,779 | 24,148 | 13,808 | 3,469 | -344 | 8.7 | 5.4 | 2.11 | 0.89 |
| 5 (long term) | 6,855 | 27,272 | 16,932 | 6,593 | 2,779 | 20,417 | 10,077 | -262 | -4,076 | 4.0 | 2.5 | 0.96 | 0.41 |
| **Central estimates, no rolling forward** | | | | | | | | | | | | | |
| 1 | 1,388 | 12,513 | 7,727 | 2,941 | 907 | 11,125 | 6,339 | 1,554 | -481 | 9.0 | 5.6 | 2.12 | 0.65 |
| 2a/2b | 734 | 5,469 | 3,481 | 1,493 | 470 | 4,735 | 2,747 | 758 | -264 | 7.4 | 4.7 | 2.03 | 0.64 |
| 3 | 1,001 | 2,742 | 1,834 | 926 | 163 | 1,741 | 833 | -76 | -839 | 2.7 | 1.8 | 0.92 | 0.16 |
| 4 | 2,122 | 17,682 | 10,910 | 4,137 | 1,244 | 15,560 | 8,787 | 2,015 | -879 | 8.3 | 5.1 | 1.95 | 0.59 |
| 5 | 3,124 | 19,687 | 12,013 | 4,339 | 1,391 | 16,564 | 8,889 | 1,215 | -1,733 | 6.3 | 3.8 | 1.39 | 0.45 |
| 5 (long term) | 6,855 | 19,687 | 12,013 | 4,339 | 1,391 | 12,832 | 5,158 | -2,516 | -5,464 | 2.9 | 1.8 | 0.63 | 0.20 |
| **Central estimates, with rolling forward** | | | | | | | | | | | | | |
| 1 | 1,388 | 13,441 | 8,283 | 3,124 | 931 | 12,053 | 6,895 | 1,736 | -457 | 9.7 | 6.0 | 2.25 | 0.67 |
| 2a/2b | 734 | 5,875 | 3,732 | 1,589 | 486 | 5,141 | 2,997 | 854 | -248 | 8.0 | 5.1 | 2.16 | 0.66 |
| 3 | 1,001 | 2,956 | 1,977 | 998 | 175 | 1,954 | 975 | -4 | -826 | 3.0 | 2.0 | 1.00 | 0.18 |
| 4 | 2,122 | 18,993 | 11,694 | 4,394 | 1,276 | 16,871 | 9,571 | 2,272 | -847 | 8.9 | 5.5 | 2.07 | 0.60 |
| 5 | 3,124 | 21,155 | 12,883 | 4,611 | 1,434 | 18,031 | 9,759 | 1,488 | -1,690 | 6.8 | 4.1 | 1.48 | 0.46 |
| 5 (long term) | 6,855 | 21,155 | 12,883 | 4,611 | 1,434 | 14,300 | 6,028 | -2,244 | -5,421 | 3.1 | 1.9 | 0.67 | 0.21 |
| **Lower estimates, no rolling forward** | | | | | | | | | | | | | |
| 1 | 1,388 | 8,831 | 5,241 | 1,652 | 228 | 7,443 | 3,853 | 264 | -1,160 | 6.4 | 3.8 | 1.19 | 0.16 |
| 2a/2b | 734 | 3,833 | 2,342 | 851 | 135 | 3,099 | 1,608 | 116 | -600 | 5.2 | 3.2 | 1.16 | 0.18 |
| 3 | 1,001 | 1,993 | 1,312 | 630 | 96 | 992 | 310 | -371 | -905 | 2.0 | 1.3 | 0.63 | 0.10 |
| 4 | 2,122 | 12,485 | 7,405 | 2,326 | 301 | 10,362 | 5,283 | 203 | -1,822 | 5.9 | 3.5 | 1.10 | 0.14 |
| 5 | 3,124 | 13,968 | 8,212 | 2,456 | 393 | 10,844 | 5,088 | -667 | -2,731 | 4.5 | 2.6 | 0.79 | 0.13 |
| 5 (long term) | 6,855 | 13,968 | 8,212 | 2,456 | 393 | 7,113 | 1,357 | -4,399 | -6,462 | 2.0 | 1.2 | 0.36 | 0.06 |
| **Lower estimates, with rolling forward** | | | | | | | | | | | | | |
| 1 | 1,388 | 9,509 | 5,640 | 1,771 | 236 | 8,121 | 4,252 | 383 | -1,152 | 6.9 | 4.1 | 1.28 | 0.17 |
| 2a/2b | 734 | 4,128 | 2,520 | 913 | 141 | 3,393 | 1,786 | 178 | -593 | 5.6 | 3.4 | 1.24 | 0.19 |
| 3 | 1,001 | 2,148 | 1,414 | 679 | 104 | 1,147 | 412 | -322 | -897 | 2.1 | 1.4 | 0.68 | 0.10 |
| 4 | 2,122 | 13,443 | 7,969 | 2,494 | 311 | 11,321 | 5,846 | 371 | -1,811 | 6.3 | 3.8 | 1.18 | 0.15 |
| 5 | 3,124 | 15,042 | 8,838 | 2,635 | 410 | 11,918 | 5,715 | -489 | -2,714 | 4.8 | 2.8 | 0.84 | 0.13 |
| 5 (long term) | 6,855 | 15,042 | 8,838 | 2,635 | 410 | 8,187 | 1,983 | -4,220 | -6,445 | 2.2 | 1.3 | 0.38 | 0.06 |

The overall results are highly sensitive to the assumptions regarding non-use benefits, with benefit cost ratios generally in the range from 1.6 to around 13 when the full non-use benefits are included. If only 50% of the non-local non-use benefits are included, the benefit cost ratio reduces to the range 1.5 to 6.0 with the central estimates. If no non-use benefits are included the NPV becomes negative in many of the cases considered, the exceptions being Options 1, 2a/ 2b and 4 with the upper bound estimates.

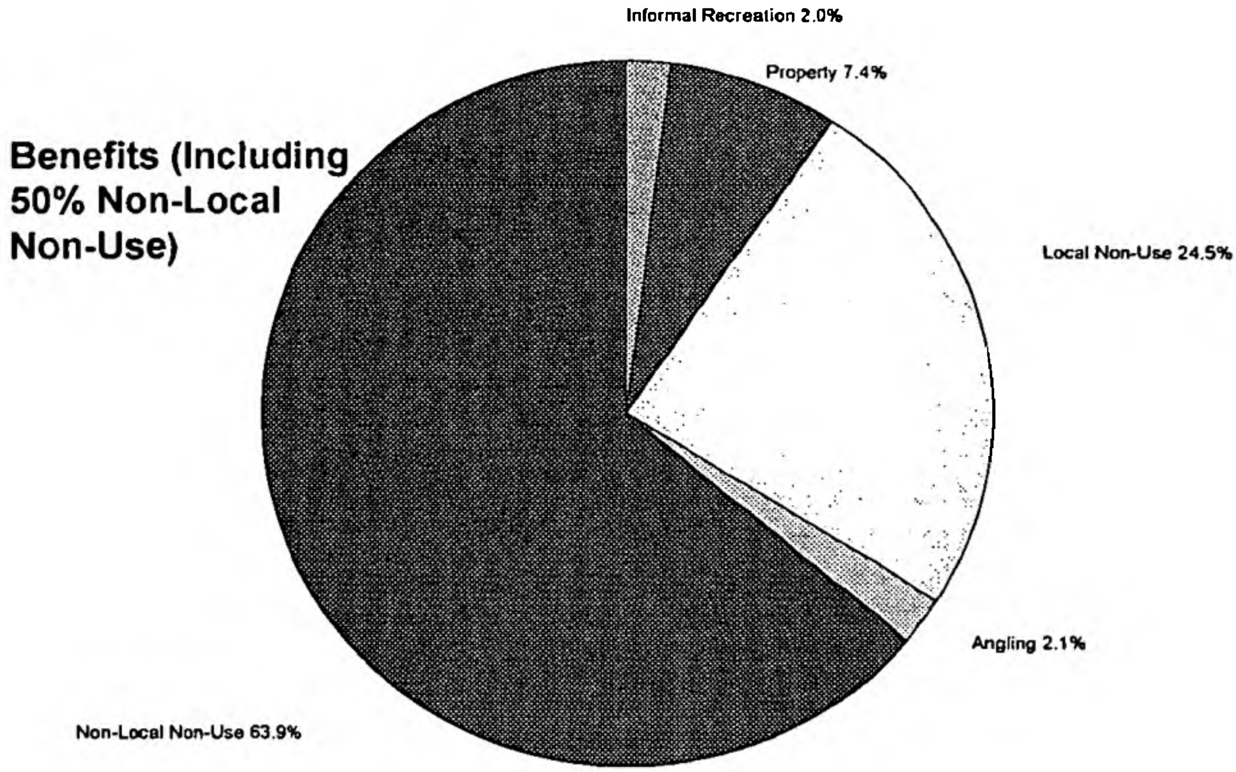
A summary of the assessment of tangibles (i.e the quantifiable costs and benefits) for the options is presented in Table 8.12. For this analysis, which has been carried forward to the Summary Business Case, the economic benefit has been determined on the following basis:

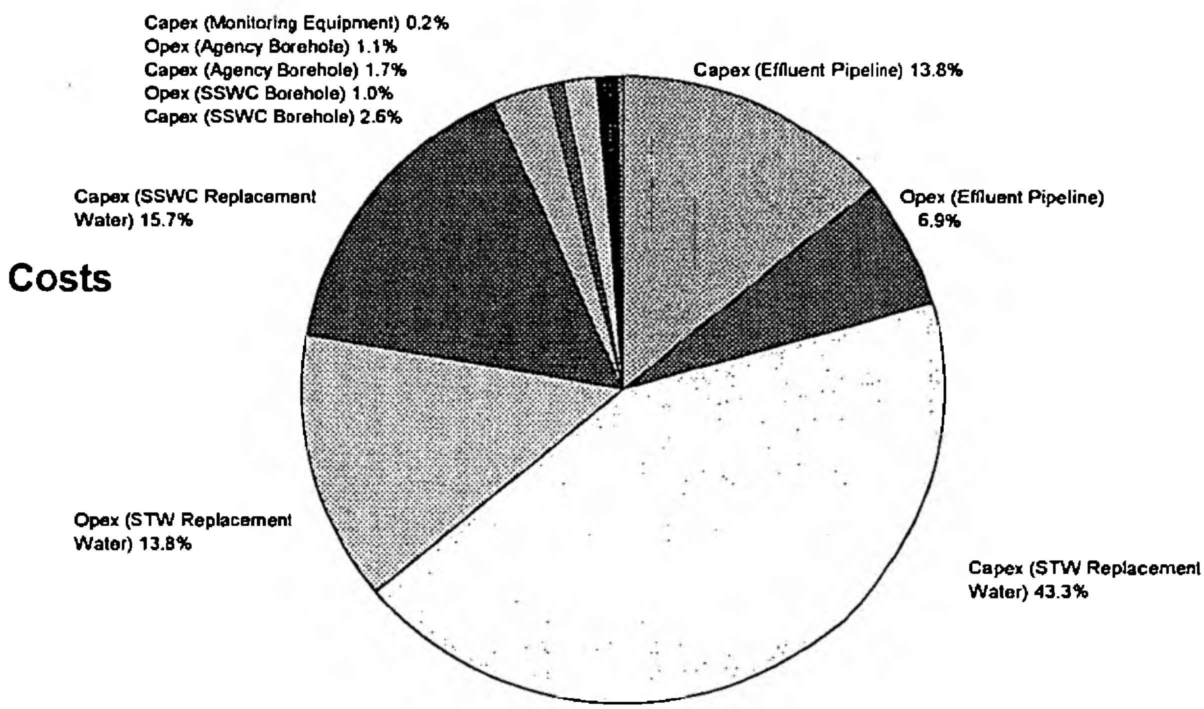
- including 50% of the general public (i.e. non-local) non-use benefits
- central estimates without rolling forward of the benefits.

**Table 8.12 Assessment of Tangibles (£000 Q4 1997)**

| Option | Agency Costs | Water Co. Costs | Economic Benefit | Net Present Value | Benefit Cost Ratio |
|---|---|---|---|---|---|
| 6% discount rate, 50 year time period | | | | | |
| **Do Nothing** | 0 | 0 | 0 | 0 | 0 |
| **Option 1** | 0 | 1,388 | 7,727 | 6,339 | 5.6 |
| **Option 2a** | 0 | 734 | 3,481 | 2,747 | 4.7 |
| **Option 2b** | 0 | 734 | 3,481 | 2,747 | 4.7 |
| **Option 3** | 187 | 814 | 1,834 | 833 | 1.8 |
| **Option 4** | 0 | 2,122 | 10,910 | 8,787 | 5.1 |
| **Option 5** | 187 | 2,936 | 12,013 | 8,889 | 3.8 |
| **Option 5 (long term)** | 201 | 6,654 | 12,013 | 5,158 | 1.8 |
| 7% discount rate, 30 year time period | | | | | |
| **Do Nothing** | 0 | 0 | 0 | 0 | 0 |
| **Option 1** | 0 | 1,279 | 6,115 | 4,836 | 4.8 |
| **Option 2a** | 0 | 712 | 2,753 | 2,041 | 3.9 |
| **Option 2b** | 0 | 712 | 2,753 | 2,041 | 3.9 |
| **Option 3** | 170 | 771 | 1,420 | 479 | 1.5 |
| **Option 4** | 0 | 1,990 | 8,633 | 6,642 | 4.3 |
| **Option 5** | 170 | 2,761 | 9,487 | 6,556 | 3.2 |
| **Option 5 (long term)** | 184 | 6,193 | 9,487 | 3,110 | 1.5 |

A breakdown of the total present value of the benefits for Option 5 (long term) by use category (central estimates, including 50% of the non-local non-use benefits) with the 6% Treasury discount rate, with no rolling forward, is shown on Figure 8.2, together with a breakdown of the present value of the costs.




Note: The area of the circles is proportional to the present value of the benefits or costs at a 6% discount rate

**Blakedown Brook Option 5 (long term)**
**Present Value of Benefits and Costs**
**Figure 8.2**

## 8.6 Assessment of Intangibles

The assessment of intangible benefits has been undertaken by a weighting and scoring system and is presented in Table 8.13. The intangibles considered in the table are:

1. Facilitation of Agency meeting objectives
2. Improved public relations and maintenance of credibility of Agency
3. Longer term benefits not quantified in economic analysis
4. Flexibility of location of release point to ensure short term objective of re-watering critical locations is more likely to be achieved

Each of the intangible benefits has been allocated a weighting within the range from 5 to 0 (from most important to least important). Scores reflecting the ability of each option to deliver the intangible benefit have been allocated from 5 to 0 (from greatest ability to least ability).

## 8.7 Risk Assessment

A risk assessment of the options has been undertaken and the results tabulated in a "Risk Register" (Table 8.14). The risks considered to be relevant in the appraisal are:

| | |
|---|---|
| Risk 1 | Operational failure of flow alleviation |
| Risk 2 | Failure to provide anticipated benefits |
| Risk 3 | Failure to supply a sustainable solution |

Within the Risk Register the likelihood of the risk happening, and the consequent effect on the solution, are classified as "high", "medium" or "low".

**Table 8.13 Assessment of Intangible Benefits**

| Intangible Benefit | Weighting Factor | Option 1<br>3 Ml/d effluent release at Hagley STW | | Option 2a<br>2 Ml/d release at Churchill (existing b'h) | | Option 2b<br>2 Ml/d release at Churchill (new b'h) | | Option 3<br>1 Ml/d release at Windmill Pool | | Option 4<br>Options 1 + 2b | | Option 5<br>Options 1 + 2b + 3 | | Option 5 (long term)<br>Options 1 + 2b + 3 + additional costs | | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | points | weighted points | points | weighted points | points | weighted points | points | weighted points | points | weighted points | points | weighted points | points | weighted points | |
| 1 | 3 | 2 | 6 | 2 | 6 | 2 | 6 | 3 | 9 | 2 | 6 | 4 | 12 | 5 | 15 | Related to the extent of flow improvement |
| 2 | 3 | 2 | 6 | 2 | 6 | 2 | 6 | 3 | 9 | 3 | 9 | 4 | 12 | 5 | 15 | |
| 3 | 3 | 1 | 3 | 2 | 6 | 2 | 6 | 1 | 3 | 2 | 6 | 3 | 9 | 5 | 15 | Limited recovery of groundwater levels, except for Option 5 (long term) |
| 4 | 2 | | | | | 4 | 8 | 4 | 8 | 4 | 8 | 4 | 8 | 4 | 8 | Only Options 2b and 3 give flexibility |
| Total weighted score | | | 15 | | 18 | | 26 | | 29 | | 29 | | 41 | | 53 | |

Intangible Benefit 1: Facilitation of Agency meeting objectives
Intangible Benefit 2: Improved public relations and maintenance of credibility of Agency
Intangible Benefit 3: Longer term benefits not quantified in economic analysis
Intangible Benefit 4: Flexibility of location of release point to ensure short term objective of re-watering critical locations is more likely to be achieved

**Table 8.14 Risk Register**

| Identified Risk | Option 1<br>3 Ml/d effluent release at Hagley STW | | Option 2a<br>2 Ml/d release at Churchill (existing b'h) | | Option 2b<br>2 Ml/d release at Churchill (new b'h) | | Option 3<br>1 Ml/d release at Windmill Pool | | Option 4<br>Options 1 + 2b | | Option 5<br>Options 1 + 2b + 3 | | Option 5 (long term)<br>Options 1 + 2b + 3 + additional costs | | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Likelihood | Effect | Likelihood | Effect | Likelihood | Effect | Likelihood | Effect | Likelihood | Effect | Likelihood | Effect | Likelihood | Effect | |
| Operational failure of flow alleviation | L | L | L | L | L | L | L | L | L | L | L | L | L | L | |
| Failure to provide anticipated benefits | M | M | M | M | M | M | M | M | M | M | M | M | L | L | Recovery of groundwater levels will be achieved sooner with Option 5 (long term) |
| Failure to supply a sustainable solution | L | L | M | M | M | M | M | M | M | M | M | M | L | L | |

Relative risks: H high M medium L low

## 8.8 Selection of Preferred Option

From the assessment of tangibles presented in Table 8.12 it can be seen that each of the individual options is justifiable in its own right and therefore the combination of the three in Option 5 represents the most cost effective solution in terms of maximum net present value (NPV). This conclusion is supported by the assessment of intangibles.

Although there is no distinction between Options 2a and 2b in economic terms, Table 8.13 confirms that Option 2b is to be preferred, since there is flexibility as to the location of the release point to ensure that the short term objective of re-watering critical locations at the SSSIs is more likely to be achieved (See English Nature document "AMP3 Scheme Proposed and Benefit SSSI").

However, without further allowance for the longer term reduction in groundwater abstractions, Options 2a/b and 3 may not be sustainable or compatible with the long term objective of a recovery of groundwater levels. This is reflected in the assessment of intangibles and the risk register in Tables 8.13 and 8.14. Only Option 5 (long term) is shown as having a low risk of failing to provide the anticipated benefits and a low risk of not supplying a sustainable solution. Reductions in abstractions have already been agreed with both water companies. The results from the West Midlands Groundwater Model, which is under development at present, will be used to address the long term sustainability of the present abstraction requirements.

**It is therefore concluded that Option 5 (long term), incorporating Options 1, 2b and 3 and including a total reduction in PWS groundwater abstractions of 10 Ml/d, should be selected as the preferred option.**

The STW effluent discharge will maintain enhanced flows in the brook over a 4 km stretch, with significantly increased flows over a further 3.5 km which includes the SSSIs. This will be supplemented by the release from a new borehole which will be sited to ensure that the SSSIs will benefit from the increased flows. The compensation release to Windmill Pool will maintain levels in the pool. In the longer term with reduced abstractions, rising groundwater levels should restore baseflows to the brook and its tributaries, with a subsequent reduction in the requirements for compensation releases.

The important wet valley alder carr habitats of the SSSIs will be safeguarded by the addition of the compensation flows.

The assessed economic benefit takes account of these ecological improvements in addition to the increase in the amenity and recreational value of the area surrounding the watercourses.

## 8.9 Tasks and Dependencies

| | | |
|---|---|---|
| Investigations: | Agency Midlands Region | Upper Severn Area<br>Regional Office |
| Design and implementation: | Severn Trent Water Ltd<br>South Staffordshire Water Company Ltd<br>Agency Midlands Region | <br><br>Upper Severn Area<br>Regional Office |

**Programme for implementation of the preferred option:**

| | |
|---|---|
| 1998 | Submission of Business Plan |
| 1999 | Construction of effluent pipeline from Roundhill WTW (Option 1)<br>Investigation and Design<br>Planning and Consents |
| 2000 | Construction of Agency borehole at Windmill Pool (Option 3) |
| 2001 | Construction of SSWC borehole near Churchill (Option 2b) |

## 8.10 Cost of Preferred Option

The estimated capital and operating costs of the preferred option are given in Table 8.15. The estimates of likely future capital costs are based on the assumption that the Construction Output Index (COPI) will rise by 4 per cent per annum. In the estimation of operating costs an annual increase of 2.5 per cent per annum in the Retail Price Index (RPI) has been assumed.

**Table 8.15 Estimated Costs of the Preferred Option (£ 000)**

| Year | Water Company | | Agency | |
|---|---|---|---|---|
| ending 31/03 | Capex | Opex | Capex | Opex |
| 1999 | 0 | 0 | 4[1] | 0 |
| 2000 | 1,082 | 32 | 16[2] | 0 |
| 2001 | 776 | 44 | 135[4] | 5[4] |
| 2002 | 819 | 51 | 0 | 6[4] |
| 2003 | 4,268[3] | 120[3] | 0 | 6[4] |

[1] Comprises submission of business plan, the cost of which has not been included in the assessment of tangibles
[2] Comprises installation of monitoring equipment
[3] Long term replacement water costs could be deferred subject to supply/demand balance
[4] Agency costs for new borehole to be recharged to STW Ltd under AMP3

# 9 BOW BROOK

## 9.1 Scheme Objectives

During the late 1980s problems with low flow were identified on the upper reaches of the Bow Brook, mainly above Priest Bridge. The area is illustrated on Figure 9.1. The reduction in flow is due to two main reasons:

- closure of small sewage treatment works on the Bow Brook tributaries; and
- reduction in base flows as a result of over-abstraction of groundwater from the Bromsgrove aquifer for public consumption.

The schemes considered for the alleviation of low flows in Bow Brook are summarised in Table 9.1. They involve a reduction in the abstraction for public water supply at the existing Webheath groundwater pumping station and augmentation of the river system from groundwater. The augmentation point would be at the Webheath pumping station as agreed with Severn Trent Water Ltd and shown on Figure 9.1. The Agency considers that a 2 Ml/d compensation release will make up the deficit in flow. In the longer term it is intended to reduce groundwater abstraction from the Bromsgrove aquifer to a sustainable level. However, it is likely that the use of compensation releases to maintain an acceptable flow regime on this watercourse will prove to be the best medium to long term solution.

**Table 9.1 Low Flow Alleviation Options**

| Option | Description | Improvements |
|---|---|---|
| 1 | Compensation release of 2 Ml/d to be in operation when the Agency gauging station at Besford Bridge is at Q20% (105 Ml/d) or below | Rewater 2.6 km, significantly increased flows 32 km. |
| 2 | Compensation release of 2 Ml/d to be in operation when the Agency gauging station at Besford Bridge is at Q50% (33.5 Ml/d) or below | Rewater 2.6 km, significantly increased flows 32 km. |

Flow duration/frequency curves were provided by the Agency to define the impact of the alleviation options and these are included in Appendix 9. Tabulated mean daily flows for 1990 to 1997 are also included in the Appendix. Most of the available data relates to the gauging station at Besford Bridge which is towards the lower end of the catchment, some 4 km upstream of the confluence with the River Avon south of Pershore. The Agency has also derived a duration/frequency graph for Old Yarr Bridge.

The available information has been used to derive appropriate factors for the economic benefits of each option for those uses which are frequency and duration dependent. The river has been divided into three reaches for this purpose:

| | |
|---|---|
| Reach 1 | Webheath to Elcock's Brook, which is thought to be the lower limit of zero flows (2.6 km) |
| Reach 2 | Elcock's Brook to Priest Bridge (8 km) |
| Reach 3 | Priest Bridge to the confluence with the Avon near Defford (24 km) |

Target flows for each reach have been assessed to determine the extent to which the low flow alleviation schemes will improve the situation. Flow improvement factors have been derived from a consideration of both the **proportional flow** improvement from the existing situation at the Q95% level, and the **proportional time** improvement that the target flow is achieved. Corresponding return periods for very low flows (i.e. about 50% of the target flows) have also been assessed for the before and after situations. The figures which have been derived are summarised in Table 9.2.

**Table 9.2 Summary of Hydrological Assessment for Bow Brook**

| | Reach 1 | Reach 2 | Reach 3 |
|---|---|---|---|
| **Target Flow (Ml/d)** | 2 | 4 | 7 |
| **% of Time above Target** | | | |
| **Before** | 25% | 25% | 55% |
| **After** Option 1 | 98% | 90% | 92% |
| Option 2 | 75% | 70% | 87% |
| **Flow Improvement Factor** | | | |
| Option 1 | 80% | 70% | 40% |
| Option 2 | 65% | 55% | 35% |
| **Return Period (years)** before → after | | | |
| Option 1 | 1 → 8 | 1 → 7 | 4 → 6 |
| Option 2 | 1 → 7 | 1 → 6 | 4 → 5 |

## 9.2 Scope of Study

Table 9.3 has been used as a checklist to focus on those impacts which are likely to be significant and need to be included in the economic appraisal.

There are three surface water abstraction licences granted on Bow Brook, only one of which is used for agriculture. Of the remaining two, one is used to supply the reservoir at Norgrove Court and the other to form an amenity lake.

Restoration of the flow will improve the continuity of the brook's linear wildlife habitat, which at present is not complete due to the brook periodically suffering extremely low flows.

The categories that have been included in the benefit assessment are:

- informal recreation;
- angling;
- agriculture;
- property;
- drinking water supply resource cost savings; and
- non-use.

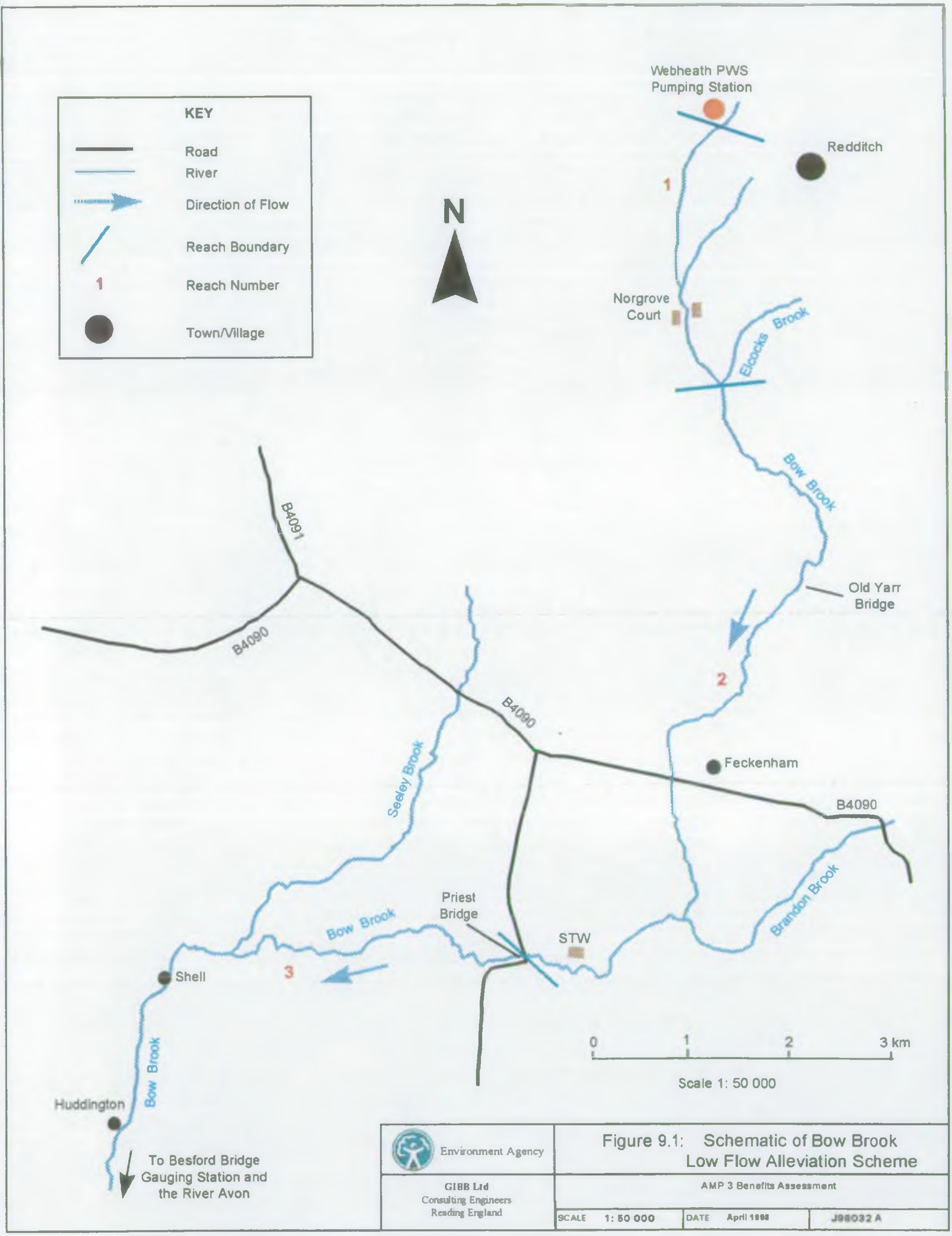



Figure 9.1: Schematic of Bow Brook Low Flow Alleviation Scheme

**Table 9.3 Summary of Impacts**

| Impact Category | | Comments |
|---|---|---|
| Drinking Water Supply | | Increased flow available for PWS abstraction downstream. |
| Industrial Abstraction | | Not applicable |
| Agriculture | Livestock | Not applicable |
| | Irrigation | Yes |
| In-stream Recreation | Boating | Not applicable |
| | Bathing | Not applicable |
| | Angling | Yes |
| Informal recreation | Walking, picnicking, photography | Yes, a dense network of footpaths with some direct access along the brook. |
| Amenity /Aesthetics | Property prices | A number of properties overlooking the brook. |
| Conservation (Non-Use or Passive Use) | Ecology | Yes |
| | Heritage | Not applicable |
| Other | | None |

Although the additional flow will provide some extra dilution to the discharge from the existing STW at Priest Bridge, the Agency water quality staff do not anticipate that consent conditions could be relaxed. No additional economic benefits due to water quality improvements can therefore be identified.

## 9.3 Capital and Operating Costs

Severn Trent Water Ltd has provided the Agency with estimates of the capital expenditure (capex) and operating expenditure (opex) necessary to provide for the replacement of the 2 Ml/d of water currently abstracted at the Webheath pumping station which would be diverted to Bow Brook. In addition some minor works will be required in the vicinity of the pumping station to effect the flow augmentation. Details of the costs are included in Appendix 9 and summarised in Table 9.4.

**Table 9.4 Summary of Cost Estimates (£ 000 Q4 1997)**

| | Option 1 | Option 2 |
|---|---|---|
| **Capital expenditure** | | |
| Replacement water | 1379 | 1379 |
| PWS option | 10 | 10 |
| Monitoring equipment | 15 | 15 |
| Total | 1404 | 1404 |
| **Operating expenditure (per annum)** | | |
| Replacement water | 23 | 14 |
| PWS Option | 12 | 8 |
| Total | 35 | 22 |

## 9.4 Estimation of Benefits

### 9.4.1 Informal Recreation

Attempts were made to obtain primary data on visitor numbers to this area by contacting the local Ramblers Association representative. Unfortunately no numbers were available. In the absence of reliable primary sources the estimation of visitor numbers to the sites has been based on the indirect approach outlined in the Agency Guidelines, related to the population within 0.8 km of the river, obtained from the Agency's GIS system. However, in the absence of any facilities to qualify as a 'honeypot' site and with no local parks in the vicinity of the river, realistic estimates of the likely number of visits have been derived from previous experience, utilising the GIS data to distribute the numbers between the river reaches.

As the informal recreational activities are unpriced there is no economic rent or profit earned by the activity. The total value of the recreational activity is measured in consumer surplus or the difference between what the consumer pays for the activity (zero) and what they would be willing to pay. The Guidelines recommend the following per visit estimates of the consumer surplus, assuming that 40% of the willingness-to-pay is attributable to the presence of water:

- Upper bound estimate: £1.48 per visitor day;
- Central estimate: £0.60 per visitor day; and
- Lower bound estimate: £0.20 per visitor day.

Combining participation rates and willingness-to-pay with the flow improvement factors from Table 9.2 produces the annual incremental benefits which are presented in Table 9.5.

**Table 9.5 Annual Informal Recreation Benefits**

| | Option | Visitor Numbers by River Reach (000) | | | Factored Benefit by River Reach (£000 Q4 1997) | | | |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 1 | 2 | 3 | Total |
| **Upper Bound** | 1 | 23 | 19 | 28 | 27 | 20 | 16 | 64 |
| | 2 | 23 | 19 | 28 | 22 | 16 | 14 | 52 |
| **Central Estimate** | 1 | 18 | 15 | 21 | 9 | 6 | 5 | 20 |
| | 2 | 18 | 15 | 21 | 7 | 5 | 4 | 16 |
| **Lower Bound** | 1 | 14 | 12 | 17 | 2 | 2 | 1 | 5 |
| | 2 | 14 | 12 | 17 | 2 | 1 | 1 | 4 |

### 9.4.2 Angling

Discussions with Agency staff revealed that there are few angling interests on the Bow Brook, although there are some brown trout in the upper reaches. The view was that the Brook would be unlikely to attract fishermen even if the low flows were alleviated. There are other fisheries, both coarse and salmonid, in the area which would act as substitute sites for the Brook.

The only existing fishery on the Brook is at Norgrove Court which abstracts from the Brook to fill a reservoir used as a trout fishery. Although the owners have been aware of low flows during the summer months this has not manifested itself as fish mortalities and has not limited the amount of angling undertaken. The syndicate which fishes the lake has a maximum desired membership of twenty and would not expect to increase this if the low flows were alleviated.

The Worcester and District Angling Club used to fish the lower reaches of the Brook, upstream of the confluence with the River Avon. The fishing here was eventually found not to be financially viable so the club gave up the rights to fish. According to the club contact this situation is unlikely to change with the alleviation of low flows in the Brook.

It is therefore assumed that there are no angling benefits to be gained on Bow Brook.

### 9.4.3 Agriculture

There is one surface water abstraction licence granted for agricultural use on Bow Brook, at Upper Wolverton Farm, Spetchley. Discussion with the farmer ascertained that the licence is only used in an emergency, and that reliance is placed on a storage reservoir filled from land drains to provide irrigation water. There is effectively no abstraction on this licence and therefore no benefits to be gained by improving the flows in the Brook.

### 9.4.4 Property

Hereford & Worcester County Council was contacted to provide Council Tax Bands for the properties identified as adjacent to the watercourses. These are summarised in Table 9.6.

**Table 9.6 Properties Adjacent to Bow Brook by Council Tax Band**

| Band | 1997 Midpoint (£ 000) | No of properties | | | | Economic Value (£ 000 Q4 1997) |
|---|---|---|---|---|---|---|
| | | Reach 1 | Reach 2 | Reach 3 | Total | |
| A | 40 | 0 | 0 | 0 | 0 | 0 |
| B | 46 | 0 | 1 | 0 | 1 | 46 |
| C | 61 | 0 | 0 | 0 | 0 | 0 |
| D | 79 | 0 | 1 | 0 | 1 | 79 |
| E | 105 | 1 | 0 | 0 | 1 | 105 |
| F | 141 | 0 | 0 | 5 | 5 | 707 |
| G | 242 | 0 | 6 | 6 | 12 | 2,908 |
| H | 323 | 1 | 0 | 1 | 2 | 646 |
| **Total** | | **2** | **8** | **12** | **22** | **4,491** |

Source: Hereford & Worcester County Council

By applying the formulae given in the Benefit Assessment Guidelines, using the assumed changes in return periods for the low flows indicated in Table 9.2, the benefit to property owners has been estimated in terms of once-off changes in stock.

**Table 9.7 Amenity and Aesthetic Stock Benefits (£000 Q4 1997)**

| Option | Total Incremental Benefits | | |
|---|---|---|---|
| | Upper Bound | Central Estimate | Lower Bound |
| 1 | 324 | 216 | 43 |
| 2 | 275 | 183 | 37 |

### 9.4.5 Resource Cost Savings

With a quantity of water being added to the Bow Brook there will be a higher discharge to the Avon and Severn which could be available for abstraction for public water supply downstream in preference to pumping from the Shropshire Groundwater Scheme. An earlier assessment by the Agency for the River Worfe indicated that this benefit might be realised on average for some 75 days per year at an estimated value of £19 per Ml. With the 2 Ml/d compensation flow with both options this gives an annual benefit in terms of resource cost savings of £ 2850.

### 9.4.6 Non-Use

Non-use (conservation) benefit estimates for Bow Brook have been derived for:

- local residents within 3 km;
- river users among the general public who do not visit these particular rivers but do hold non-use values towards the alleviation of low flows in rivers; and
- the wider general public who are not river users.

The non-use benefits have been derived using the procedures given in Section 9 of the Benefit Assessment Guidelines.

**Local resident non-use valuation**

It has been assumed that there are just over 20,000 households within 3 km of the low flow site, distributed between the three river reaches as indicated below, based on population data obtained from the Agency GIS model and assuming 2.7 people/household:

| | |
|---|---|
| Reach I | 7,106 |
| Reach 2 | 5,258 |
| Reach 3 | 7,728 |

In accordance with the Guidelines, the following values per household per annum are applied where full low flow alleviation is achieved:

| | |
|---|---|
| Upper Bound | £12.00 |
| Central Estimate | £10.00 |
| Lower Bound | £ 7.00 |

**General public non-use valuation**

It is assumed that there are 3.15 million households within Severn Trent Water's area and that 45% of the population are general river users, from which the actual number of local households already included are subtracted. The remaining 55% of the population in the service area are taken as non-users for whom a lower scale of benefits applies. The central estimates are based on the figures of £0.05 and £0.03 per household per km of river per annum for full low flow alleviation in accordance with the Guidelines, with +/- 25% for upper and lower bounds.

The annual non-use (conservation) benefit of each option, applying the flow improvement factors from Table 9.2 for each river reach, are summarised in Table 9.8 in terms of the local resident non-use benefits and the full (local resident plus general public non-use) benefits.

**Table 9.8 Annual Non-Use Benefits (£000 Q4 1997)**

| Option | Extent | Upper | Central | Lower |
|---|---|---|---|---|
| 1 | Local | 149 | 125 | 87 |
| | Full | 2,769 | 2,220 | 1,659 |
| 2 | Local | 123 | 102 | 72 |
| | Full | 2,320 | 1,860 | 1,390 |

## 9.5 Assessment of Tangibles (Cost Benefit Analysis)

The costs and the annual benefit streams have been aggregated in terms of present values in accordance with the procedures given in the Benefit Assessment Guidelines. The indicators in terms of net present values (NPV) and benefit cost ratios for the two options are presented in Table 9.9. The results are shown:

- both including and excluding non-use, together with two intermediate figures: one including only 50% of the general public (i.e. non-local) non-use and the other including only local non-use;
- for the central estimates, with upper and lower bounds;
- using the different discount rates and time horizons; and
- with and without rolling forward the benefits.

For all combinations of assumptions Option 1 generates a higher net present value and a higher benefit cost ratio than Option 2. It can therefore be concluded that the incremental benefits of the greater degree of low flow alleviation achieved with the longer duration of pumping with Option 1 are sufficiently great as to justify the incremental operating costs.

The overall results are highly sensitive to the assumptions regarding non-use benefits, with benefit cost ratios in the range 10 to over 20 when the full non-use benefits are included. If only the local non-use benefits are included, the benefit cost ratio reduces to the range 1 to 1.4 with the central estimates. If no non-use benefits are included the NPV becomes negative in all cases considered.

A summary of the assessment of tangibles (i.e the quantifiable costs and benefits) for the two options is presented in Table 9.10. For this analysis, which has been carried forward to the Summary Business Case, the economic benefit has been determined on the following basis:

- including 50% of the general public (i.e. non-local) non-use benefits
- central estimates without rolling forward of the benefits.

A breakdown of the total present value of the benefits by use category for Option 1 (central estimates, including 50% of the non-local non-use benefits) with the 6% Treasury discount rate, with no rolling forward, is shown on Figure 9.2, together with a breakdown of the present value of the costs.

**Table 9.9 (Sheet 1)** **Bow Brook : Summary of Costs and Benefits**

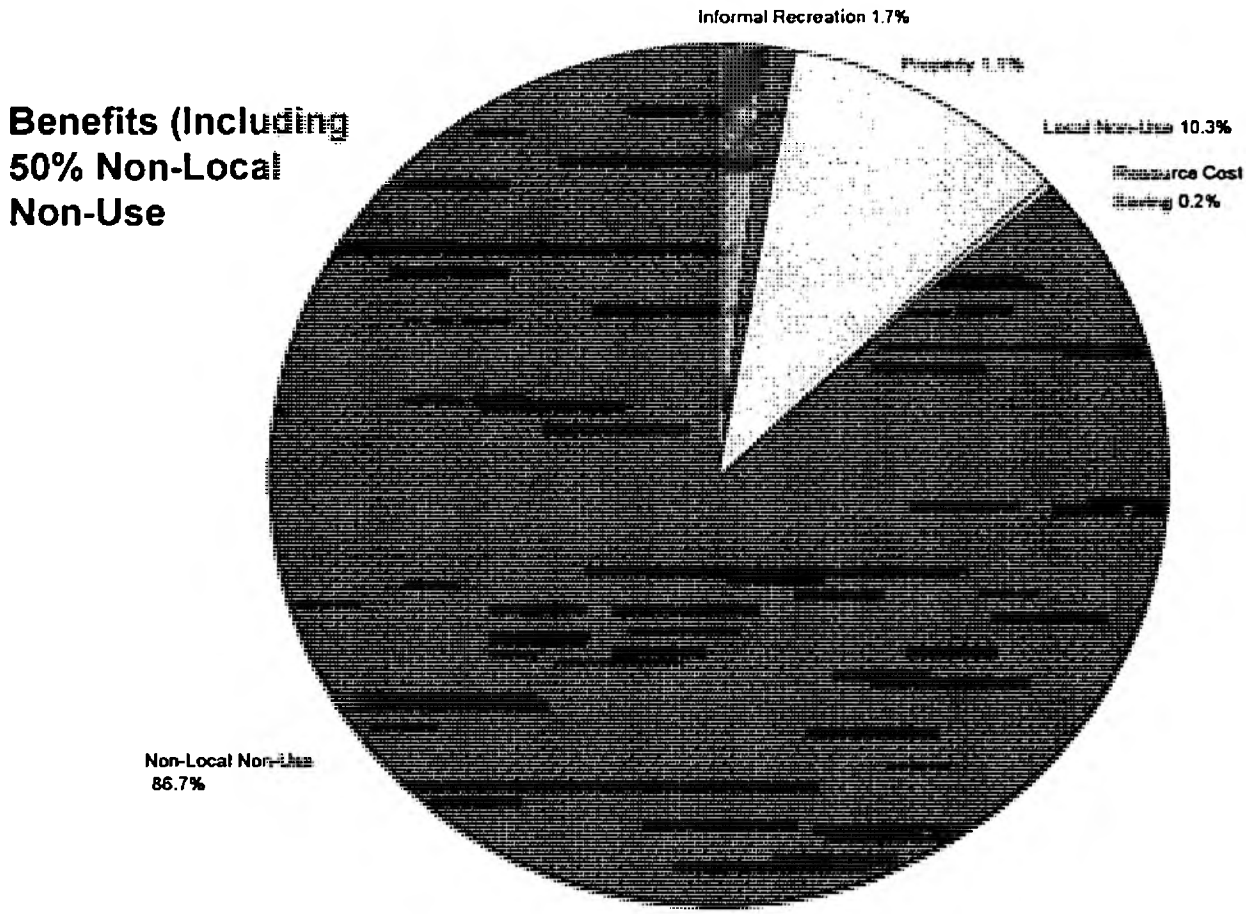
**(£ 000 Q4 1997 expressed as present values)**

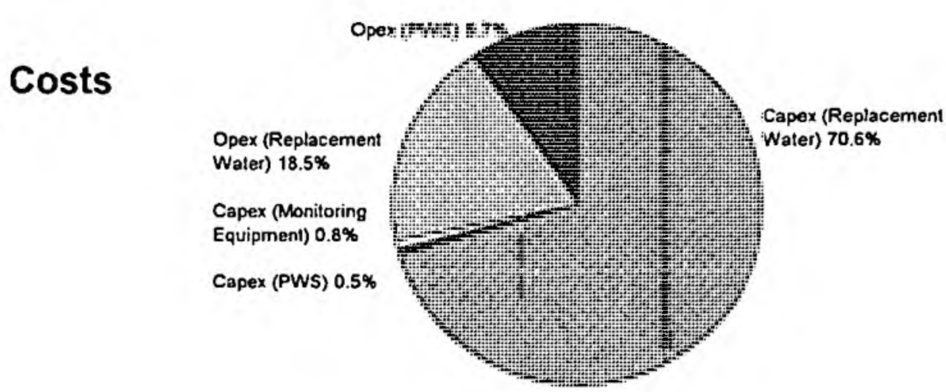
| Option | 7% Discount Rate, 30 year time period | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Costs | Benefits | | | | Total NPV | | | | Benefit Cost Ratio | | | |
| | | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use |
| **Upper estimates, no rolling forward** | | | | | | | | | | | | | |
| 1 | 1,714 | 32,823 | 17,794 | 2,764 | 1,049 | 31,110 | 16,080 | 1,050 | -665 | 19.2 | 10.4 | 1.61 | 0.61 |
| 2 | 1,565 | 27,490 | 14,885 | 2,281 | 874 | 25,926 | 13,321 | 716 | -691 | 17.6 | 9.5 | 1.46 | 0.56 |
| **Upper estimates, with rolling forward** | | | | | | | | | | | | | |
| 1 | 1,714 | 34,607 | 18,754 | 2,901 | 1,092 | 32,893 | 17,040 | 1,188 | -622 | 20.2 | 10.9 | 1.69 | 0.64 |
| 2 | 1,565 | 28,984 | 15,689 | 2,394 | 910 | 27,419 | 14,124 | 829 | -655 | 18.5 | 10.0 | 1.53 | 0.58 |
| **Central estimates, no rolling forward** | | | | | | | | | | | | | |
| 1 | 1,714 | 25,927 | 13,904 | 1,880 | 451 | 24,214 | 12,190 | 166 | -1,263 | 15.1 | 8.1 | 1.10 | 0.26 |
| 2 | 1,565 | 21,721 | 11,637 | 1,553 | 381 | 20,156 | 10,072 | -12 | -1,184 | 13.9 | 7.4 | 0.99 | 0.24 |
| **Central estimates, with rolling forward** | | | | | | | | | | | | | |
| 1 | 1,714 | 27,338 | 14,656 | 1,973 | 466 | 25,624 | 12,942 | 260 | -1,248 | 16.0 | 8.6 | 1.15 | 0.27 |
| 2 | 1,565 | 22,902 | 12,266 | 1,630 | 394 | 21,338 | 10,701 | 65 | -1,171 | 14.6 | 7.8 | 1.04 | 0.25 |
| **Lower estimates, no rolling forward** | | | | | | | | | | | | | |
| 1 | 1,714 | 19,168 | 10,150 | 1,132 | 132 | 17,454 | 8,436 | -581 | -1,582 | 11.2 | 5.9 | 0.66 | 0.08 |
| 2 | 1,565 | 16,061 | 8,499 | 936 | 115 | 14,497 | 6,934 | -629 | -1,449 | 10.3 | 5.4 | 0.60 | 0.07 |
| **Lower estimates, with rolling forward** | | | | | | | | | | | | | |
| 1 | 1,714 | 20,216 | 10,704 | 1,193 | 137 | 18,502 | 8,990 | -521 | -1,577 | 11.8 | 6.2 | 0.70 | 0.08 |
| 2 | 1,565 | 16,939 | 8,962 | 985 | 120 | 15,375 | 7,398 | -579 | -1,445 | 10.8 | 5.7 | 0.63 | 0.08 |

**Table 9.9 (Sheet 2)** **Bow Brook : Summary of Costs and Benefits**

**(£ 000 Q4 1997 expressed as present values)**

| Option | Costs | Benefits | | | | Total NPV | | | | Benefit Cost Ratio | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 6% Discount Rate, 50 year time period | | | | | | | | | | | | |
| | | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use |
| Upper estimates, no rolling forward | | | | | | | | | | | | | |
| 1 | 1,843 | 42,312 | 22,902 | 3,492 | 1,277 | 40,469 | 21,059 | 1,649 | -566 | 23.0 | 12.4 | 1.89 | 0.69 |
| 2 | 1,651 | 35,436 | 19,158 | 2,880 | 1,063 | 33,786 | 17,508 | 1,229 | -587 | 21.5 | 11.6 | 1.74 | 0.64 |
| Upper estimates, with rolling forward | | | | | | | | | | | | | |
| 1 | 1,843 | 45,584 | 24,664 | 3,743 | 1,356 | 43,741 | 22,821 | 1,900 | -487 | 24.7 | 13.4 | 2.03 | 0.74 |
| 2 | 1,651 | 38,177 | 20,631 | 3,086 | 1,128 | 36,526 | 18,981 | 1,436 | -522 | 23.1 | 12.5 | 1.87 | 0.68 |
| Central estimates, no rolling forward | | | | | | | | | | | | | |
| 1 | 1,843 | 33,432 | 17,904 | 2,376 | 531 | 31,589 | 16,061 | 533 | -1,313 | 18.1 | 9.7 | 1.29 | 0.29 |
| 2 | 1,651 | 28,007 | 14,985 | 1,962 | 448 | 26,357 | 13,334 | 311 | -1,202 | 17.0 | 9.1 | 1.19 | 0.27 |
| Central estimates, with rolling forward | | | | | | | | | | | | | |
| 1 | 1,843 | 36,020 | 19,284 | 2,547 | 558 | 34,177 | 17,441 | 704 | -1,285 | 19.5 | 10.5 | 1.38 | 0.30 |
| 2 | 1,651 | 30,175 | 16,139 | 2,103 | 471 | 28,525 | 14,488 | 452 | -1,179 | 18.3 | 9.8 | 1.27 | 0.29 |
| Lower estimates, no rolling forward | | | | | | | | | | | | | |
| 1 | 1,843 | 24,744 | 13,098 | 1,452 | 160 | 22,901 | 11,255 | -391 | -1,683 | 13.4 | 7.1 | 0.79 | 0.09 |
| 2 | 1,651 | 20,733 | 10,967 | 1,200 | 140 | 19,083 | 9,316 | -451 | -1,511 | 12.6 | 6.6 | 0.73 | 0.08 |
| Lower estimates, with rolling forward | | | | | | | | | | | | | |
| 1 | 1,843 | 26,667 | 14,115 | 1,562 | 170 | 24,824 | 12,271 | -281 | -1,673 | 14.5 | 7.7 | 0.85 | 0.09 |
| 2 | 1,651 | 22,345 | 11,818 | 1,291 | 148 | 20,694 | 10,167 | -360 | -1,502 | 13.5 | 7.2 | 0.78 | 0.09 |




Note: The area of the circles is proportional to the present value of the benefits or costs at a 6% discount rate

**Bow Brook Option 1**
**Present Value of Benefits and Costs**
**Figure 9.2**

**Table 9.10 Assessment of Tangibles (£000 Q4 1997)**

| Option | Agency Costs | Water Co. Costs | Economic Benefit | Net Present Value | Benefit Cost Ratio |
|---|---|---|---|---|---|
| 6% discount rate, 50 year time period | | | | | |
| **Do Nothing** | 0 | 0 | 0 | 0 | 0 |
| **Option 1** | 14 | 1,829 | 17,904 | 16,061 | 9.7 |
| **Option 2** | 14 | 1,636 | 14,985 | 13,334 | 9.1 |
| 7% discount rate, 30 year time period | | | | | |
| **Do Nothing** | 0 | 0 | 0 | 0 | 0 |
| **Option 1** | 14 | 1,700 | 13,904 | 12,190 | 8.1 |
| **Option 2** | 14 | 1,551 | 11,637 | 10,072 | 7.4 |

## 9.6 Assessment of Intangibles

The assessment of intangible benefits (or disbenefits) has been undertaken by a weighting and scoring system and is presented in Table 9.11. The intangibles considered in the table are:

1. Facilitation of Agency meeting objectives
2. Improved public relations and maintenance of credibility of Agency
3. Longer term benefits not quantified in economic analysis

Each of the intangible benefits has been allocated a weighting within the range from 5 to 0 (from most important to least important). Scores reflecting the ability of each option to deliver the intangible benefit have been allocated from 5 to 0 (from greatest ability to least ability).

## 9.7 Risk Assessment

A risk assessment of the options has been undertaken and the results tabulated in a "Risk Register" (Table 9.12). The risks considered to be relevant in the appraisal are:

Risk 1 Operational failure of flow alleviation
Risk 2 Failure to provide anticipated benefits
Risk 3 Failure to supply a sustainable solution

Within the Risk Register the likelihood of the risk happening, and the consequent effect on the solution, are classified as "high", "medium" or "low".

## Table 9.11 Assessment of Intangible Benefits

| Intangible Benefit | Weighting Factor | Option 1 2 Ml/d release above Q20% | | Option 2 2 Ml/d release above Q50% | | Comment |
|---|---|---|---|---|---|---|
| | | points | weighted points | points | weighted points | |
| 1 | 3 | 4 | 12 | 3 | 9 | |
| 2 | 3 | 4 | 12 | 3 | 9 | |
| 3 | 3 | 4 | 12 | 3 | 9 | Improved dilution of urban runoff from southern part of Redditch |
| Total weighted score | | | 36 | | 27 | |

Intangible Benefit 1: Facilitation of Agency meeting objectives
Intangible Benefit 2: Improved public relations and maintenance of credibility of Agency
Intangible Benefit 3: Longer term benefits not quantified in economic analysis

## Table 9.12 Risk Register

| Identified Risk | Option 1 2 Ml/d release above Q20% | | Option 2 2 Ml/d release above Q50% | | Comment |
|---|---|---|---|---|---|
| | Likelihood | Effect | Likelihood | Effect | |
| Operational failure of flow alleviation | L | L | L | L | |
| Failure to provide anticipated benefits | L | M | L | M | |
| Failure to supply a sustainable solution | M | M | L | M | In the long term, total reductions in groundwater abstractions will provide a sustainable solution |

Relative risks:
H high
M medium
L low

## 9.8 Selection of Preferred Option

From the summary of costs and benefits presented in Table 9.10 it can be seen that Option 1 represents the most cost effective solution both in terms of maximum net present value (NPV) and maximum benefit cost ratio. This conclusion is supported by the assessment of intangibles in Table 9.11.

Although the risk register presented in Table 9.12 suggests that Option 1 may have slightly higher risk than Option 2 of not providing a sustainable solution, this risk will be mitigated by the planned long term overall reduction in abstractions from the Bromsgrove aquifer.

**It is therefore concluded that Option 1, comprising a compensation releases of 2 Ml/d from the existing borehole at Webheath, should be selected as the preferred option.**

The compensation releases will be triggered by low flows at the gauging station at Besford Bridge and, in the early years, are expected to be operational for about 80% of the time. To ensure the best usage of the compensation water being provided from Webheath borehole, studies will be undertaken to assess the benefits of the additional water releases. These studies, including flow measurements at a new gauging site near Feckenham, will enable the control rules for release of water to be refined, thereby ensuring optimum use of the available water.

Almost 3 km of the brook will be re-watered, including the trout fishery at Norgrove Court lake, whilst 32 km will benefit from a significant increase during low flow periods.

It is expected that there will be a reduction in fish deaths due to a lack of dissolved oxygen caused by the algal blooms which are exacerbated by the low flows. The increased flows will dilute the effects of eutrophication caused by runoff from the agricultural land uses in the surrounding area.

Restoration of the flow will improve the continuity of the brook's linear wildlife habitat.

The assessed economic benefit takes account of these ecological improvements in addition to the increase in the amenity and recreational value of the area surrounding the watercourse.

It is also considered that there will be some water quality improvement due to dilution of urban run-off from the southern part of Redditch.

## 9.9 Tasks and Dependencies

| | |
|---|---|
| Investigations: | Agency Midlands Region, Lower Severn Area |
| Design and implementation: | Agency Midlands Region, Lower Severn Area<br>Severn Trent Water Ltd. |

**Programme for implementation of preferred option:**

| | |
|---|---|
| 1998 | Submission of Business Plan<br>Installation of monitoring devices |
| 1999 | Investigation and Design<br>Planning and Consents |
| 2000 | Construction |

## 9.10 Cost of Preferred Option

The estimated capital and operating costs of the preferred option are given in Table 9.13. The estimates of likely future capital costs are based on the assumption that the Construction Output Index (COPI) will rise by 4 per cent per annum. In the estimation of operating costs an annual increase of 2.5 per cent per annum in the Retail Price Index (RPI) has been assumed.

**Table 9.13 Estimated Costs of the Preferred Option (£ 000)**

| Year | Water Company | | Agency | |
|---|---|---|---|---|
| ending 31/03 | Capex | Opex | Capex | Opex |
| 1999 | 0 | 0 | 4[1] | 0 |
| 2000 | 0 | 0 | 16[2] | 0 |
| 2001 | 1,562 | 38 | 0 | 0 |
| 2002 | 0 | 39 | 0 | 0 |
| 2003 | 0 | 40 | 0 | 0 |

[1] comprises submission of business plan, the cost of which has not been included in the assessment of tangibles
[2] comprises installation of monitoring equipment

# 10 HEWELL GRANGE LAKE

## 10.1 Scheme Objectives

Discussions with the Agency have highlighted the fact that Hewell Grange Lake, which was artificially landscaped by Repton, is of considerable wildlife importance and as such has been designated as a SSSI. The lake has suffered low flows for over 150 years according to a recent report (Arthur Amos Associates, A Report on Hewell Grange Lake, 1995, p24). In recent years a contributory factor has been over-abstraction from the Bromsgrove aquifer for public water supply. A recent informal agreement with British Waterways Board will provide for some additional winter inflow to the lake from the Worcester and Birmingham Canal.

The location of the lake, which is about 800 m in length and up to 250 m wide, is shown in Figure 10.1. It is situated within the overall grounds of HM Prison at Brockhill and the nearby HM Young Offenders Institution. The policy of the prison governor is to encourage use of the gardens and the lake area by the general public.

There is a single scheme for alleviating the low lake levels involving the augmentation of the lake from groundwater. The augmentation point would be from a borehole upstream of the lake as shown on Figure 10.1. There is the opportunity to keep the lake at various levels depending on the quantity of augmentation flow, these are summarised in Table 10.1.

**Table 10.1 Low Flow Alleviation Options**

| Option | Description | Improvements |
|---|---|---|
| 1 | Compensation release to keep the lake at <100 mm below the full surface level. | Raised lake level. |
| 2 | Compensation release to keep the lake at <200 mm below the full surface level. | Raised lake level. |
| 3 | Compensation release to keep the lake at <300 mm below the full surface level. | Raised lake level. |
| 4 | Compensation release to keep the lake at <400 mm below the full surface level. | Raised lake level. |

The Agency has provided figures for the years 1993 to 1997 inclusive which show the number of days on which compensation flow would be required and at what rate it will be required to maintain the lake at the given level below the normal surface level. Rates of leakage have been assumed based on field data.

On average the lake currently achieves Option 1: 28% of the time, Option 2: 41%, Option 3: 59% and Option 4: 81%. See Table 10.2. Option 1 incurs the highest cost as a greater quantity of compensation flow is required to keep the lake at near to bankfull conditions.

In the longer term it is intended to reduce the total abstraction from the Bromsgrove aquifer to a sustainable level. Of the overall reduction, 1 Ml/d has been attributed to the scheme to alleviate low flow problems at Hewell Grange Lake. This should result in rising groundwater levels re-watering the lake and its tributary streams, with a subsequent reduction in the requirements for compensation releases.

**Table 10.2 Summary of Compensation Flow Requirements**

| Required Level Below Surface | Average no. days/year Required | Average % Time Required | Average % Time Not Required | Compen-sation Requirement Ml/day | Average Annual Requirement Ml/year |
|---|---|---|---|---|---|
| < 100 mm | 263 | 72 | 28 | 0.62 | 163 |
| < 200 mm | 214 | 59 | 41 | 0.52 | 111 |
| < 300 mm | 151 | 41 | 59 | 0.47 | 71 |
| < 400 mm | 71 | 19 | 81 | 0.45 | 32 |

Source: EA Pers. Comm. 26.02.98. Average figures derived from EA data 1993 - 1997.

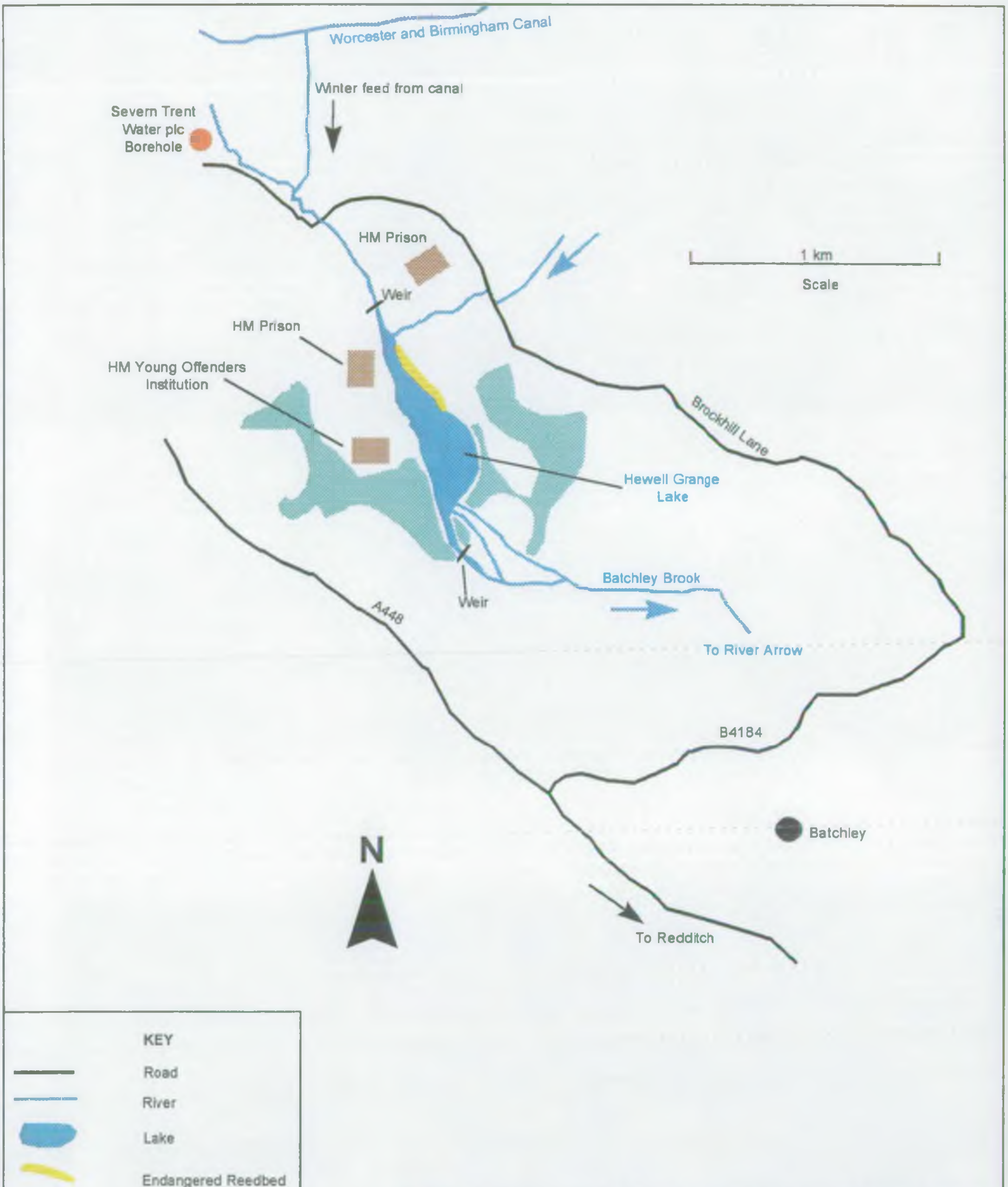
## 10.2 Scope of Study

Table 10.3 has been used as a checklist to focus on those impacts which are likely to be significant and need to be included in the economic appraisal.

**Table 10.3 Summary of Impacts**

| Impact Category | | Comments |
|---|---|---|
| Drinking Water Supply | | Not applicable |
| Industrial Abstraction | | Not applicable |
| Agriculture | Livestock | Not applicable |
| | Irrigation | Not applicable |
| In-stream Recreation | Boating | Not applicable |
| | Bathing | Not applicable |
| | Angling | Yes |
| Informal recreation | Walking, picnicking, photography | Yes, footpaths along the lakeside |
| Amenity /Aesthetics | Property prices | Not applicable |
| Conservation (Non-Use or Passive Use) | Ecology | Yes - designated SSSI |
| | Heritage | Yes |
| Other | | None |

Of particular ecological value are the large reedbeds which form part of the north-east shore. These support one of the largest Reed Warbler (*Acrocephalus scirpaceus*) colonies in Worcestershire as well as a number of breeding wildfowl colonies. There are also good populations of amphibians and reptiles including a high density of grass snakes (*Natrix natrix*).




Environment Agency

**Figure 10.1: Schematic of Hewell Grange Lake Low Flow Alleviation Scheme**

GIBB Ltd
Consulting Engineers
Reading England

AMP 3 Benefits Assessment

| SCALE As Shown | DATE April 1998 | J98032 A |
|---|---|---|

The drying out of the reedbeds is allowing terrestrial vegetation to become established which has led to the main block of reeds losing their population of breeding Reed Warblers. There will be conservation benefits associated with restoring the high water levels as it is expected that they will reverse the losses currently being experienced by the wildlife.

There are no abstractions from the lake itself and therefore no benefits to be gained by industry or agriculture. There are however abstractions within the local area which may be causing the lake levels to fall. However as these are groundwater abstractions they have not been included in the assessment.

The categories included in the benefit assessment are:

- informal recreation;
- angling; and
- non-use.

In order to distinguish between the four options it has been assumed that the scheme with the highest compensation flow will achieve the full level of benefits as determined from the Guidelines. For lesser flows (and hence lower lake levels) the benefits have been reduced pro rata, i.e. 75% for Option 2, 50% for Option 3 and 25% for Option 4.

## 10.3 Capital and Operating Costs

Severn Trent Water Ltd has provided the Agency with estimates of the capital expenditure (capex) and operating expenditure (opex) necessary to provide for the replacement of the water currently abstracted at the groundwater pumping station which would be diverted to Hewell Grange Lake. In addition some minor works will be required in the vicinity of the pumping station to effect the flow augmentation. Details of the costs are summarised in Table 10.4.

**Table 10.4 Summary of Cost Estimates (£ 000 Q4 1997)**

| | Option 1 | Option 2 | Option 3 | Option 4 |
|---|---|---|---|---|
| **Capital expenditure** | | | | |
| Replacement water | 427 | 359 | 324 | 310 |
| PWS option | 10 | 10 | 10 | 10 |
| Total | 437 | 369 | 334 | 320 |
| **Operating expenditure (per annum)** | | | | |
| Replacement water | 6 | 4 | 3 | 1 |
| PWS Option | 10 | 7 | 4 | 2 |
| Total | 16 | 11 | 7 | 3 |

## 10.4 Estimation of Benefits

### 10.4.1 Informal Recreation

Although the prison govemor, Mr Bamber, encourages the use of the lake area for informal recreation, there is little data available concerning the number of visitors to the site. There is an annual Heritage Open Day which is reported to attract up to 5000 visitors. The presence of the SSSI and the associated wildlife will attract visitors who may otherwise not have visited the area. It is also used by local people for dog walking. However there are substitute sites in the area, the lake is not the only place to walk and suffers from having few facilities for parking or for the provision of other amenities. Its position within the grounds of a prison may also serve as a deterrent to some potential visitors. For the purposes of the assessment an estimate of 10 000 visitors per annum has been used.

As the informal recreational activities are unpriced there is no economic rent or profit earned by the activity. The total value of the recreational activity is measured in consumer surplus or the difference between what the consumer pays for the activity (zero) and what they would be willing to pay. The Guidelines recommend the following per visit estimates of the consumer surplus, assuming 40% of the willingness-to-pay is attributable to the presence of water:

- Upper bound estimate: £1.48 per visitor day;
- Central estimate: £0.60 per visitor day; and
- Lower bound estimate: £0.20 per visitor day.

Combining participation rates and willingness-to-pay with the flow improvement factors from Table 10.3 produces the annual incremental benefits which are presented in Table 10.5.

**Table 10.5 Annual Informal Recreation Benefits**

| | Option | Number of visits | Total Informal Recreation Benefits £ |
|---|---|---|---|
| Upper Bound | 1 | 12,957 | 19,177 |
| | 2 | 12,957 | 14,383 |
| | 3 | 12,957 | 9,588 |
| | 4 | 12,957 | 4,794 |
| Central Estimate | 1 | 10,000 | 6,000 |
| | 2 | 10,000 | 4,500 |
| | 3 | 10,000 | 3,000 |
| | 4 | 10,000 | 1,500 |
| Lower Bound | 1 | 8,028 | 1,606 |
| | 2 | 8,028 | 1,204 |
| | 3 | 8,028 | 803 |
| | 4 | 8,028 | 401 |

### 10.4.2 Angling

Hewell Grange Lake is a mixed coarse fishery of poor to moderate quality. Recently fishermen have complained about the declining standards of fishing in the lake. It is thought (Arthur Amos, 1995) that the reductions in lake levels may represent significant habitat loss, particularly to young fish. If the lake levels could be guaranteed then the fishery could be improved above its current level by artificial stocking. Currently the governor is unwilling to put too many resources into restocking as there have been fish mortalities in the past due to the low flows. Discussions with Agency staff suggest that in order to raise it to a good quality fishery, stocking rates in the order of 1500 to 2000 lb/acre would be required.

It is currently fished by the HGB Angling Club which is run from the prison. Membership is open to all at the discretion of the prison authorities. There are currently 230 members plus a further 63 individuals with permission to fish the lake. A figure of 300 anglers has been assumed.

There are tentative plans to open the lake as a day fishery to a wider angling community. This would require a number of problems to be overcome, such as the lack of car parking facilities, before it went ahead. As this would involve costs outside those associated with the alleviation of the low flows and would take time to implement it has been assumed for the purposes of the benefit assessment that the lake will remain a club fishery open to members only.

The Low Flow Benefit Assessment Guidelines suggest anglers willingness-to-pay values and participation rates for the introduction of a new coarse fishery as follows:

- poor £3.86 per person per trip 4.21 trips per angler per annum
- moderate £4.07 per person per trip 13.5 trips per angler per annum
- good £6.21 per person per trip 21.28 trips per angler per annum

Combining these with the total number of anglers allows the incremental benefits of a change in the quality of fishery to be calculated. These are then factored by the percentage of benefit applicable to each option giving the annual values summarised in Table 10.6.

**Table 10.6: Annual Angling Benefits for Improving Flows to Hewell Grange Lake.**

| Option | Upper Bound £ | Central Estimate £ | Lower Bound £ |
|---|---|---|---|
| 1 | 34,769 | 11,608 | 5,804 |
| 2 | 26,077 | 8,706 | 4,353 |
| 3 | 17,385 | 5,804 | 2,902 |
| 4 | 8,692 | 2,902 | 1,451 |

### 10.4.3 Agriculture

There are no agricultural abstractions from the lake at Hewell Grange. Therefore there is no benefit to be gained in this sector.

### 10.4.4 Property

The only property on the site is the prison and its associated buildings. These will not achieve any stock benefits due to the alleviation of low flows in the lake.

### 10.4.5 Non-Use

Non-use (conservation) benefit estimates for Hewell Grange have been derived for:

- local residents within 3 km;
- river users among the general public who do not visit these particular rivers but do hold non-use values towards the alleviation of low flows in rivers;
- the wider general public who are not river users.

The non-use benefits have been derived using the procedures given in Section 9 of the Benefit Assessment Guidelines, assuming that the lake is equivalent to a 2 km length of river.

**Local resident non-use valuation**

It has been assumed that there are just over 6,300 households within 3 km of the low flow site, based on population data obtained from the Agency GIS model for a point in the centre of the lake, and assuming 2.7 people/household.

In accordance with the Guidelines, the following values per household per annum are applied where full low flow alleviation is achieved:

| | |
|---|---|
| Upper Bound | £12.00 |
| Central Estimate | £10.00 |
| Lower Bound | £ 7.00 |

**General public non-use valuation**

It is assumed that there are 3.15 million households within Severn Trent Water's area. Assuming 45% of the population to be general river users, from which the actual number of local households already included are subtracted. The remaining 55% of the population in the service area are taken as non-users for whom a lower scale of benefits applies. The central estimates are based on the figures of £0.05 and £0.03 per household per km of river per annum for full low flow alleviation in accordance with the Guidelines, with +/- 25% for upper and lower bounds.

The annual non-use (conservation) benefits of each option are summarised in Table 10.6 in terms of the local resident non-use benefits and the full (local resident plus general public non-use) benefits.

**Table 10.6 Annual Non-Use Benefits (£000 Q4 1997)**

| Option | Extent | Upper | Central | Lower |
|---|---|---|---|---|
| 1 | Local | 76 | 63 | 44 |
| | Full | 382 | 308 | 228 |
| 2 | Local | 57 | 48 | 33 |
| | Full | 287 | 231 | 171 |
| 3 | Local | 38 | 32 | 22 |
| | Full | 191 | 154 | 114 |
| 4 | Local | 19 | 16 | 11 |
| | Full | 96 | 77 | 57 |

## 10.5 Assessment of Tangibles (Cost Benefit Analysis)

The costs and the annual benefit streams have been aggregated in terms of present values in accordance with the procedures given in the Benefit Assessment Guidelines. The indicators in terms of net present values (NPV) and benefit cost ratios for the two options are presented in Table 10.7. The results are shown:

- both including and excluding non-use, together with two intermediate figures: one including only 50% of the general public (i.e. non-local) non-use and the other including only local non-use;
- for the central estimates, with upper and lower bounds;
- using the different discount rates and time horizons; and
- with and without rolling forward the benefits.

In addition, a variant on Option 1 is also shown which has the same benefit as Option 1, but includes the additional costs of providing a total of 1 Ml/d of replacement water in the long term. As indicated in Section 10.1, 1 Ml/d is the proportion of the reduction in abstractions from the Bromsgrove aquifer which has been attributed to this local problem. The overall reduction is expected to be required in order to provide a long term sustainable solution to the problem of over-abstraction.

For all combinations of assumptions Option 1 generates a higher net present value and a higher benefit cost ratio than any of Options 2, 3 or 4. On the basis of the linear proportioning of the benefits it can therefore be concluded that the incremental benefits of the greater degree of low flow alleviation achieved with the higher rate of pumping with Option 1 are sufficiently great as to justify the incremental capital and operating costs.

The overall results are highly sensitive to the assumptions regarding non-use benefits, with benefit cost ratios in the range 2 to 11 when the full non-use benefits are included. If only 50% of the non-local non-use benefits are included, the benefit cost ratio reduces to the range 1.8 to 5 with the central estimates. If non-use benefits are not included at all, the benefit cost ratio reduces well below 1.5 in all cases.

A summary of the assessment of tangibles (i.e the quantifiable costs and benefits) for all the options is presented in Table 10.8. For this analysis, which has been carried forward to the Summary Business Case, the economic benefit has been determined on the following basis:

- including 50% of the general public (i.e. non-local) non-use benefits
- central estimates without rolling forward of the benefits.

A breakdown of the total present value of the benefits for Option 1 (long term) by use category (central estimates, including 50% of the non-local non-use benefits) with the 6% Treasury discount rate, with no rolling forward, is shown on Figure 10.2, together with a breakdown of the present value of the costs.

Table 10.7 (Sheet 1)

**Hewell Grange Lake : Summary of Costs and Benefits**
(£ 000 Q4 1997 expressed as present values)

| Option | Costs | 7% Discount Rate, 30 year time period | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Benefits | | | | Total NPV | | | | Benefit Cost Ratio | | | |
| | | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use |
| **Upper estimates, no rolling forward** | | | | | | | | | | | | | |
| 1 | 592 | 5,006 | 3,249 | 1,491 | 619 | 4,414 | 2,657 | 899 | 27 | 8.5 | 5.5 | 2.52 | 1.05 |
| 2 | 471 | 3,755 | 2,437 | 1,118 | 464 | 3,284 | 1,965 | 647 | -7 | 8.0 | 5.2 | 2.37 | 0.99 |
| 3 | 392 | 2,503 | 1,624 | 746 | 310 | 2,111 | 1,232 | 353 | -83 | 6.4 | 4.1 | 1.90 | 0.79 |
| 4 | 333 | 1,252 | 812 | 373 | 155 | 918 | 479 | 39 | -179 | 3.8 | 2.4 | 1.12 | 0.46 |
| 1 (long term) | 807 | 5,006 | 3,249 | 1,491 | 619 | 4,200 | 2,442 | 685 | -188 | 6.2 | 4.0 | 1.85 | 0.77 |
| **Upper estimates, with rolling forward** | | | | | | | | | | | | | |
| 1 | 592 | 5,280 | 3,427 | 1,573 | 653 | 4,688 | 2,835 | 981 | 61 | 8.9 | 5.8 | 2.66 | 1.10 |
| 2 | 471 | 3,960 | 2,570 | 1,180 | 490 | 3,489 | 2,099 | 709 | 19 | 8.4 | 5.5 | 2.50 | 1.04 |
| 3 | 392 | 2,640 | 1,713 | 786 | 326 | 2,248 | 1,321 | 394 | -66 | 6.7 | 4.4 | 2.00 | 0.83 |
| 4 | 333 | 1,320 | 857 | 393 | 163 | 987 | 523 | 60 | -170 | 4.0 | 2.6 | 1.18 | 0.49 |
| 1 (long term) | 807 | 5,280 | 3,427 | 1,573 | 653 | 4,474 | 2,620 | 766 | -154 | 6.5 | 4.2 | 1.95 | 0.81 |
| **Central estimates, no rolling forward** | | | | | | | | | | | | | |
| 1 | 592 | 3,741 | 2,335 | 929 | 202 | 3,149 | 1,743 | 337 | -390 | 6.3 | 3.9 | 1.57 | 0.34 |
| 2 | 471 | 2,806 | 1,751 | 697 | 152 | 2,335 | 1,280 | 226 | -320 | 6.0 | 3.7 | 1.48 | 0.32 |
| 3 | 392 | 1,870 | 1,167 | 464 | 101 | 1,478 | 775 | 72 | -291 | 4.8 | 3.0 | 1.18 | 0.26 |
| 4 | 333 | 935 | 584 | 232 | 51 | 602 | 250 | -101 | -283 | 2.8 | 1.8 | 0.70 | 0.15 |
| 1 (long term) | 807 | 3,741 | 2,335 | 929 | 202 | 2,934 | 1,528 | 122 | -605 | 4.6 | 2.9 | 1.15 | 0.25 |
| **Central estimates, with rolling forward** | | | | | | | | | | | | | |
| 1 | 592 | 3,946 | 2,463 | 980 | 213 | 3,354 | 1,871 | 388 | -379 | 6.7 | 4.2 | 1.65 | 0.36 |
| 2 | 471 | 2,959 | 1,847 | 735 | 160 | 2,488 | 1,376 | 264 | -311 | 6.3 | 3.9 | 1.56 | 0.34 |
| 3 | 392 | 1,973 | 1,231 | 490 | 107 | 1,580 | 839 | 97 | -286 | 5.0 | 3.1 | 1.25 | 0.27 |
| 4 | 333 | 986 | 616 | 245 | 53 | 653 | 282 | -89 | -280 | 3.0 | 1.8 | 0.73 | 0.16 |
| 1 (long term) | 807 | 3,946 | 2,463 | 980 | 213 | 3,139 | 1,656 | 173 | -594 | 4.9 | 3.1 | 1.21 | 0.26 |
| **Lower estimates, no rolling forward** | | | | | | | | | | | | | |
| 1 | 592 | 2,703 | 1,648 | 594 | 85 | 2,111 | 1,056 | 2 | -507 | 4.6 | 2.8 | 1.00 | 0.14 |
| 2 | 471 | 2,027 | 1,236 | 445 | 64 | 1,556 | 765 | -26 | -407 | 4.3 | 2.6 | 0.95 | 0.14 |
| 3 | 392 | 1,351 | 824 | 297 | 43 | 959 | 432 | -96 | -350 | 3.4 | 2.1 | 0.76 | 0.11 |
| 4 | 333 | 676 | 412 | 148 | 21 | 342 | 79 | -185 | -312 | 2.0 | 1.2 | 0.45 | 0.06 |
| 1 (long term) | 807 | 2,703 | 1,648 | 594 | 85 | 1,896 | 842 | -213 | -722 | 3.4 | 2.0 | 0.74 | 0.11 |
| **Lower estimates, with rolling forward** | | | | | | | | | | | | | |
| 1 | 592 | 2,851 | 1,739 | 626 | 90 | 2,259 | 1,147 | 34 | -502 | 4.8 | 2.9 | 1.06 | 0.15 |
| 2 | 471 | 2,138 | 1,304 | 470 | 67 | 1,667 | 833 | -1 | -404 | 4.5 | 2.8 | 1.00 | 0.14 |
| 3 | 392 | 1,425 | 869 | 313 | 45 | 1,033 | 477 | -79 | -348 | 3.6 | 2.2 | 0.80 | 0.11 |
| 4 | 333 | 713 | 435 | 157 | 22 | 379 | 101 | -177 | -311 | 2.1 | 1.3 | 0.47 | 0.07 |
| 1 (long term) | 807 | 2,851 | 1,739 | 626 | 90 | 2,044 | 932 | -180 | -717 | 3.5 | 2.2 | 0.78 | 0.11 |

Table 10.7 (Sheet 2) **Hewell Grange Lake : Summary of Costs and Benefits**

(£ 000 Q4 1997 expressed as present values)

| Option | 6% Discount Rate, 50 year time period | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Costs | Benefits | | | | Total NPV | | | | Benefit Cost Ratio | | | |
| | | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use |
| **Upper estimates, no rolling forward** | | | | | | | | | | | | | |
| 1 | 649 | 6,465 | 4,195 | 1,926 | 799 | 5,816 | 3,546 | 1,276 | 150 | 10.0 | 6.5 | 2.97 | 1.23 |
| 2 | 511 | 4,849 | 3,147 | 1,444 | 600 | 4,338 | 2,636 | 933 | 88 | 9.5 | 6.2 | 2.83 | 1.17 |
| 3 | 419 | 3,233 | 2,098 | 963 | 400 | 2,814 | 1,679 | 544 | -19 | 7.7 | 5.0 | 2.30 | 0.95 |
| 4 | 346 | 1,616 | 1,049 | 481 | 200 | 1,270 | 703 | 135 | -146 | 4.7 | 3.0 | 1.39 | 0.58 |
| 1 (long term) | 870 | 6,465 | 4,195 | 1,926 | 799 | 5,595 | 3,325 | 1,056 | -71 | 7.4 | 4.8 | 2.21 | 0.92 |
| **Upper estimates, with rolling forward** | | | | | | | | | | | | | |
| 1 | 649 | 6,968 | 4,522 | 2,076 | 862 | 6,319 | 3,873 | 1,426 | 212 | 10.7 | 7.0 | 3.20 | 1.33 |
| 2 | 511 | 5,226 | 3,392 | 1,557 | 646 | 4,715 | 2,880 | 1,046 | 135 | 10.2 | 6.6 | 3.05 | 1.26 |
| 3 | 419 | 3,484 | 2,261 | 1,038 | 431 | 3,065 | 1,842 | 619 | 12 | 8.3 | 5.4 | 2.48 | 1.03 |
| 4 | 346 | 1,742 | 1,131 | 519 | 215 | 1,396 | 784 | 173 | -131 | 5.0 | 3.3 | 1.50 | 0.62 |
| 1 (long term) | 870 | 6,968 | 4,522 | 2,076 | 862 | 6,098 | 3,652 | 1,206 | -9 | 8.0 | 5.2 | 2.39 | 0.99 |
| **Central estimates, no rolling forward** | | | | | | | | | | | | | |
| 1 | 649 | 4,831 | 3,015 | 1,200 | 261 | 4,182 | 2,366 | 550 | -388 | 7.4 | 4.6 | 1.85 | 0.40 |
| 2 | 511 | 3,623 | 2,262 | 900 | 196 | 3,112 | 1,750 | 389 | -315 | 7.1 | 4.4 | 1.76 | 0.38 |
| 3 | 419 | 2,416 | 1,508 | 600 | 130 | 1,997 | 1,089 | 181 | -288 | 5.8 | 3.6 | 1.43 | 0.31 |
| 4 | 346 | 1,208 | 754 | 300 | 65 | 861 | 407 | -46 | -281 | 3.5 | 2.2 | 0.87 | 0.19 |
| 1 (long term) | 870 | 4,831 | 3,015 | 1,200 | 261 | 3,961 | 2,145 | 329 | -609 | 5.6 | 3.5 | 1.38 | 0.30 |
| **Central estimates, with rolling forward** | | | | | | | | | | | | | |
| 1 | 649 | 5,207 | 3,250 | 1,293 | 281 | 4,558 | 2,601 | 644 | -368 | 8.0 | 5.0 | 1.99 | 0.43 |
| 2 | 511 | 3,905 | 2,438 | 970 | 211 | 3,394 | 1,926 | 459 | -300 | 7.6 | 4.8 | 1.90 | 0.41 |
| 3 | 419 | 2,604 | 1,625 | 646 | 141 | 2,185 | 1,206 | 228 | -278 | 6.2 | 3.9 | 1.54 | 0.34 |
| 4 | 346 | 1,302 | 813 | 323 | 70 | 955 | 466 | -23 | -276 | 3.8 | 2.3 | 0.93 | 0.20 |
| 1 (long term) | 870 | 5,207 | 3,250 | 1,293 | 281 | 4,337 | 2,380 | 423 | -589 | 6.0 | 3.7 | 1.49 | 0.32 |
| **Lower estimates, no rolling forward** | | | | | | | | | | | | | |
| 1 | 649 | 3,491 | 2,129 | 767 | 110 | 2,841 | 1,479 | 118 | -540 | 5.4 | 3.3 | 1.18 | 0.17 |
| 2 | 511 | 2,618 | 1,597 | 575 | 82 | 2,107 | 1,085 | 64 | -429 | 5.1 | 3.1 | 1.13 | 0.16 |
| 3 | 419 | 1,745 | 1,064 | 383 | 55 | 1,326 | 646 | -35 | -364 | 4.2 | 2.5 | 0.92 | 0.13 |
| 4 | 346 | 873 | 532 | 192 | 27 | 526 | 186 | -155 | -319 | 2.5 | 1.5 | 0.55 | 0.08 |
| 1 (long term) | 870 | 3,491 | 2,129 | 767 | 110 | 2,620 | 1,259 | -103 | -760 | 4.0 | 2.4 | 0.88 | 0.13 |
| **Lower estimates, with rolling forward** | | | | | | | | | | | | | |
| 1 | 649 | 3,762 | 2,294 | 827 | 118 | 3,113 | 1,645 | 177 | -531 | 5.8 | 3.5 | 1.27 | 0.18 |
| 2 | 511 | 2,822 | 1,721 | 620 | 89 | 2,311 | 1,210 | 109 | -422 | 5.5 | 3.4 | 1.21 | 0.17 |
| 3 | 419 | 1,881 | 1,147 | 413 | 59 | 1,462 | 728 | -6 | -360 | 4.5 | 2.7 | 0.99 | 0.14 |
| 4 | 346 | 941 | 574 | 207 | 30 | 594 | 227 | -140 | -317 | 2.7 | 1.7 | 0.60 | 0.09 |
| 1 (long term) | 870 | 3,762 | 2,294 | 827 | 118 | 2,892 | 1,424 | -44 | -752 | 4.3 | 2.6 | 0.95 | 0.14 |

**Table 10.8 Assessment of Tangibles (£000 Q4 1997)**

| Option | Agency Costs | Water Co. Costs | Economic Benefit | Net Present Value | Benefit Cost Ratio |
|---|---|---|---|---|---|
| 6% discount rate, 50 year time period | | | | | |
| **Do Nothing** | 0 | 0 | 0 | 0 | 0 |
| **Option 1** | 0 | 649 | 3,015 | 2,366 | 4.6 |
| **Option 1 (long term)** | 0 | 870 | 3,015 | 2,145 | 4.4 |
| **Option 2** | 0 | 511 | 2,262 | 1,750 | 3.6 |
| **Option 3** | 0 | 419 | 1,508 | 1,089 | 2.2 |
| **Option 4** | 0 | 346 | 754 | 407 | 3.5 |
| 7% discount rate, 30 year time period | | | | | |
| **Do Nothing** | 0 | 0 | 0 | 0 | 0 |
| **Option 1** | 0 | 592 | 2,335 | 1,743 | 3.9 |
| **Option 1 (long term)** | 0 | 807 | 2,335 | 1,528 | 3.7 |
| **Option 2** | 0 | 471 | 1,751 | 1,280 | 3.0 |
| **Option 3** | 0 | 392 | 1,167 | 775 | 1.8 |
| **Option 4** | | 333 | 584 | 250 | 2.9 |

## 10.6 Assessment of Intangibles

The assessment of intangible benefits (or disbenefits) has been undertaken by a weighting and scoring system and is presented in Table 10.9. The intangibles considered in the table are:

1. Facilitation of Agency meeting objectives
2. Improved public relations and maintenance of credibility of Agency
3. Longer term benefits not quantified in economic analysis

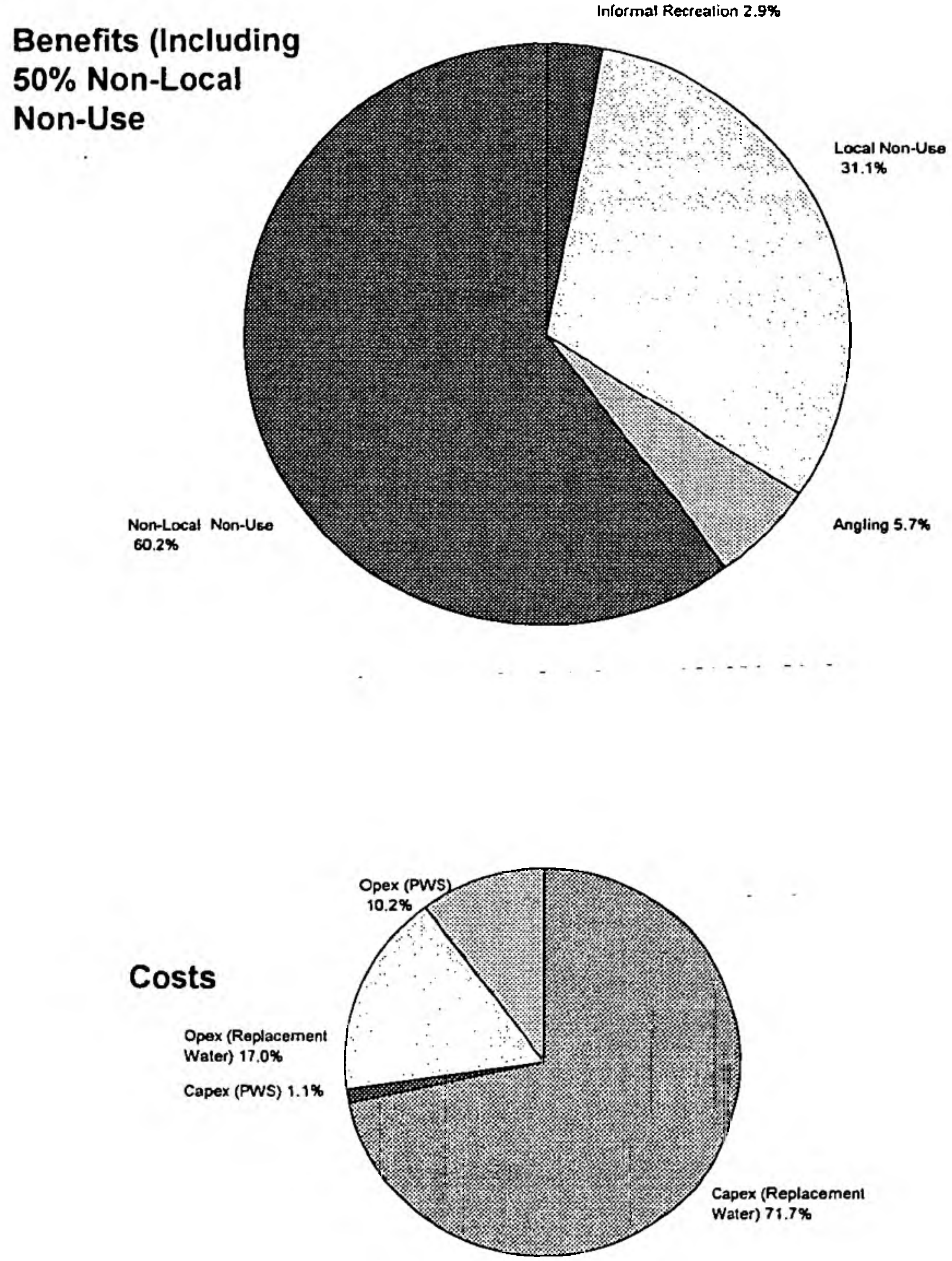
Each of the intangible benefits has been allocated a weighting within the range from 5 to 0 (from most important to least important). Scores reflecting the ability of each option to deliver the intangible benefit have been allocated from 5 to 0 (from greatest ability to least ability).

## 10.7 Risk Assessment

A risk assessment of the options has been undertaken and the results tabulated in a "Risk Register" (Table 10.10). The risks considered to be relevant in the appraisal are:

Risk 1 Operational failure of flow alleviation
Risk 2 Failure to provide anticipated benefits
Risk 3 Failure to supply a sustainable solution

Within the Risk Register the likelihood of the risk happening, and the consequent effect on the solution, are classified as "high", "medium" or "low".




Note: The area of the circles is proportional to the present value of the benefits or costs at a 6% discount rate

**Hewell Grange Lake Option 1 (long term)**
**Present Value of Benefits and Costs**
**Figure 10.2**

**Table 10.9** **Assessment of Intangible Benefits**

| Intangible Benefit | Weighting Factor | Option 1 0.62 Ml/d < 100mm | | Option 2 0.52 Ml/d < 200mm | | Option 3 0.47 Ml/d < 300mm | | Option 4 0.45 Ml/d < 400mm | | Option 1 (long term) 1 Ml/d | | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | points | weighted points | points | weighted points | points | weighted points | points | weighted points | points | weighted points | |
| 1 | 3 | 4 | 12 | 3 | 9 | 2 | 6 | 1 | 3 | 5 | 15 | |
| 2 | 3 | 4 | 12 | 3 | 9 | 2 | 6 | 1 | 3 | 5 | 15 | |
| 3 | 3 | | | | | | | | | | | Not applicable |
| Total weighted score | | | 24 | | 18 | | 12 | | 6 | | 30 | |

Intangible Benefit 1: Facilitation of Agency meeting objectives
Intangible Benefit 2: Improved public relations and maintenance of credibility of Agency
Intangible Benefit 3: Longer term benefits not quantified in economic analysis

**Table 10.10** **Risk Register**

| Identified Risk | Option 1 0.62 Ml/d < 100mm | | Option 2 0.52 Ml/d < 200mm | | Option 3 0.47 Ml/d < 300mm | | Option 4 0.45 Ml/d < 400mm | | Option 1 (long term) 1 Ml/d | | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Likelihood | Effect | Likelihood | Effect | Likelihood | Effect | Likelihood | Effect | Likelihood | Effect | |
| Operational failure of flow alleviation | L | L | L | L | L | L | L | L | L | L | |
| Failure to provide anticipated benefits | L | L | L | L | L | L | L | L | L | L | |
| Failure to supply a sustainable solution | M | M | M | M | M | M | M | M | L | L | In the long term, total reductions in groundwater abstractions will provide a sustainable solution |

Relative risks: H high M medium L low

## 10.8 Selection of Preferred Option

From the assessment of tangibles presented in Table 10.8 it can be seen that Option 1 represents the most cost effective solution in terms of maximum net present value (NPV). This conclusion is supported by the assessment of intangibles. This option is also supported by English Nature (see the document "AMP3 Scheme Proposed and Benefit SSSI").

However, without further allowance for the longer term reduction in groundwater abstractions, Option1 may not be sustainable or compatible with the long term objective of a recovery of groundwater levels. This is reflected in the assessment of intangibles and the risk register in Tables 10.9 and 10.10. Only Option 1 (long term) is shown as having a low risk of failing to provide the anticipated benefits and a low risk of not supplying a sustainable solution.

**It is therefore concluded that Option 1 (long term), including a total reduction in PWS groundwater abstractions of 1 Ml/d, should be selected as the preferred option.**

In the short term it is expected that a compensation release of 0.62 Ml/d will maintain the lake level within 100 mm below the full capacity level. Trials will be undertaken to confirm lake water requirements as well as proving the optimum retention level for the lake to ensure that the SSSI is maintained in its peak condition. The encroachment of terrestrial vegetation into the reedbeds will be slowed and eventually reversed before the situation becomes too dire. The higher lake level is also expected to reverse the decline in the reed warbler colony and in the visiting population of breeding waterfowl. The improvement in habitat will attract greater numbers of visitors to the area, especially those with a specialist interest such as ornithologists.

The status of the fishery in the lake could also be improved due to improvement in habitat for juvenile fish and by making the lake capable of supporting greater numbers of fish. This would allow some artificial re-stocking of the lake allowing it to be raised to a good quality fishery.

In the longer term there may be some reduction in the requirements for compensation releases if there is a rise in groundwater levels resulting from reduced abstraction.

The assessed economic benefit takes account of these ecological improvements in addition to the increase in the amenity and recreational value of the area surrounding the lake.

## 10.9 Tasks and Dependencies

| | |
|---|---|
| Investigations: | Agency Midlands Region, Lower Severn Area<br>Agency Midlands Region, Regional Office |
| Design and implementation: | Agency Midlands Region, Regional Office<br>Severn Trent Water Ltd. |

**Programme for implementation of the preferred option:**

| | |
|---|---|
| 1998 | Submission of Business Plan |
| 1999 | Investigation and Design<br>Planning and Consents |
| 2000 | Construction<br>Investigation |

## 10.10 Cost of Preferred Option

The estimated capital and operating costs of the preferred option are given in Table 10.11. The estimates of likely future capital costs are based on the assumption that the Construction Output Index (COPI) will rise by 4 per cent per annum. In the estimation of operating costs an annual increase of 2.5 per cent per annum in the Retail Price Index (RPI) has been assumed.

**Table 10.11 Estimated Costs of the Preferred Option (£ 000)**

| Year | Water Company | | Agency | |
|---|---|---|---|---|
| ending 31/03 | Capex | Opex | Capex | Opex |
| 1999 | 0 | 0 | 4[1] | 0 |
| 2000 | 0 | 0 | 0 | 0 |
| 2001 | 492 | 17 | 0 | 0 |
| 2002 | 0 | 18 | 0 | 0 |
| 2003 | 320[3] | 18 | 0 | 0 |

[1] Comprises submission of business plan, the cost of which has not been included in the assessment of tangibles
[3] long term replacement water costs could be deferred subject to supply/demand balance

# 11 RIVER SHERBOURNE

## 11.1 Scheme Objectives

The River Sherbourne and its tributaries the Pickford Brook and the Guphill Brook have been affected by over-abstraction of groundwater in the area west of Coventry for public water supply. This has resulted in the upper reaches of the river having periods of low or zero flow. Spot gaugings and local information suggest that the river and tributaries are dry for considerable periods each year.

The schemes considered for the alleviation of low flows in the River Sherbourne are summarised in Table 11.1 and the augmentation points are shown in Figure 11.1. The current proposals do not address the Guphill Brook, which is to the south of the area shown in the figure. Most options involve a reduction in the abstraction for public water supply at the existing public water supply boreholes and augmentation of the river system from groundwater, although in one case the augmentation would be with treated water from an existing main pipeline. The compensation release envisaged by the Agency is available from a number of boreholes or combinations thereof. In the longer term it is intended to reduce the total groundwater abstractions to a sustainable level which should result in rising groundwater levels re-watering the river and its tributaries, with a subsequent reduction in the requirements for compensation releases.

**Table 11.1 Low Flow Alleviation Options**

| Option | Description | Improvements |
|---|---|---|
| 1 | Compensation release of 1 Ml/day from an existing water company borehole (Meriden) to a tributary of the Pickford Brook | Rewater 4.8 km, significantly increased flows 7.6 km. |
| 2 | Compensation release of 1 Ml/day from an existing water company borehole (Brownshill Green) to a tributary of the River Sherbourne | Rewater 2.8 km, significantly increased flows 7.6 km. |
| 3a | Compensation release of 1 Ml/day from an existing water company pipeline (chlorinated water) to the River Sherbourne. | Rewater 3.2 km, significantly increased flows 7.6 km. |
| 3b | Compensation release of 1 Ml/day from a proposed new borehole to the River Sherbourne | Rewater 5.2 km, significantly increased flows 7.6 km. |
| 4 | A combination of Options 1+2 | Rewater 7.6 km, significantly increased flows 7.6 km. |
| 5 | A combination of Options 1+2+3a | Rewater 10 km, significantly increased flows 7.6 km. |
| 6 | A combination of Options 1+2+3b | Rewater 12 km, significantly increased flows 7.6 km. |

For the initial studies it has been agreed that the compensation flows would be triggered when the flow at Kingsbury Road is at Q50% (2 Ml/d) or below.

Details of spot gauging and derived flow duration/frequency curves were provided by the Agency to define the impact of the alleviation options and these are included in Appendix 11.

The flow duration data relates to 1994-96 data for the point just downstream of the confluence of the Pickford Brook with the River Sherbourne at Kingsbury Road and for the point just upstream of the confluence with the River Sowe at the A45 road bridge at Baginton.

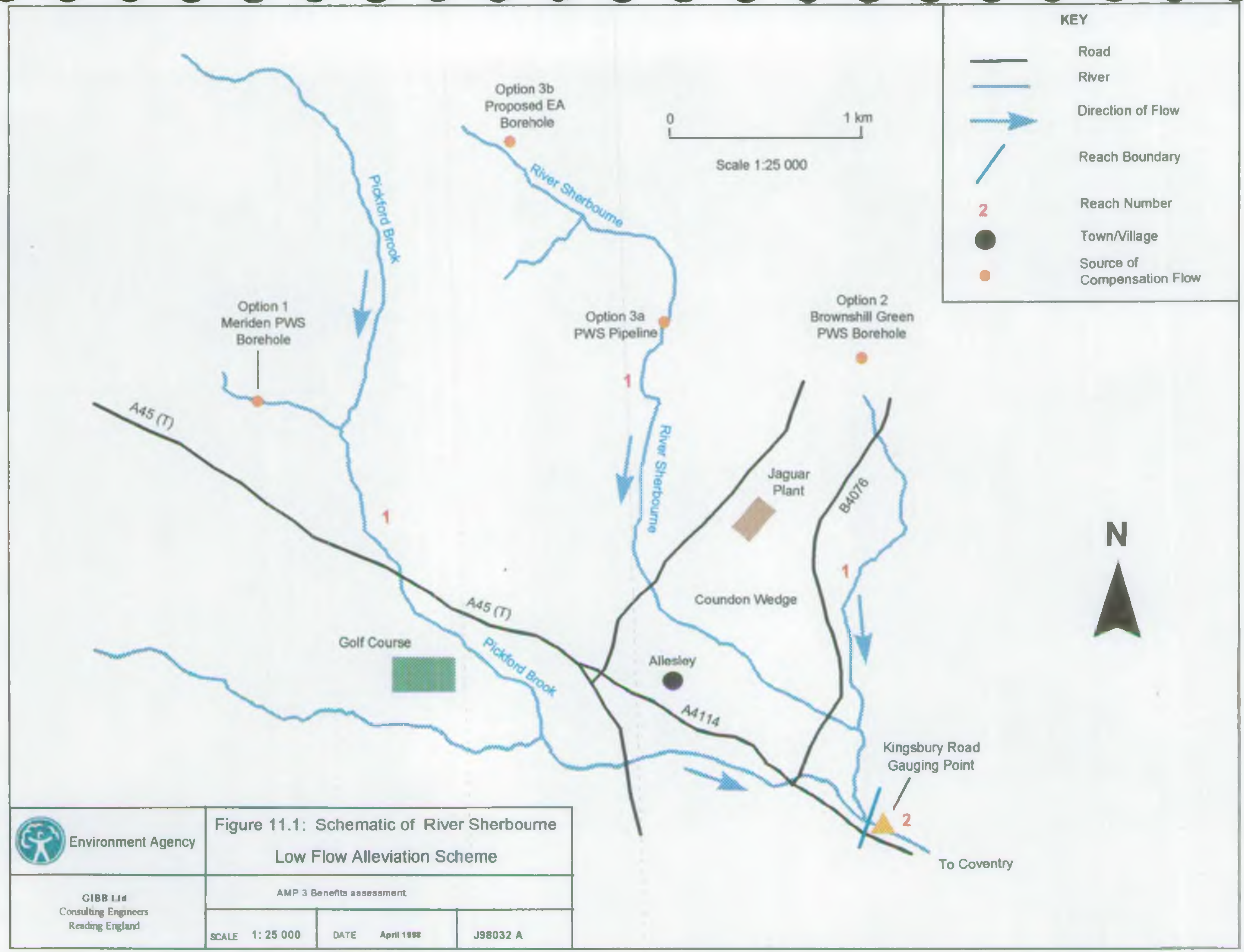
The available information has been used to derive appropriate factors for the economic benefits of each option for those uses which are frequency and duration dependent. In addition to the tributary reaches rewatered, the River Sherbourne has been divided into two reaches for this purpose:

| | |
|---|---|
| Reach 1 | Above Kingsbury Road (length varies with each option) |
| Reach 2 | Kingsbury Road through the centre of Coventry to the confluence with the River Sowe (7.6 km) |

Target flows for each reach have been assessed to determine the extent to which the low flow alleviation schemes will improve the situation. Flow improvement factors have been derived from a consideration of both the **proportional flow** improvement from the existing situation at the Q95% level, and the **proportional time** improvement that the target flow is achieved. Corresponding return periods for very low flows (i.e. about 50% of the target flows) have also been assessed for the before and after situations. The figures which have been derived are summarised in Table 11.2.

**Table 11.2 Summary of Hydrological Assessment for the River Sherbourne**

| | | Reach 1 | Reach 2 |
|---|---|---|---|
| **Target Flow (Ml/d)** | | 1 | 5 |
| **% of Time above Target** | | | |
| **Before** | | 25% | 50% |
| **After** | Option 1 | 95% | 83% |
| | Option 2 | 95% | 83% |
| | Option 3a | 95% | 83% |
| | Option 3b | 95% | 83% |
| | Option 4 (1 + 2) | 95% | 89% |
| | Option 5 (1 + 2 + 3a) | 95% | 95% |
| | Option 6 (1 + 2 + 3b) | 95% | 95% |
| **Flow Improvement Factor** | | | |
| | Option 1 | 100% | 35% |
| | Option 2 | 100% | 35% |
| | Option 3a | 100% | 35% |
| | Option 3b | 100% | 35% |
| | Option 4 (1 + 2) | 100% | 50% |
| | Option 5 (1 + 2 + 3a) | 100% | 65% |
| | Option 6 (1 + 2 + 3b) | 100% | 65% |
| **Return Period (years)** before → after | | | |
| | Option 1 | 1 → 5 | 2 → 4 |
| | Option 2 | 1 → 5 | 2 → 4 |
| | Option 3a | 1 → 5 | 2 → 4 |
| | Option 3b | 1 → 5 | 2 → 4 |
| | Option 4 (1 + 2) | 1 → 5 | 2 → 5 |
| | Option 5 (1 + 2 + 3a) | 1 → 5 | 2 → 6 |
| | Option 6 (1 + 2 + 3b) | 1 → 5 | 2 → 6 |




Environment Agency

Figure 11.1: Schematic of River Sherbourne Low Flow Alleviation Scheme

GIBB Ltd
Consulting Engineers
Reading England

AMP 3 Benefits assessment

SCALE 1: 25 000 | DATE April 1998 | J98032 A

The Agency has proposed cutbacks in Water Company groundwater licences in the Coventry/Meriden groundwater units to reduce deployable output by a total of 10.8 Ml/d during the AMP3 period. This figure has been calculated following an assessment by the Agency of the available resources and long term sustainable abstraction for these aquifers. This information has been presented to the Water Company and the proposed reduction has been included in the Company's draft water resources plan.

## 11.2 Scope of Study

Table 11.3 has been used as a checklist to focus on those impacts which are likely to be significant and need to be included in the economic appraisal.

**Table 11.3 Summary of Impacts**

| Impact Category | | Comments |
|---|---|---|
| Drinking Water Supply | | Increased flow available for PWS abstraction downstream. |
| Industrial Abstraction | | Not applicable |
| Agriculture | Livestock | Not applicable |
| | Irrigation | Not Applicable |
| In-stream Recreation | Boating | Not applicable |
| | Bathing | Not applicable |
| | Angling | Not applicable |
| Informal recreation | Walking, picnicking, photography | Yes, a network of footpaths with some direct access to the river. The Coundon Wedge is a very popular recreational area. |
| Amenity /Aesthetics | Property prices | A number of properties overlooking the river. |
| Conservation (Non-Use or Passive Use) | Ecology | Yes |
| | Heritage | Not applicable |
| Other | | None |

Restoration of the flow will improve the continuity of the brook's linear wildlife habitat, which at present is not complete due to the brook periodically suffering extremely low flows.

The categories that have been included in the benefit assessment are:

- informal recreation;
- property;
- drinking water supply resource cost savings; and
- non-use.

## 11.3 Capital and Operating Costs

Severn Trent Water Ltd has provided the Agency with estimates of the capital expenditure (capex) and operating expenditure (opex) necessary to provide for the replacement of the water currently abstracted at the various boreholes which could be diverted to alleviate low flows in the River Sherbourne. In addition to the costs of providing replacement water, some minor works will be required in the vicinity of the augmentation points to effect the flow augmentation. For Option 3b a new borehole would be installed by the Agency. Details of the costs are summarised in Table 11.4.

**Table 11.4 Summary of Cost Estimates (£ 000 Q4 1997)**

| | Option 1 | Option 2 | Option 3a | Option 3b |
|---|---|---|---|---|
| **Capital expenditure** | | | | |
| Replacement water | 690 | 690 | 690 | 690 |
| PWS option | 10 | 10 | 10 | |
| Agency borehole | | | | 120[2] |
| Total | 700 | 700 | 700 | 810 |
| **Operating expenditure (per annum)** | | | | |
| Replacement water | 7 | 7 | 7 | 7 |
| PWS Option | 4 | 4 | 4 (See Note 1)* | |
| Agency borehole | | | | 4[2] |
| Total | 11 | 11 | 11 | 11 |

Notes: 1. Additional treatment costs may be required with this option
2. Agency costs to be recharged to STW Ltd under AMP3

## 11.4 Estimation of Benefits

### 11.4.1 Informal Recreation

In the absence of reliable primary sources the estimation of visitor numbers to the sites has been based on the indirect approach outlined in the Agency Guidelines, related to the population within 0.8 km of the river, obtained from the Agency's GIS system. Taking account of the popular area of Coundon Wedge and other local amenity areas in the vicinity of the river, realistic estimates of the likely number of visits have been derived from previous experience, utilising the GIS data to distribute the numbers between the river reaches.

As the informal recreational activities are unpriced there is no economic rent or profit earned by the activity. The total value of the recreational activity is measured in consumer surplus or the difference between what the consumer pays for the activity (zero) and what they would be willing to pay. The Guidelines recommend the following per visit estimates of the consumer surplus, assuming 40% of the willingness-to-pay is attributable to the presence of water:

- Upper bound estimate: £1.48 per visitor day;
- Central estimate: £0.60 per visitor day; and
- Lower bound estimate: £0.20 per visitor day.

Combining participation rates and willingness-to-pay with the flow improvement factors from Table 11.2 produces the annual incremental benefits which are presented in Table 11.5.

**Table 11.5 Annual Informal Recreation Benefits**

| | Option | Visitor Numbers by River Reach (000) | | | Factored Benefit by River Reach (£000 Q4 1997) | | | |
|---|---|---|---|---|---|---|---|---|
| | | Coundon Wedge | 1 | 2 | Coundon Wedge | 1 | 2 | Total |
| **Upper Bound** | **1** | | 15 | 33 | | 22 | 17 | 39 |
| | **2** | 12 | 15 | 33 | 18 | 22 | 17 | 58 |
| | **3a** | 12 | 12 | 33 | 18 | 18 | 17 | 53 |
| | **3b** | 12 | 14 | 33 | 18 | 21 | 17 | 57 |
| | **4** | 12 | 23 | 33 | 18 | 34 | 24 | 76 |
| | **5** | 25 | 28 | 33 | 37 | 42 | 31 | 110 |
| | **6** | 25 | 26 | 33 | 37 | 38 | 31 | 107 |
| **Central Estimate** | **1** | | 12 | 25 | | 7 | 5 | 12 |
| | **2** | 10 | 12 | 25 | 6 | 7 | 5 | 18 |
| | **3a** | 10 | 9 | 25 | 6 | 6 | 5 | 17 |
| | **3b** | 10 | 11 | 25 | 6 | 7 | 5 | 18 |
| | **4** | 10 | 17 | 25 | 6 | 10 | 8 | 24 |
| | **5** | 20 | 22 | 25 | 12 | 13 | 10 | 35 |
| | **6** | 20 | 20 | 25 | 12 | 12 | 10 | 34 |
| **Lower Bound** | **1** | | 9 | 20 | | 2 | 1 | 3 |
| | **2** | 8 | 9 | 20 | 2 | 2 | 1 | 5 |
| | **3a** | 8 | 8 | 20 | 2 | 2 | 1 | 4 |
| | **3b** | 8 | 9 | 20 | 2 | 2 | 1 | 5 |
| | **4** | 8 | 14 | 20 | 2 | 3 | 2 | 6 |
| | **5** | 15 | 17 | 20 | 3 | 3 | 3 | 9 |
| | **6** | 15 | 16 | 20 | 3 | 3 | 3 | 9 |

### 11.4.2 Angling

Discussions with Agency staff revealed that there are no angling interests on the River Sherbourne.

### 11.4.3 Agriculture

There are no abstractions from the surface water for agricultural purposes and therefore no benefit to be gained by this sector.

### 11.4.4 Property

Nuneaton District Council was contacted to provide Council Tax Bands for the properties identified as adjacent to the watercourses. These are summarised in Table 11.6. The only properties considered to accrue any benefits are those on the rewatered section with Options 3a and 3b. There are no riverside properties associated with Options 1, 2 and 4. Reach 2 will receive some increased flow but this will not be significant enough to justify an increase in property value.

**Table 11.6 Properties Adjacent to River Sherbourne by Council Tax Band**

| Band | 1997 Midpoint (£ 000) | No of properties (Options 3a and 3b only) | Economic Value (£ 000 Q4 1997) |
|---|---|---|---|
| A | 40 | 0 | 0 |
| B | 46 | 0 | 0 |
| C | 61 | 3 | 182 |
| D | 79 | 7 | 551 |
| E | 105 | 12 | 1,260 |
| F | 141 | 1 | 141 |
| G | 242 | 2 | 485 |
| H | 323 | 0 | 0 |
| **Total** | | | **2,619** |

Source: Nuneaton District Council

By applying the formulae given in the Benefit Assessment Guidelines, using the assumed changes in return periods for the low flows indicated in Table 11.2, the benefit to property owners has been estimated in terms of once-off changes in stock.

**Table 11.7 Amenity and Aesthetic Stock Benefits (£000 Q4 1997)**

| Option | Total Incremental Benefits | | |
|---|---|---|---|
| | Upper Bound | Central Estimate | Lower Bound |
| 1 | - | - | - |
| 2 | - | - | - |
| 3a | 274 | 183 | 37 |
| 3b | 274 | 183 | 37 |
| 4 | - | - | - |
| 5 | 274 | 183 | 37 |
| 6 | 274 | 183 | 37 |

### 11.4.5 Resource Cost Savings

With a quantity of water being added to the River Sherbourne there will be a higher discharge to the Avon and Severn which could be available for abstraction for public water supply downstream in preference to pumping from the Shropshire Groundwater Scheme. An earlier assessment by the Agency for the River Worfe indicated that this benefit might be realised on average for some 75 days per year at an estimated value of £19 per Ml. This gives the following annual benefits in terms of resource cost savings:

| | | |
|---|---|---|
| Options 1, 2, 3a and 3b | 1 Ml/d | £ 1425 |
| Option 4 | 2 Ml/d | £ 2850 |
| Option 5 | 3 Ml/d | £ 4275 |

### 11.4.6 Non-Use

Non-use (conservation) benefit estimates for the River Sherbourne have been derived for:

- local residents within 3 km;
- river users among the general public who do not visit this particular river and its tributaries but do hold non-use values towards the alleviation of low flows in rivers;
- the wider general public who are not river users.

The non-use benefits have been derived using the procedures given in Section 9 of the Benefit Assessment Guidelines.

**Local resident non-use valuation**

It has been assumed that there are around 80,000 households within 3 km of the River Sherbourne, distributed between the two river reaches as indicated below, based on population data obtained from the Agency GIS model and assuming 2.7 people/household:

| | |
|---|---|
| Reach I | 21,000 - 28,000, depending on option |
| Reach 2 | 56,000 |

In accordance with the Guidelines, the following values per household per annum are applied where full low flow alleviation is achieved:

| | |
|---|---|
| Upper Bound | £12.00 |
| Central Estimate | £10.00 |
| Lower Bound | £ 7.00 |

**General public non-use valuation**

It is assumed that there are 3.15 million households within Severn Trent Water's area and that 45% of the population are general river users, from which the actual number of local households already included are subtracted. The remaining 55% of the population in the service area are taken as non-users for whom a lower scale of benefits applies. The central estimates are based on the figures of £0.05 and £0.03 per household per km of river per annum for full low flow alleviation in accordance with the Guidelines, with +/- 25% for upper and lower bounds.

The annual non-use (conservation) benefit of each option, applying the flow improvement factors from Table 11.2 for each river reach, are summarised in Table 11.8 in terms of the local resident non-use benefits and the full (local resident plus general public non-use) benefits.

**Table 11.8 Annual Non-Use Benefits (£000 Q4 1997)**

| Option | Extent | Upper | Central | Lower |
|---|---|---|---|---|
| **1** | Local<br>Full | 510<br>1,619 | 425<br>1,312 | 298<br>963 |
| **2** | Local<br>Full | 497<br>1,308 | 414<br>1,063 | 290<br>777 |
| **3a** | Local<br>Full | 490<br>1,361 | 408<br>1,105 | 286<br>809 |
| **3b** | Local<br>Full | 501<br>1,670 | 418<br>1353 | 292<br>994 |
| **4** | Local<br>Full | 663<br>2,354 | 553<br>1,906 | 387<br>1,402 |
| **5** | Local<br>Full | 773<br>2,988 | 644<br>2,417 | 451<br>1,780 |
| **6** | Local<br>Full | 767<br>3,280 | 640<br>2,650 | 448<br>1,955 |

## 11.5 Assessment of Tangibles (Cost Benefit Analysis)

The costs and the annual benefit streams have been aggregated in terms of present values in accordance with the procedures given in the Benefit Assessment Guidelines. The indicators in terms of net present values (NPV) and benefit cost ratios for the two options are presented in Table 11.9. The results are shown for a variety of combinations of the economic factors:

- both including and excluding non-use, together with two intermediate figures: one including only 50% of the general public (i.e. non-local) non-use and the other including only local non-use;
- for the central estimates, with upper and lower bounds;
- using the different discount rates and time horizons; and
- with and without rolling forward the benefits.

In addition, a variant on Option 6 is also shown which has the same benefits as Option 6, but allows for phasing of the capital costs over the implementation period and includes the additional costs of the replacement water which is expected to be required in order to provide a long term sustainable solution to the problem of over-abstraction. This variant also includes additional Agency costs for the installation of monitoring equipment. The costs for a total of 10.15 Ml/d of replacement water have been allowed for with Option 6 (long term).

All the individual options (1, 2, 3a and 3b) show a positive net present value except when non-use benefits are excluded completely. For each combination of economic factors, the benefit cost ratios of the four options are similar. This indicates that each option is justifiable in its own right. When any proportion of the non-local non-use benefits is included, Option 3b is seen to be preferable to Option 3a, with the slightly higher costs being justified by the higher benefits due to the greater length of watercourse being impacted. It therefore follows that the combination of the three options (1, 2 and 3b), designated as Option 6, has the highest NPV, except when non-local non-use benefits are excluded.

Table 11.9 (Sheet 1) **River Sherbourne : Summary of Costs and Benefits**

(£ 000 Q4 1997 expressed as present values)

| Option | 7% Discount Rate, 30 year time period | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Costs | Benefits | | | | Total NPV | | | | Benefit Cost Ratio | | | |
| | | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use |
| **Upper estimates, no rolling forward** | | | | | | | | | | | | | |
| 1 | 780 | 19,044 | 12,683 | 6,322 | 466 | 18,263 | 11,902 | 5,541 | -315 | 24.4 | 16.3 | 8.10 | 0.60 |
| 2 | 780 | 15,692 | 11,034 | 6,376 | 678 | 14,912 | 10,254 | 5,596 | -102 | 20.1 | 14.1 | 8.17 | 0.87 |
| 3a | 780 | 16,492 | 11,491 | 6,491 | 870 | 15,711 | 10,711 | 5,711 | 89 | 21.1 | 14.7 | 8.32 | 1.11 |
| 3b | 883 | 20,068 | 13,364 | 6,660 | 907 | 19,185 | 12,481 | 5,776 | 23 | 22.7 | 15.1 | 7.54 | 1.03 |
| 4 | 1,560 | 27,922 | 18,219 | 8,516 | 907 | 26,362 | 16,659 | 6,956 | -652 | 17.9 | 11.7 | 5.46 | 0.58 |
| 5 | 2,340 | 35,842 | 23,130 | 10,418 | 1,551 | 33,502 | 20,790 | 8,077 | -789 | 15.3 | 9.9 | 4.45 | 0.66 |
| 6 | 2,443 | 39,154 | 24,737 | 10,321 | 1,515 | 36,711 | 22,294 | 7,878 | -929 | 16.0 | 10.1 | 4.22 | 0.62 |
| 6 (long term) | 7,525 | 39,154 | 24,737 | 10,321 | 1,515 | 31,629 | 17,212 | 2,796 | -6,010 | 5.2 | 3.3 | 1.37 | 0.20 |
| **Upper estimates, with rolling forward** | | | | | | | | | | | | | |
| 1 | 780 | 20,087 | 13,377 | 6,668 | 491 | 19,306 | 12,597 | 5,887 | -289 | 25.7 | 17.1 | 8.54 | 0.63 |
| 2 | 780 | 16,552 | 11,639 | 6,726 | 715 | 15,771 | 10,858 | 5,945 | -65 | 21.2 | 14.9 | 8.62 | 0.92 |
| 3a | 780 | 17,383 | 12,109 | 6,834 | 905 | 16,602 | 11,328 | 6,054 | 125 | 22.3 | 15.5 | 8.76 | 1.16 |
| 3b | 883 | 21,155 | 14,084 | 7,012 | 944 | 20,272 | 13,201 | 6,129 | 61 | 24.0 | 15.9 | 7.94 | 1.07 |
| 4 | 1,560 | 29,451 | 19,216 | 8,982 | 957 | 27,891 | 17,656 | 7,422 | -603 | 18.9 | 12.3 | 5.76 | 0.61 |
| 5 | 2,340 | 37,793 | 24,385 | 10,976 | 1,624 | 35,453 | 22,045 | 8,636 | -716 | 16.1 | 10.4 | 4.69 | 0.69 |
| 6 | 2,443 | 41,286 | 26,080 | 10,874 | 1,586 | 38,843 | 23,637 | 8,431 | -858 | 16.9 | 10.7 | 4.45 | 0.65 |
| 6 (long term) | 7,525 | 41,286 | 26,080 | 10,874 | 1,586 | 33,761 | 18,555 | 3,349 | -5,939 | 5.5 | 3.5 | 1.45 | 0.21 |
| **Central estimates, no rolling forward** | | | | | | | | | | | | | |
| 1 | 780 | 15,215 | 10,126 | 5,037 | 157 | 14,434 | 9,345 | 4,256 | -623 | 19.5 | 13.0 | 6.45 | 0.20 |
| 2 | 780 | 12,427 | 8,701 | 4,974 | 226 | 11,647 | 7,920 | 4,194 | -555 | 15.9 | 11.1 | 6.37 | 0.29 |
| 3a | 780 | 13,056 | 9,055 | 5,055 | 371 | 12,275 | 8,275 | 4,275 | -410 | 16.7 | 11.6 | 6.48 | 0.47 |
| 3b | 883 | 15,903 | 10,540 | 5,176 | 382 | 15,020 | 9,657 | 4,293 | -501 | 18.0 | 11.9 | 5.86 | 0.43 |
| 4 | 1,560 | 22,174 | 14,411 | 6,649 | 309 | 20,614 | 12,851 | 5,089 | -1,251 | 14.2 | 9.2 | 4.26 | 0.20 |
| 5 | 2,340 | 28,337 | 18,167 | 7,998 | 609 | 25,997 | 15,827 | 5,657 | -1,732 | 12.1 | 7.8 | 3.42 | 0.26 |
| 6 | 2,443 | 31,003 | 19,469 | 7,936 | 597 | 28,559 | 17,026 | 5,493 | -1,846 | 12.7 | 8.0 | 3.25 | 0.24 |
| 6 (long term) | 7,525 | 31,003 | 19,469 | 7,936 | 597 | 23,478 | 11,944 | 411 | -6,928 | 4.1 | 2.6 | 1.05 | 0.08 |
| **Central estimates, with rolling forward** | | | | | | | | | | | | | |
| 1 | 780 | 16,048 | 10,680 | 5,313 | 166 | 15,267 | 9,900 | 4,532 | -615 | 20.6 | 13.7 | 6.81 | 0.21 |
| 2 | 780 | 13,108 | 9,177 | 5,247 | 238 | 12,327 | 8,397 | 4,466 | -542 | 16.8 | 11.8 | 6.72 | 0.31 |
| 3a | 780 | 13,763 | 9,543 | 5,324 | 383 | 12,982 | 8,763 | 4,543 | -398 | 17.6 | 12.2 | 6.82 | 0.49 |
| 3b | 883 | 16,766 | 11,109 | 5,452 | 395 | 15,883 | 10,226 | 4,569 | -488 | 19.0 | 12.6 | 6.17 | 0.45 |
| 4 | 1,560 | 23,388 | 15,201 | 7,013 | 326 | 21,828 | 13,641 | 5,453 | -1,234 | 15.0 | 9.7 | 4.50 | 0.21 |
| 5 | 2,340 | 29,881 | 19,154 | 8,428 | 634 | 27,541 | 16,814 | 6,087 | -1,706 | 12.8 | 8.2 | 3.60 | 0.27 |
| 6 | 2,443 | 32,692 | 20,527 | 8,362 | 622 | 30,249 | 18,084 | 5,919 | -1,821 | 13.4 | 8.4 | 3.42 | 0.25 |
| 6 (long term) | 7,525 | 32,692 | 20,527 | 8,362 | 622 | 25,167 | 13,002 | 837 | -6,903 | 4.3 | 2.7 | 1.11 | 0.08 |
| **Lower estimates, no rolling forward** | | | | | | | | | | | | | |
| 1 | 780 | 11,103 | 7,286 | 3,470 | 54 | 10,323 | 6,506 | 2,689 | -726 | 14.2 | 9.3 | 4.45 | 0.07 |
| 2 | 780 | 8,985 | 6,190 | 3,395 | 71 | 8,204 | 5,410 | 2,615 | -709 | 11.5 | 7.9 | 4.35 | 0.09 |
| 3a | 780 | 9,379 | 6,379 | 3,378 | 99 | 8,598 | 5,598 | 2,598 | -681 | 12.0 | 8.2 | 4.33 | 0.13 |
| 3b | 883 | 11,503 | 7,481 | 3,458 | 102 | 10,620 | 6,598 | 2,575 | -781 | 13.0 | 8.5 | 3.92 | 0.12 |
| 4 | 1,560 | 16,187 | 10,365 | 4,543 | 105 | 14,627 | 8,805 | 2,984 | -1,455 | 10.4 | 6.6 | 2.91 | 0.07 |
| 5 | 2,340 | 20,613 | 12,985 | 5,358 | 186 | 18,272 | 10,645 | 3,017 | -2,155 | 8.8 | 5.5 | 2.29 | 0.08 |
| 6 | 2,443 | 22,620 | 13,970 | 5,320 | 183 | 20,177 | 11,526 | 2,876 | -2,261 | 9.3 | 5.7 | 2.18 | 0.07 |
| 6 (long term) | 7,525 | 22,620 | 13,970 | 5,320 | 183 | 15,095 | 6,445 | -2,205 | -7,342 | 3.0 | 1.9 | 0.71 | 0.02 |
| **Lower estimates, with rolling forward** | | | | | | | | | | | | | |
| 1 | 780 | 11,711 | 7,685 | 3,660 | 57 | 10,931 | 6,905 | 2,879 | -723 | 15.0 | 9.8 | 4.69 | 0.07 |
| 2 | 780 | 9,477 | 6,529 | 3,581 | 75 | 8,696 | 5,749 | 2,801 | -705 | 12.1 | 8.4 | 4.59 | 0.10 |
| 3a | 780 | 9,891 | 6,726 | 3,562 | 103 | 9,110 | 5,946 | 2,781 | -677 | 12.7 | 8.6 | 4.56 | 0.13 |
| 3b | 883 | 12,132 | 7,889 | 3,646 | 106 | 11,248 | 7,006 | 2,763 | -777 | 13.7 | 8.9 | 4.13 | 0.12 |
| 4 | 1,560 | 17,074 | 10,933 | 4,792 | 111 | 15,514 | 9,373 | 3,232 | -1,449 | 10.9 | 7.0 | 3.07 | 0.07 |
| 5 | 2,340 | 21,740 | 13,695 | 5,650 | 194 | 19,399 | 11,354 | 3,309 | -2,146 | 9.3 | 5.9 | 2.41 | 0.08 |
| 6 | 2,443 | 23,857 | 14,733 | 5,609 | 191 | 21,414 | 12,290 | 3,166 | -2,252 | 9.8 | 6.0 | 2.30 | 0.08 |
| 6 (long term) | 7,525 | 23,857 | 14,733 | 5,609 | 191 | 16,332 | 7,208 | -1,916 | -7,334 | 3.2 | 2.0 | 0.75 | 0.03 |

**Table 11.9 (Sheet 2)** **River Sherbourne : Summary of Costs and Benefits**

(£ 000 Q4 1997 expressed as present values)

| Option | 6% Discount Rate, 50 year time period | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Costs | Benefits | | | | Total NPV | | | | Benefit Cost Ratio | | | |
| | | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use |
| **Upper estimates, no rolling forward** | | | | | | | | | | | | | |
| 1 | 823 | 24,594 | 16,379 | 8,164 | 602 | 23,770 | 15,555 | 7,340 | -222 | 29.9 | 19.9 | 9.92 | 0.73 |
| 2 | 823 | 20,266 | 14,250 | 8,235 | 876 | 19,442 | 13,427 | 7,411 | 52 | 24.6 | 17.3 | 10.00 | 1.06 |
| 3a | 823 | 21,233 | 14,775 | 8,317 | 1,058 | 20,409 | 13,952 | 7,494 | 234 | 25.8 | 17.9 | 10.10 | 1.28 |
| 3b | 927 | 25,851 | 17,193 | 8,535 | 1,105 | 24,924 | 16,266 | 7,608 | 178 | 27.9 | 18.5 | 9.21 | 1.19 |
| 4 | 1,646 | 36,059 | 23,528 | 10,997 | 1,172 | 34,413 | 21,882 | 9,351 | -474 | 21.9 | 14.3 | 6.68 | 0.71 |
| 5 | 2,469 | 46,223 | 29,806 | 13,389 | 1,938 | 43,754 | 27,336 | 10,919 | -531 | 18.7 | 12.1 | 5.42 | 0.78 |
| 6 | 2,573 | 50,500 | 31,881 | 13,263 | 1,891 | 47,927 | 29,308 | 10,690 | -682 | 19.6 | 12.4 | 5.15 | 0.73 |
| 6 (long term) | 8,145 | 50,500 | 31,881 | 13,263 | 1,891 | 42,354 | 23,736 | 5,118 | -6,255 | 6.2 | 3.9 | 1.63 | 0.23 |
| **Upper estimates, with rolling forward** | | | | | | | | | | | | | |
| 1 | 823 | 26,508 | 17,654 | 8,799 | 648 | 25,684 | 16,830 | 7,976 | -175 | 32.2 | 21.4 | 10.69 | 0.79 |
| 2 | 823 | 21,843 | 15,359 | 8,876 | 944 | 21,020 | 14,536 | 8,052 | 121 | 26.5 | 18.7 | 10.78 | 1.15 |
| 3a | 823 | 22,867 | 15,907 | 8,947 | 1,122 | 22,044 | 15,084 | 8,124 | 299 | 27.8 | 19.3 | 10.87 | 1.36 |
| 3b | 927 | 27,846 | 18,514 | 9,182 | 1,174 | 26,918 | 17,586 | 8,254 | 247 | 30.0 | 20.0 | 9.90 | 1.27 |
| 4 | 1,646 | 38,866 | 25,359 | 11,853 | 1,263 | 37,220 | 23,714 | 10,207 | -383 | 23.6 | 15.4 | 7.20 | 0.77 |
| 5 | 2,469 | 49,803 | 32,108 | 14,413 | 2,071 | 47,333 | 29,638 | 11,944 | -398 | 20.2 | 13.0 | 5.84 | 0.84 |
| 6 | 2,573 | 54,412 | 34,345 | 14,278 | 2,020 | 51,839 | 31,772 | 11,705 | -553 | 21.1 | 13.3 | 5.55 | 0.79 |
| 6 (long term) | 8,145 | 54,412 | 34,345 | 14,278 | 2,020 | 46,267 | 26,200 | 6,132 | -6,125 | 6.7 | 4.2 | 1.75 | 0.25 |
| **Central estimates, no rolling forward** | | | | | | | | | | | | | |
| 1 | 823 | 19,648 | 13,077 | 6,505 | 203 | 18,825 | 12,253 | 5,681 | -621 | 23.9 | 15.9 | 7.90 | 0.25 |
| 2 | 823 | 16,049 | 11,236 | 6,424 | 292 | 15,225 | 10,413 | 5,601 | -532 | 19.5 | 13.6 | 7.80 | 0.35 |
| 3a | 823 | 16,817 | 11,651 | 6,485 | 435 | 15,993 | 10,827 | 5,661 | -388 | 20.4 | 14.1 | 7.88 | 0.53 |
| 3b | 927 | 20,494 | 13,568 | 6,641 | 450 | 19,567 | 12,641 | 5,714 | -477 | 22.1 | 14.6 | 7.16 | 0.49 |
| 4 | 1,646 | 28,636 | 18,611 | 8,587 | 399 | 26,990 | 16,966 | 6,941 | -1,247 | 17.4 | 11.3 | 5.22 | 0.24 |
| 5 | 2,469 | 36,552 | 23,418 | 10,285 | 743 | 34,083 | 20,949 | 7,815 | -1,727 | 14.8 | 9.5 | 4.17 | 0.30 |
| 6 | 2,573 | 39,994 | 25,099 | 10,205 | 728 | 37,421 | 22,526 | 7,632 | -1,845 | 15.5 | 9.8 | 3.97 | 0.28 |
| 6 (long term) | 8,145 | 39,994 | 25,099 | 10,205 | 728 | 31,849 | 16,954 | 2,060 | -7,417 | 4.9 | 3.1 | 1.25 | 0.09 |
| **Central estimates, with rolling forward** | | | | | | | | | | | | | |
| 1 | 823 | 21,178 | 14,094 | 7,011 | 219 | 20,354 | 13,271 | 6,187 | -605 | 25.7 | 17.1 | 8.51 | 0.27 |
| 2 | 823 | 17,298 | 12,111 | 6,924 | 314 | 16,475 | 11,288 | 6,101 | -509 | 21.0 | 14.7 | 8.41 | 0.38 |
| 3a | 823 | 18,114 | 12,546 | 6,977 | 457 | 17,290 | 11,722 | 6,154 | -366 | 22.0 | 15.2 | 8.47 | 0.56 |
| 3b | 927 | 22,078 | 14,612 | 7,146 | 473 | 21,150 | 13,685 | 6,219 | -454 | 23.8 | 15.8 | 7.71 | 0.51 |
| 4 | 1,646 | 30,865 | 20,060 | 9,255 | 430 | 29,219 | 18,414 | 7,609 | -1,216 | 18.8 | 12.2 | 5.62 | 0.26 |
| 5 | 2,469 | 39,385 | 25,229 | 11,073 | 789 | 36,916 | 22,760 | 8,604 | -1,681 | 16.0 | 10.2 | 4.48 | 0.32 |
| 6 | 2,573 | 43,095 | 27,041 | 10,987 | 773 | 40,522 | 24,468 | 8,414 | -1,800 | 16.7 | 10.5 | 4.27 | 0.30 |
| 6 (long term) | 8,145 | 43,095 | 27,041 | 10,987 | 773 | 34,950 | 18,896 | 2,842 | -7,373 | 5.3 | 3.3 | 1.35 | 0.09 |
| **Lower estimates, no rolling forward** | | | | | | | | | | | | | |
| 1 | 823 | 14,339 | 9,410 | 4,481 | 70 | 13,516 | 8,587 | 3,658 | -754 | 17.4 | 11.4 | 5.44 | 0.08 |
| 2 | 823 | 11,603 | 7,994 | 4,385 | 92 | 10,780 | 7,171 | 3,561 | -731 | 14.1 | 9.7 | 5.33 | 0.11 |
| 3a | 823 | 12,103 | 8,229 | 4,354 | 119 | 11,280 | 7,405 | 3,531 | -704 | 14.7 | 10.0 | 5.29 | 0.14 |
| 3b | 927 | 14,847 | 9,652 | 4,457 | 123 | 13,920 | 8,725 | 3,530 | -804 | 16.0 | 10.4 | 4.81 | 0.13 |
| 4 | 1,646 | 20,905 | 13,386 | 5,868 | 136 | 19,259 | 11,740 | 4,222 | -1,510 | 12.7 | 8.1 | 3.57 | 0.08 |
| 5 | 2,469 | 26,611 | 16,761 | 6,911 | 231 | 24,142 | 14,292 | 4,441 | -2,238 | 10.8 | 6.8 | 2.80 | 0.09 |
| 6 | 2,573 | 29,203 | 18,032 | 6,861 | 227 | 26,630 | 15,459 | 4,288 | -2,346 | 11.3 | 7.0 | 2.67 | 0.09 |
| 6 (long term) | 8,145 | 29,203 | 18,032 | 6,861 | 227 | 21,058 | 9,887 | -1,284 | -7,918 | 3.6 | 2.2 | 0.84 | 0.03 |
| **Lower estimates, with rolling forward** | | | | | | | | | | | | | |
| 1 | 823 | 15,455 | 10,142 | 4,830 | 75 | 14,632 | 9,319 | 4,006 | -748 | 18.8 | 12.3 | 5.87 | 0.09 |
| 2 | 823 | 12,506 | 8,616 | 4,726 | 99 | 11,683 | 7,793 | 3,903 | -724 | 15.2 | 10.5 | 5.74 | 0.12 |
| 3a | 823 | 13,043 | 8,867 | 4,691 | 126 | 12,220 | 8,043 | 3,867 | -697 | 15.8 | 10.8 | 5.70 | 0.15 |
| 3b | 927 | 16,000 | 10,401 | 4,802 | 131 | 15,073 | 9,474 | 3,875 | -797 | 17.3 | 11.2 | 5.18 | 0.14 |
| 4 | 1,646 | 22,532 | 14,428 | 6,324 | 147 | 20,886 | 12,782 | 4,678 | -1,499 | 13.7 | 8.8 | 3.84 | 0.09 |
| 5 | 2,469 | 28,680 | 18,063 | 7,446 | 247 | 26,211 | 15,594 | 4,977 | -2,223 | 11.6 | 7.3 | 3.02 | 0.10 |
| 6 | 2,573 | 31,473 | 19,433 | 7,393 | 242 | 28,901 | 16,860 | 4,820 | -2,331 | 12.2 | 7.6 | 2.87 | 0.09 |
| 6 (long term) | 8,145 | 31,473 | 19,433 | 7,393 | 242 | 23,328 | 11,288 | -753 | -7,903 | 3.9 | 2.4 | 0.91 | 0.03 |

The overall results are highly sensitive to the assumptions regarding non-use benefits, with benefit cost ratios generally in the range 3 to over 30 when the full non-use benefits are included. If only the local non-use benefits are included, the benefit cost ratio reduces to the range 1 to 9 with the central estimates. If non-use benefits are not included at all, the NPV becomes negative in most cases considered, the exceptions being some of the options with the upper bound estimates.

A summary of the assessment of tangibles (i.e. the quantifiable costs and benefits) for all the options is presented in Table 11.10. For this analysis, which has been carried forward to the Summary Business Case, the economic benefit has been determined on the following basis:

- including 50% of the general public (i.e. non-local) non-use benefits
- central estimates without rolling forward of the benefits.

**Table 11.10 Assessment of Tangibles (£000 Q4 1997)**

| Option | Agency Costs | Water Co. Costs | Economic Benefit | Net Present Value | Benefit Cost Ratio |
|---|---|---|---|---|---|
| 6% discount rate, 50 year time period | | | | | |
| **Do Nothing** | 0 | 0 | 0 | 0 | 0 |
| **Option 1** | 0 | 823 | 13,077 | 12,253 | 15.9 |
| **Option 2** | 0 | 823 | 11,236 | 10,413 | 13.6 |
| **Option 3a** | 0 | 823 | 11,651 | 10,827 | 14.1 |
| **Option 3b** | 172 | 755 | 13,568 | 12,641 | 14.6 |
| **Option 4** | 0 | 1,646 | 18,611 | 16,966 | 11.3 |
| **Option 5** | 0 | 2,469 | 23,418 | 20,949 | 9.5 |
| **Option 6** | 172 | 2,400 | 25,099 | 22,526 | 9.8 |
| **Option 6 (long term)** | 187 | 7,959 | 25,099 | 16,954 | 3.1 |
| 7% discount rate, 30 year time period | | | | | |
| **Do Nothing** | 0 | 0 | 0 | 0 | 0 |
| **Option 1** | 0 | 780 | 10,126 | 9,345 | 13.0 |
| **Option 2** | 0 | 780 | 8,701 | 7,920 | 11.1 |
| **Option 3a** | 0 | 780 | 9,055 | 8,275 | 11.6 |
| **Option 3b** | 158 | 725 | 10,540 | 9,657 | 11.9 |
| **Option 4** | 0 | 1,560 | 14,411 | 12,851 | 9.2 |
| **Option 5** | 0 | 2,340 | 18,167 | 15,827 | 7.8 |
| **Option 6** | 158 | 2,285 | 19,469 | 17,026 | 8.0 |
| **Option 6 (long term)** | 172 | 7,353 | 19,469 | 11,944 | 2.6 |

A breakdown of the total present value of the benefits for Option 6 (long term) by use category (central estimates, including 50% of the non-local non-use benefits) with the 6% Treasury discount rate, with no rolling forward, is shown on Figure 11.2, together with a breakdown of the present value of the costs.

## 11.6 Assessment of Intangibles

The assessment of intangible benefits (or disbenefits) has been undertaken by a weighting and scoring system and is presented in Table 11.11. The intangibles considered in the table are:

1. Facilitation of Agency meeting objectives
2. Improved public relations and maintenance of credibility of Agency
3. Longer term benefits not quantified in economic analysis

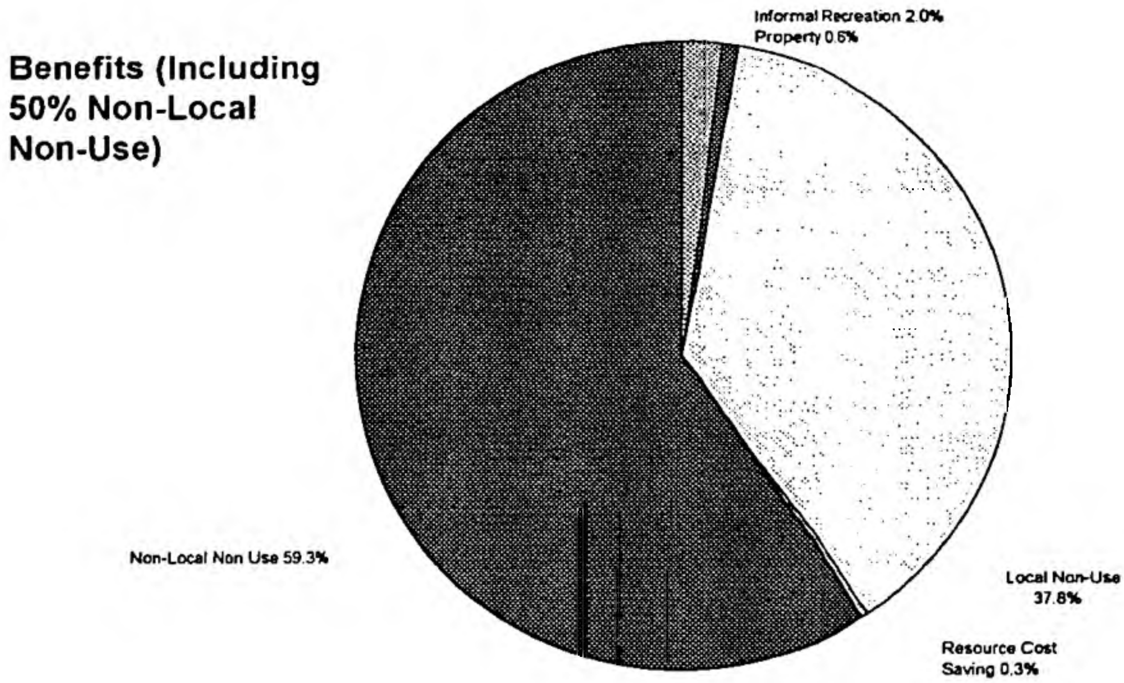
Each of the intangible benefits has been allocated a weighting within the range from 5 to 0 (from most important to least important). Scores reflecting the ability of each option to deliver the intangible benefit have been allocated from 5 to 0 (from greatest ability to least ability).

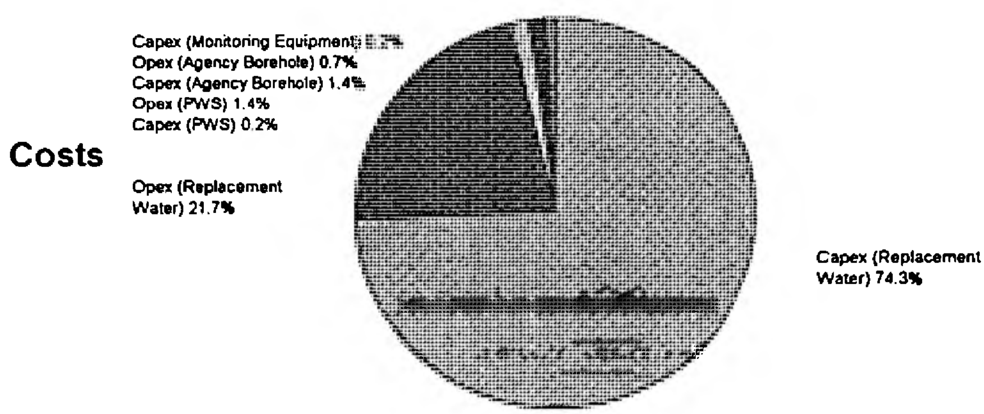
## 11.7 Risk Assessment

A risk assessment of the options has been undertaken and the results tabulated in a "Risk Register" (Table 11.12). The risks considered to be relevant in the appraisal are:

| | |
|---|---|
| Risk 1 | Operational failure of flow alleviation |
| Risk 2 | Failure to provide anticipated benefits |
| Risk 3 | Failure to supply a sustainable solution |

Within the Risk Register the likelihood of the risk happening, and the consequent effect on the solution, are classified as "high", "medium" or "low".




Note: The area of the circles is proportional to the present value of the benefits or costs at 6% discount rate

**River Sherbourne Option 6 (long term)**
**Present Value of Benefits and Costs**
**Figure 11.2**

**Table 11.11** **Assessment of Intangible Benefits**

| Intangible Benefit | Weighting Factor | Option 1 1 Ml/d release from Meriden | | Option 2 1 Ml/d release from Brownshill Gn | | Option 3a 1 Ml/d release from pipeline | | Option 3b 1 Ml/d release from new borehole | | Option 4 2 Ml/d release Options 1 + 2 | | Option 5 3 Ml/d release Options 1 + 2 + 3a | | Option 6 3 Ml/d release Options 1 + 2 + 3b | | Option 6 (long term) Options 1 + 2 + 3b + additional costs | | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | points | weighted points | points | weighted points | points | weighted points | points | weighted points | points | weighted points | points | weighted points | points | weighted points | points | weighted points | |
| 1 | 3 | 2 | 6 | 2 | 6 | 1 | 3 | 2 | 6 | 2.5 | 7.5 | 3 | 9 | 4 | 12 | 5 | 15 | Option 3a releases chlorinated water |
| 2 | 3 | 2 | 6 | 2 | 6 | 1 | 3 | 2 | 6 | 2.5 | 7.5 | 2.5 | 7.5 | 3.5 | 10.5 | 5 | 15 | |
| 3 | 3 | 1 | 3 | 1 | 3 | 1 | 3 | 1 | 3 | 1 | 3 | 1 | 3 | 1 | 3 | 5 | 15 | Limited recovery of groundwater levels, except for Option 6 (long term) |
| Total weighted score | | | 15 | | 15 | | 9 | | 15 | | 18 | | 19.5 | | 25.5 | | 45 | |

Intangible Benefit 1: Facilitation of Agency meeting objectives
Intangible Benefit 2: Improved public relations and maintenance of credibility of Agency
Intangible Benefit 3: Longer term benefits not quantified in economic analysis

**Table 11.12** **Risk Register**

| Identified Risk | Option 1 1 Ml/d release from Meriden | | Option 2 1 Ml/d release from Brownshill Gn | | Option 3a 1 Ml/d release from pipeline | | Option 3b 1 Ml/d release from new borehole | | Option 4 2 Ml/d release Options 1 + 2 | | Option 5 3 Ml/d release Options 1 + 2 + 3a | | Option 6 3 Ml/d release Options 1 + 2 + 3b | | Option 6 (long term) Options 1 + 2 + 3b + additional costs | | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Likeli-hood | Effect | Likeli-hood | Effect | Likeli-hood | Effect | Likeli-hood | Effect | Likeli-hood | Effect | Likeli-hood | Effect | Likeli-hood | Effect | Likeli-hood | Effect | |
| Operational failure of flow alleviation | L | L | L | L | L | L | L | L | L | L | L | L | L | L | L | L | |
| Failure to provide anticipated benefits | M | M | M | M | M | M | M | M | M | M | M | M | M | M | L | L | Recovery of groundwater levels will be achieved sooner with Option 6 (long term) |
| Failure to supply a sustainable solution | M | M | M | M | M | M | M | M | M | M | M | M | M | M | L | L | |

Relative risks: H high M medium L low

## 11.8 Selection of Preferred Option

From the assessment of tangibles presented in Table 11.10 it can be seen that each of the individual options is justifiable in its own right, with Option 3b being preferable to 3a. Therefore the combination of the three options (1, 2 and 3b), designated as Option 6, represents the most cost effective solution in terms of maximum net present value (NPV). This conclusion is supported by the assessment of intangibles, particularly confirming that Option 3b is preferable to 3a, with a greater length of watercourse being impacted and avoiding the need for chlorinated water to be used for compensation releases.

However, without further allowance for the longer term reduction in groundwater abstractions, Options 1, 2 and 3b may not be sustainable or compatible with the long term objective of a recovery of groundwater levels. This is reflected in the assessment of intangibles and the risk register in Tables 11.11 and 11.12. Only Option 6 (long term) is shown as having a low risk of failing to provide the anticipated benefits and a low risk of not supplying a sustainable solution. As indicated in Section 11.1, the Agency has proposed cutbacks in Water Company groundwater licences in the Coventry/Meriden groundwater units to reduce deployable output by a total of 10.8 Ml/d. This information has been presented to the Water Company and the proposed reduction has been included in the Company's draft water resources plan.

**It is therefore concluded that Option 6 (long term), incorporating Options 1, 2 and 3b with a total compensation release from groundwater sources of 3 Ml/d and including a total reduction in PWS groundwater abstractions of over 10 Ml/d, should be selected as the preferred option.**

The interim remedial measures will re-water 12 km of the main stream and its tributaries as well as significantly increasing the flow over a further 8 km.

In the longer term, with reduced groundwater abstractions, rising groundwater levels should restore baseflows to the river and its tributaries, with a subsequent reduction in the requirements for compensation releases.

The restoration of flow should improve the continuity of the river's linear wildlife habitat, which at present is incomplete due to the extremely low flows periodically experienced.

The higher flows in the River Sherbourne would provide a greater discharge to the Avon and the Severn which could be available for abstraction to the public water supply downstream.

The assessed economic benefit takes account of the ecological improvements and the greater water availability, in addition to the increase in the amenity and recreational value of the area surrounding the watercourses.

## 11.9 Tasks and Dependencies

| | | |
|---|---|---|
| Investigations: | Agency Midlands Region | Upper Severn Area Regional Office |
| Design and implementation: | Severn Trent Water Ltd<br>Agency Midlands Region | <br>Upper Severn Area Regional Office |

**Programme for implementation of the preferred option:**

| | |
|---|---|
| 1998 | Submission of Business Plan |
| 1999 | Investigation and Design<br>Planning and Consents |
| 2000 | Construction Part 1 |
| 2001 | Construction Part 2 |

## 11.10 Cost of Preferred Option

The estimated capital and operating costs of the preferred option are given in Table 11.13. The estimates of likely future capital costs are based on the assumption that the Construction Output Index (COPI) will rise by 4 per cent per annum. In the estimation of operating costs an annual increase of 2.5 per cent per annum in the Retail Price Index (RPI) has been assumed.

**Table 11.13 Estimated Costs of the Preferred Option (£ 000)**

| Year | Water Company | | Agency | |
|---|---|---|---|---|
| ending 31/03 | Capex | Opex | Capex | Opex |
| 1999 | 0 | 0 | 4[1] | 0 |
| 2000 | 0 | 0 | 16[2] | 0 |
| 2001 | 1,562 | 19 | 135[4] | 4[4] |
| 2002 | 819 | 32 | 0 | 4[4] |
| 2003 | 5,998[3] | 160[3] | 0 | 5[4] |

[1] Comprises submission of business plan, the cost of which has not been included in the assessment of tangibles
[2] Comprises the installation of monitoring equipment
[3] Long term replacement water costs could be deferred subject to supply/demand balance
[4] Agency costs for new borehole to be recharged to STW Ltd under AMP3

# 12 RIVER WORFE

## 12.1 Scheme Objectives

Historically, within the upper reaches of the River Worfe, which lie to the north west of Wolverhampton, there were springs, pools and water mills throughout the Ruckley, Neachley, Albrighton and Wesley Brooks. The area is illustrated on Figure 12.1. There are known to have been at least forty watermills working at one time within the catchment in the early part of the 19th century. Following groundwater development of the upper catchment (the Cosford Groundwater Unit) there have been reports of wells and pools drying up. Since the commissioning of boreholes at Neachley (1968) and Lizard Mill (1977), abstractions in the Cosford Groundwater Unit have exceeded the long term average recharge rate which has resulted in a further depletion of flows.

In 1990 the River Worfe was included as one of the original top 20 low flow alleviation sites listed before AMP2. Following the provision of an alternative water supply to one user for spray irrigation, the section between the confluences with the Albrighton and Wesley Brooks has been reclassified from intermittent to low flow.

The current proposals target the Ruckley and Cramp Pool Brooks for the further alleviation of low flows in the River Worfe as summarised in Table 12.1. All options involve a reduction in the abstraction for public water supply at the existing public water supply boreholes and augmentation of the river system from groundwater. In the longer term it is intended to reduce the total groundwater abstractions to a sustainable level which should result in rising groundwater levels re-watering the river and its tributaries, with a subsequent reduction in the requirements for compensation releases.

**Table 12.1 Low Flow Alleviation Options**

| Option | Description | Improvements |
|---|---|---|
| 1 | Pipeline from Sheriffhales Borehole to the Ruckley Brook. Compensation release of 5 Ml/day. | Rewater 11 km, significantly increased flows for 21 km. |
| 2 | Output from Lizard Mill Borehole to the Ruckley Brook. Compensation release of 2 Ml/day. | Rewater 8 km, significantly increased flows for 21 km. |
| 3 | Output from Hell Bank Borehole to the Neachley Brook. Compensation release of 1 Ml/day. | Rewater 1.5 km of tributary and 0.5 km of main stream, with some increase in flows downstream. |
| 4 | Output from Cramp Pool Borehole to the Cramp Pool Brook. Compensation release of 1 Ml/day. | Rewater 2 km of tributary and 2 km of main stream, with some increase in flows downstream. |
| 5 | Options 1, 2 and 3 combined. Total compensation release of 8 Ml/day. | Rewater 11 km of main stream and 1.5 km of tributary, with greater increase in flows for 21 km. |
| 6 | Options 1, 2 and 4 combined. Total compensation release of 8 Ml/day. | Rewater 11 km of main stream and 2 km of tributary, with greater increase in flows for 21 km |

In all cases the compensation flow would be triggered when the Agency gauging station at Cosford is at Q20% (21.6Ml/d) or below.

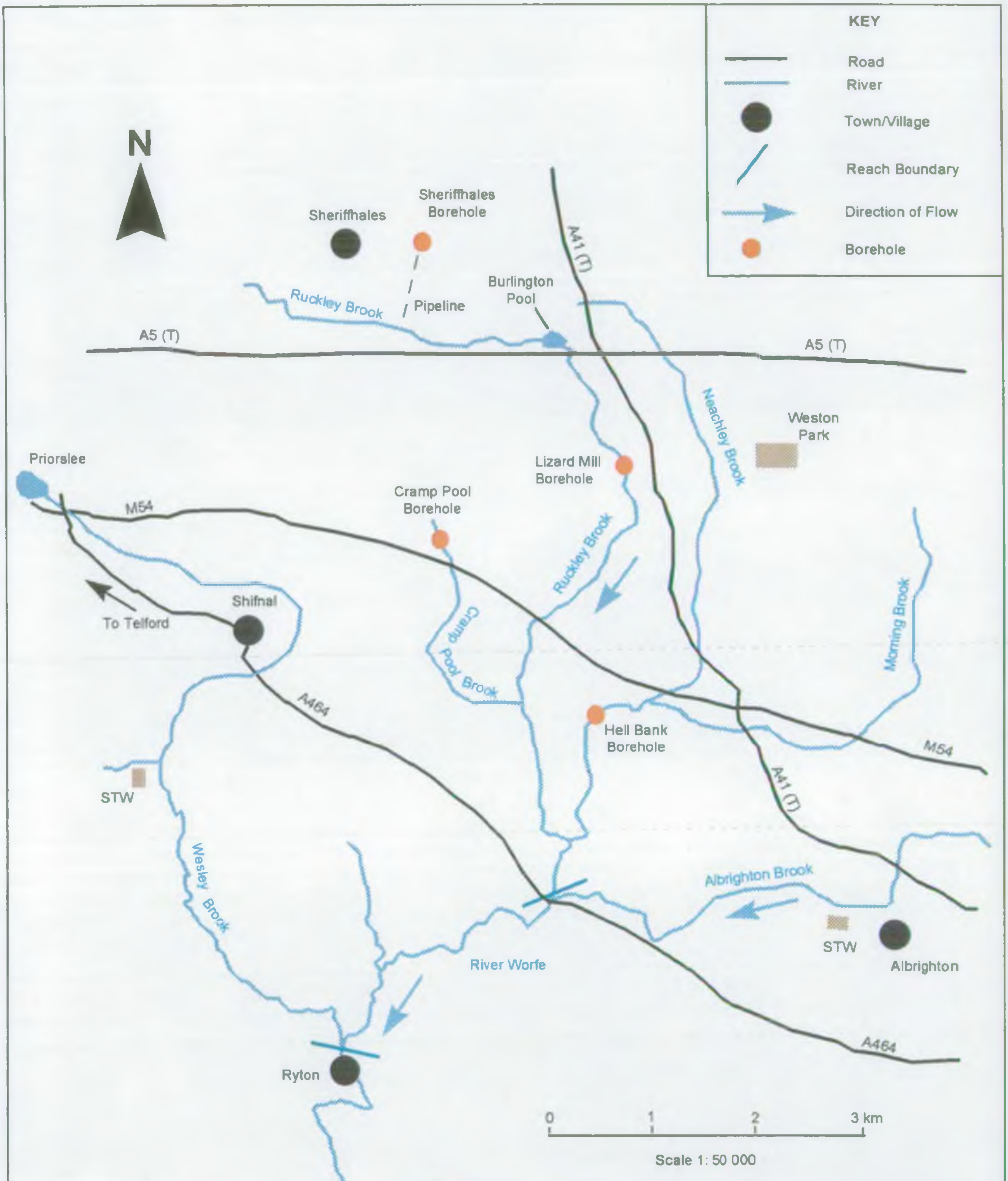
Flow duration/frequency curves were provided by the Agency to define the impact of the alleviation options and these are included in Appendix 12. The data relate to the gauging stations at Cosford, just upstream of the confluence of the Albrighton Brook, and at Burcote, towards the lower end of the catchment, some 3 km upstream of the confluence with the Severn, just north of Bridgnorth.

The available information has been used to derive appropriate factors for the economic benefits of each option for those uses which are frequency and duration dependent. In addition to the tributary reaches which are rewatered, the River Worfe has been divided into three reaches for this purpose:

| | |
|---|---|
| Reach 1 | Above Albrighton Brook (length varies with each option) |
| Reach 2 | Albrighton Brook to Wesley Brook (3.9 km) |
| Reach 3 | Wesley Brook to the confluence with the Severn (21.2 km) |

It has been noted that low flow conditions are less severe below the Wesley Brook as this tributary currently receives discharges from the Shifnal STW (dry weather flow 3 Ml/d) and releases by Wrekin District Council from Priorslee Pools (approximately 1 Ml/d).

Target flows for each reach have been assessed to determine the extent to which the low flow alleviation schemes will improve the situation. Flow improvement factors have been derived from a consideration of both the **proportional flow** improvement from the existing situation at the Q95% level, and the **proportional time** improvement that the target flow is achieved. Corresponding return periods for very low flows (i.e. about 50% of the target flows) have also been assessed for the before and after situations. The figures which have been derived are summarised in Table 12.2. For the tributaries which are re-watered with some of the options, the flow improvement factor is taken as 100%.




Environment Agency

Figure 12.1: Schematic of River Worfe Low Flow Alleviation Scheme

GIBB Ltd
Consulting Engineers
Reading England

AMP 3 Benefits Assessment

| SCALE | 1:50 000 | DATE | April 1998 | J98032 A |
|---|---|---|---|---|

Table 12.2 **Summary of Hydrological Assessment for River Worfe**

| | Reach 1 | Reach 2 | Reach 3 |
|---|---|---|---|
| **Target Flow (Ml/d)** | 5 | 9 | 20 |
| **% of Time above Target** | | | |
| **Before** | 25% | 55% | 65% |
| **After** Option 1 | 100% | 80% | 75% |
| Option 2 | 85% | 70% | 70% |
| Option 3 | 60% | 60% | 67% |
| Option 4 | 60% | 60% | 67% |
| Option 5 (1 + 2 + 3) | 100% | 100% | 80% |
| Option 6 (1 + 2 + 4) | 100% | 100% | 80% |
| **Flow Improvement Factor** | | | |
| Option 1 | 100% | 45% | 20% |
| Option 2 | 60% | 20% | 10% |
| Option 3 | 35% | 5% | 5% |
| Option 4 | 35% | 5% | 5% |
| Option 5 (1 + 2 + 3) | 100% | 65% | 35% |
| Option 6 (1 + 2 + 4) | 100% | 65% | 35% |
| **Return Period (years)** before → after | | | |
| Option 1 | 1 → 10 | 2 → 5 | 5 → 7 |
| Option 2 | 1 → 5 | 2 → 4 | 5 → 6 |
| Option 3 | 1 → 2 | 2 → 3 | 5 → 5 |
| Option 4 | 1 → 2 | 2 → 3 | 5 → 5 |
| Option 5 (1 + 2 + 3) | 1 → >10 | 2 → 7 | 5 → 8 |
| Option 6 (1 + 2 + 4) | 1 → >10 | 2 → 7 | 5 → 8 |

Severn Trent Water Limited have included proposals in their draft water resources plan, which was recently submitted to the Agency, for a reduction of 17 Ml/d in deployable output from groundwater sources located in the Cosford unit over the AMP3 period.

## 12.2 Scope of Study

Table 12.3 has been used as a checklist to focus on those impacts which are likely to be significant and need to be included in the economic appraisal.

**Table 12.3 Summary of Impacts**

| Impact Category | | Comments |
|---|---|---|
| Drinking Water Supply | | Increased flow available for PWS abstraction downstream. |
| Industrial Abstraction | | Not applicable |
| Agriculture | Livestock | Not applicable |
| | Irrigation | Yes |
| In-stream Recreation | Boating | Not applicable |
| | Bathing | Not applicable |
| | Angling | Yes |
| Informal recreation | Walking, picnicking, photography | Yes, a network of footpaths with some direct access to the river. |
| Amenity /Aesthetics | Property prices | A number of properties overlooking the river. |
| Conservation (Non-Use or Passive Use) | Ecology | Yes |
| | Heritage | Not applicable |
| Other | | None |

There are 23 surface water abstraction licences granted on the River Worfe, of which only six are situated above the Wesley Brook. It is these six which were considered most likely to provide benefits, although abstractors downstream with restricted licences may also benefit from the fact that there will be a increase in the number of days when flow at Burcote gauging station exceeds the prescribed flow.

Restoration of the flow will improve the continuity of the river's linear wildlife habitat, which at present is not complete due to the river periodically suffering extremely low flows.

The categories that have been included in the benefit assessment are:

- informal recreation;
- angling
- agriculture
- property;
- drinking water supply resource cost savings; and
- non-use.

## 12.3 Capital and Operating Costs

Severn Trent Water Ltd has provided the Agency with estimates of the capital expenditure (capex) and operating expenditure (opex) necessary to provide for the replacement of the water currently abstracted at the various boreholes which could be diverted to alleviate low flows in the River Worfe. In addition to the costs of providing replacement water, some minor works will be required in the vicinity of the boreholes to effect the flow augmentation. For Option 1 a pipeline some 2 km in length will be required from the Sheriffhales Borehole. Details of the costs are summarised in Table 12.4.

**Table 12.4 Summary of Cost Estimates (£ 000 Q4 1997)**

| | Option 1 | Option 2 | Option 3 | Option 4 |
|---|---|---|---|---|
| **Capital expenditure** | | | | |
| Replacement water | 3448 | 1379 | 690 | 690 |
| PWS option | 300 | 10 | 10 | 10 |
| Total | 3,748 | 1,389 | 700 | 700 |
| **Operating expenditure (per annum)** | | | | |
| Replacement water | 54 | 22 | 11 | 11 |
| PWS Option | 32 | 13 | 7 | 7 |
| Total | 86 | 35 | 18 | 18 |

## 12.4 Estimation of Benefits

### 12.4.1 Informal Recreation

Attempts were made to ascertain primary data on visitor numbers to this area by contacting the local Ramblers Association representative and other sources. Unfortunately no numbers were available, other than an estimate of about 5000 per annum to the Woodland Walk at Cosford, which actually lies on the Albrighton Brook rather than the river reaches affected by the proposed alleviation schemes. In the absence of reliable primary sources the estimation of visitor numbers to the sites has been based on the indirect approach outlined in the Agency Guidelines, related to the population within 0.8 km of the river, obtained from the Agency's GIS system. However, in the absence of any facilities to qualify as a 'honeypot' site and with no local parks in the vicinity of the river, realistic estimates of the likely number of visits have been derived from previous experience, utilising the GIS data to distribute the numbers between the river reaches.

As the informal recreational activities are unpriced there is no economic rent or profit earned by the activity. The total value of the recreational activity is measured in consumer surplus or the difference between what the consumer pays for the activity (zero) and what they would be willing to pay. The Guidelines recommend the following per visit estimates of the consumer surplus, assuming 40% of the willingness-to-pay is attributable to the presence of water:

- Upper bound estimate: £1.48 per visitor day;
- Central estimate: £0.60 per visitor day; and
- Lower bound estimate: £0.20 per visitor day.

Combining participation rates and willingness-to-pay with the flow improvement factors from Table 12.2 produces the annual incremental benefits which are presented in Table 12.5.

**Table 12.5 Annual Informal Recreation Benefits**

| | Option | Visitor Numbers by River Reach (000) | | | | Factored Benefit by River Reach (£000 Q4 1997) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Tributary | 1 | 2 | 3 | Tributary | 1 | 2 | 3 | Total |
| **Upper Bound** | **1** | - | 8.5 | 1.8 | 15 | - | 12.6 | 1.2 | 4.4 | 18.3 |
| | **2** | - | 5.4 | 1.8 | 15 | - | 4.8 | 0.5 | 2.2 | 7.6 |
| | **3** | 0.5 | 0.8 | 1.8 | 15 | 0.8 | 0.4 | 0.1 | 1.1 | 2.5 |
| | **4** | 0.3 | 2.2 | 1.8 | 15 | 0.4 | 1.1 | 0.1 | 1.1 | 2.8 |
| | **5** | 0.5 | 8.5 | 1.8 | 15 | 0.8 | 12.7 | 1.8 | 7.8 | 23.0 |
| | **6** | 0.3 | 8.5 | 1.8 | 15 | 0.8 | 12.7 | 1.8 | 7.8 | 22.6 |
| **Central Estimate** | **1** | - | 6.6 | 1.4 | 11.6 | - | 4.0 | 0.4 | 1.4 | 5.7 |
| | **2** | - | 4.2 | 1.4 | 11.6 | - | 1.5 | 0,2 | 0.7 | 2.4 |
| | **3** | 0.4 | 0.6 | 1.4 | 11.6 | 0.3 | 0.1 | 0.1 | 0.3 | 0.8 |
| | **4** | 0.2 | 1.7 | 1.4 | 11.6 | 0.1 | 0.4 | 0.1 | 0.3 | 0.9 |
| | **5** | 0.4 | 6.6 | 1.4 | 11.6 | 0.3 | 4.0 | 0.5 | 2.4 | 7.2 |
| | **6** | 0.2 | 6.6 | 1.4 | 11.6 | 0.1 | 4.0 | 0.5 | 2.4 | 7.0 |
| **Lower Bound** | **1** | - | 5.3 | 1.1 | 9.3 | - | 1.1 | 0.1 | 0.4 | 1.5 |
| | **2** | - | 3.4 | 1.1 | 9.3 | - | 0.4 | 0.1 | 0.2 | 0.6 |
| | **3** | 0.3 | 0.5 | 1.1 | 9.3 | 0.1 | 0 | 0 | 0.1 | 0.2 |
| | **4** | 0.2 | 1.4 | 1.1 | 9.3 | 0 | 0.1 | 0 | 0.1 | 0.2 |
| | **5** | 0.3 | 5.3 | 1.1 | 9.3 | 0.1 | 1.1 | 0.1 | 0.7 | 1.9 |
| | **6** | 0.2 | 5.3 | 1.1 | 9.3 | 0 | 1.1 | 0.1 | 0.7 | 1.9 |

## 12.4.2 Angling

Discussions with Agency staff revealed that there are few angling interests on the River Worfe, although there are brown trout in the river. The only significant angling club with waters on the Worfe is the Salopian Flyfishers Ltd, who fish waters in the Worfield area, at the lower end of the catchment, which are considered to be very good quality fishing, due at least in part to the annual stocking during the months of April, May and June with a total of some 1000 fish. Although they have suffered from low flows during the summer months, on one occasion leaving the river as a string of pools until it rained again, it has not in their opinion affected the fishing or led to any fish mortalities. Regardless of the level of flow in the river they would not be looking to increase their membership beyond its current levels. Any other fishing on the lower reaches of the river is on an informal basis and could not be quantified.

There is no organised angling on the upper reaches of the Worfe or its tributaries, although there used to be a fishery in Burlington Pool, just downstream of the proposed augmentation point with Option 1. This pool was fished by the Weston Under Lizard Angling Club, but was given up when the low flows eventually led to the drying up of the pool. Re-watering would have the potential to open it up as a coarse fishery. However discussions with the Fisheries department at the Agency suggest that so much siltation has occurred that for it to achieve the status of even a moderate fishery extensive dredging would be required. Therefore there are unlikely to be any significant net benefits to be gained.

Agency staff stated that the Upper Worfe between Cosford and the confluence with the River Severn, 12.5 km, is a designated brown trout fishery. A report on the application of the Instream Flow Incremental Methodology / Physical Habitat Simulation (IFIM/PHABSIM) concludes that both spawning and juvenile brown trout would benefit from an increase in flows. This benefit would be significant for the juvenile fish between the key period of April to September (Application of IFIM/PHABSIM for the Upper Worfe, WS Atkins, 1996).

The report goes on to say that there is possibly no self-supporting brown trout population in the Worfe and that increased flows could lead to better survival rates in the brown trout population, both wild and introduced stocks.

The effect of this on angling is difficult to ascertain. Juvenile brown trout do not reach maturity for 2 to 3 years so there will be a period of time between the improvement of flows and the time when the wild brown trout stocks become self-sufficient and therefore a viable fishery. However it seems clear that there will be some improvement in the angling potential of the river over time, at least downstream of Cosford. This, combined with the increased survival rate amongst the artificial stocks, will mean that benefits will accrue to angling.

Agency staff have suggested a figure of 4 anglers per mile as a realistic estimate of the number of trout fishermen likely to be attracted to such a fishery (Further hydrological investigations following the IFIM/PHABSIM application to the River Worfe, P.A.Johnston, 1997). The Low Flow Benefit Assessment Guidelines suggest anglers' willingness-to-pay values and participation rates for the introduction of a new trout fishery as follows:

- poor £8.92 per person per trip 3.02 trips per angler per annum
- moderate £10.39 per person per trip 13.02 trips per angler per annum
- good £16.28 per person per trip 10.98 trips per angler per annum

Combining these values with the total number of anglers allows the incremental benefits of a change in the quality of fishery to be calculated. The quality achieved by the various options has been related to the degree of flow improvement in river reaches 2 and 3, giving the annual values summarised in Table 12.6.

**Table 12.6 Annual Angling Benefits for Improving Flows to the River Worfe (£000)**

| Option | Upper Bound | Central Estimate | Lower Bound |
|---|---|---|---|
| 1 | 6 | 1 | 0 |
| 2 | 1 | 0 | 0 |
| 3 and 4 | 0 | 0 | 0 |
| 5 and 6 | 8 | 6 | 1 |

### 12.4.3 Agriculture

Of the 23 surface water abstraction licences granted on the River Worfe, it is primarily the six located above the Wesley Brook confluence which may accrue agricultural benefits. Of these six it was possible to contact the holders of four of the licences.

Hatton Grange Farm holds licence numbers 18/54/5/82 and 18/54/5/137. The former is a licence of right and therefore less affected by low flows. They have lost very few days of irrigation in recent years and simply would not irrigate on the odd day lost. The second is a winter abstraction licence which has been unaffected by low flows. There is therefore no benefit to be gained on these licences.

18/54/5/104 is held by Atchley Manor and is a licence of right. In order to ease the water requirements made on the River Worfe during periods of low flows, Atchley Manor now has a borehole, the licence for which prohibits pumping from the surface water during low flows (i.e. when the flow at Burcote gauging station is below the prescribed flow of 54.6 Ml/d). From discussions with the electricity supplier, the licence holder apparently was led to believe that it would be cheaper to use the borehole rather than pump surface water. Hence during 1997, the first year that the borehole was in operation, he exclusively used the borehole regardless of the state of flow in the river. The licencee did not know on how many days he would have had to turn to the borehole rather than use the river in the last year. It is therefore not possible to ascertain the level of any benefits which may accrue in terms of savings made by pumping constantly from the river rather than incurring the costs of pumping from the borehole, which in reality are likely to be higher.

Licence number 18/54/5/67 is held by Rookery Farm and is a licence of right, there are therefore few benefits to be gained as the licencee can normally pump from the river regardless of the level of flow. The only time he loses irrigation time is when he does not restart the pump after it has sucked air in as the flows drop. As soon as he restarts the pumps irrigation begins again.

Other licence holders further downstream could benefit, particularly from the reduction in time when Burcote gauging station is below the prescribed flow. The holder of licence numbers 18/54/5/64 and 18/54/5/92 was also contacted but again it was considered that little benefit was to be gained as they are also licences of right and therefore very few days of irrigation are lost.

The timescale for completion of the report did not permit further enquiries. However, an earlier analysis by Agency staff identified a total annual benefit of £41,130 for a flow augmentation of 10 Ml/d. With the findings described above this may be considered to be an upper bound and for the purposes of this report the central estimate has been based on 50% of this figure, adjusted for the compensation flow achieved by the various options.

### 12.4.4 Property

Bridgnorth District Council was contacted to provide Council Tax Bands for the properties identified as adjacent to the watercourses. These are summarised in Table 12.7.

**Table 12.7 Properties Adjacent to River Worfe by Council Tax Band**

| Band | 1997 Midpoint | No of properties | | | | Economic Value |
|---|---|---|---|---|---|---|
| | (£ 000) | Reach 1 | Reach 2 | Reach 3 | Total | (£ 000 Q4 1997) |
| A | 40 | | | | | |
| B | 46 | | | | | |
| C | 61 | | | 2 | 2 | 121 |
| D | 79 | 3 | | | 3 | 236 |
| E | 105 | 7 | 1 | 4 | 12 | 1,260 |
| F | 141 | 4 | 1 | 6 | 11 | 1,555 |
| G | 242 | 2 | | 4 | 6 | 1,454 |
| H | 323 | 2 | | 1 | 3 | 969 |
| **Total** | | **18** | **2** | **17** | **37** | **5,596** |

Source: Bridgnorth District Council

By applying the formulae given in the Benefit Assessment Guidelines, using the assumed changes in return periods for the low flows indicated in Table 12.2, the benefit to property owners has been estimated in terms of once-off changes in stock.

**Table 12.8 Amenity and Aesthetic Stock Benefits (£000 Q4 1997)**

| Option | Total Incremental Benefits | | |
|---|---|---|---|
| | Upper Bound | Central Estimate | Lower Bound |
| 1 | 473 | 316 | 63 |
| 2 | 226 | 151 | 30 |
| 3 | 14 | 9 | 2 |
| 4 | 39 | 26 | 5 |
| 5 | 502 | 335 | 67 |
| 6 | 508 | 339 | 68 |

### 12.4.5 Resource Cost Savings

With a significant quantity of water being added to the River Worfe there will be a higher discharge to the Severn which could be available for abstraction for public water supply downstream in preference to pumping from the Shropshire Groundwater Scheme. An earlier assessment by the Agency indicated that this benefit might pertain on average for some 75 days per year, allowing for preferential abstractions for spray irrigation upstream when the flow at Burcote gauging station is above the prescribed flow, at an estimated value of £19 per Ml. This gives the following annual benefits in terms of resource cost savings:

| | | |
|---|---|---|
| Option 1 | 5 Ml/d | £ 7125 |
| Option 2 | 2 Ml/d | £ 2850 |
| Options 3 and 4 | 1 Ml/d | £ 1425 |
| Options 5 and 6 | 8 Ml/d | £11400 |

### 12.4.6 Non-Use

Non-use (conservation) benefit estimates for the River Worfe have been derived for:

- local residents within 3 km;
- river users among the general public who do not visit this particular river and its tributaries but do hold non-use values towards the alleviation of low flows in rivers;
- the wider general public who are not river users.

The non-use benefits have been derived using the procedures given in Section 9 of the Benefit Assessment Guidelines.

**Local resident non-use valuation**

It has been assumed that there are some 8,000 households within 3 km of the River Worfe, distributed between the three river reaches as indicated below, based on population data obtained from the Agency GIS model and assuming 2.7 people/household:

| | |
|---|---|
| Reach I | 3,021 (1,834 for Option 2, with minor adjustments for other options) |
| Reach 2 | 816 |
| Reach 3 | 3,993 |

In accordance with the Guidelines, the following values per household per annum are applied where full low flow alleviation is achieved:

| | |
|---|---|
| Upper Bound | £12.00 |
| Central Estimate | £10.00 |
| Lower Bound | £ 7.00 |

**General public non-use valuation**

It is assumed that there are 3.15 million households within Severn Trent Water's area and that 45% of the population are general river users, from which the actual number of local households already included are subtracted. The remaining 55% of the population in the service area are taken as non-users for whom a lower scale of benefits applies. The central estimates are based on the figures of £0.05 and £0.03 per household per km of river per annum for full low flow alleviation in accordance with the Guidelines, with +/- 25% for upper and lower bounds.

The annual non-use (conservation) benefit of each option, applying the flow improvement factors from Table 12.2 for each river reach, are summarised in Table 12.9 in terms of the local resident non-use benefits and the full (local resident plus general public non-use) benefits.

**Table 12.9 Annual Non-Use Benefits (£000 Q4 1997)**

| Option | Extent | Upper | Central | Lower |
|---|---|---|---|---|
| 1 | Local | 50 | 42 | 29 |
| | Full | 2,499 | 2,001 | 1,498 |
| 2 | Local | 20 | 17 | 12 |
| | Full | 1,043 | 835 | 625 |
| 3 | Local | 12 | 10 | 7 |
| | Full | 461 | 369 | 276 |
| 4 | Local | 12 | 10 | 7 |
| | Full | 617 | 494 | 370 |
| 5 | Local | 60 | 50 | 35 |
| | Full | 3,344 | 2,677 | 2,006 |
| 6 | Local | 61 | 51 | 36 |
| | Full | 3,422 | 2,739 | 2,052 |

## 12.5 Assessment of Tangibles (Cost Benefit Analysis)

The costs and the annual benefit streams have been aggregated in terms of present values in accordance with the procedures given in the Benefit Assessment Guidelines. The indicators in terms of net present values (NPV) and benefit cost ratios for the various options are presented in Table 12.10. The results are shown for a variety of combinations of the economic factors:

- both including and excluding non-use, together with two intermediate figures: one including only 50% of the general public (i.e. non-local) non-use and the other including only local non-use;
- for the central estimates, with upper and lower bounds;
- using the different discount rates and time horizons; and
- with and without rolling forward the benefits.

In addition, a variant on Option 6 is also shown which has the same benefits as Option 6, but allows for phasing of the capital costs over the implementation period and includes the additional costs of the replacement water which is expected to be required in order to provide a long term sustainable solution to the problem of over-abstraction. This variant also includes additional Agency costs for the installation of monitoring equipment. The costs for a total of 16.9 Ml/d of replacement water have been allowed for with Option 6 (long term).

All the individual options (1, 2, 3 and 4) show a positive net present value when any proportion of the non-local non-use benefits are included. For each combination of economic factors, the benefit cost ratios of the four options are similar. This indicates that each option is justifiable in its own right. When any proportion of the non-local non-use benefits is included, Option 4 is consistently seen as preferable to Option 3, with the higher benefits due to the greater length of watercourse being impacted. It therefore follows that the combination of the three options (1, 2 and 4), designated as Option 6, has the highest NPV, except when non-local non-use benefits are excluded.

The overall results are highly sensitive to the assumptions regarding non-use benefits, with benefit cost ratios in the range 2 to 11 when the full non-use benefits are included. If only the local non-use benefits are included, the NPV becomes negative in all cases considered and the benefit cost ratio reduces to the range 0.1 to 0.3 with the central estimates. If no non-use benefits are included NPVs and benefit cost ratios are even lower.

A summary of the assessment of tangibles (i.e the quantifiable costs and benefits) for all options is presented in Table 12.11. For this analysis, which has been carried forward to the Summary Business Case, the economic benefit has been determined on the following basis:

- including 50% of the general public (i.e. non-local) non-use benefits
- central estimates without rolling forward of the benefits.

A breakdown of the total present value of the benefits for Option 6 (long term) by use category (central estimates, including 50% of the non-local non-use benefits) with the 6% Treasury discount rate, with no rolling forward, is shown on Figure 12.2, together with a breakdown of the present value of the costs.

**Table 12.10 (Sheet 1)** **River Worfe : Summary of Costs and Benefits**
**(£ 000 Q4 1997 expressed as present values)**

| Option | 7% Discount Rate, 30 year time period | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Costs | Benefits | | | | Total NPV | | | | Benefit Cost Ratio | | | |
| | | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use |
| **Upper estimates, no rolling forward** | | | | | | | | | | | | | |
| 1 | 4,490 | 29,675 | 15,627 | 1,580 | 1,004 | 25,185 | 11,138 | -2,909 | -3,486 | 6.6 | 3.5 | 0.35 | 0.22 |
| 2 | 1,700 | 12,391 | 6,522 | 653 | 424 | 10,692 | 4,822 | -1,047 | -1,276 | 7.3 | 3.8 | 0.38 | 0.25 |
| 3 | 861 | 5,396 | 2,820 | 245 | 104 | 4,535 | 1,960 | -616 | -757 | 6.3 | 3.3 | 0.28 | 0.12 |
| 4 | 861 | 7,214 | 3,739 | 263 | 130 | 6,354 | 2,878 | -598 | -731 | 8.4 | 4.3 | 0.31 | 0.15 |
| 5 | 7,049 | 39,668 | 20,827 | 1,985 | 1,293 | 32,619 | 13,778 | -5,064 | -5,756 | 5.6 | 3.0 | 0.28 | 0.18 |
| 6 | 7,049 | 40,556 | 21,276 | 1,996 | 1,294 | 33,507 | 14,227 | -5,053 | -5,755 | 5.8 | 3.0 | 0.28 | 0.18 |
| 6 (long term) | 12,681 | 40,556 | 21,276 | 1,996 | 1,294 | 27,875 | 8,595 | -10,685 | -11,387 | 3.2 | 1.7 | 0.16 | 0.10 |
| **Upper estimates, with rolling forward** | | | | | | | | | | | | | |
| 1 | 4,490 | 31,279 | 16,463 | 1,647 | 1,039 | 26,790 | 11,974 | -2,843 | -3,451 | 7.0 | 3.7 | 0.37 | 0.23 |
| 2 | 1,700 | 13,060 | 6,870 | 679 | 437 | 11,361 | 5,170 | -1,021 | -1,262 | 7.7 | 4.0 | 0.40 | 0.26 |
| 3 | 861 | 5,690 | 2,974 | 258 | 109 | 4,830 | 2,113 | -603 | -752 | 6.6 | 3.5 | 0.30 | 0.13 |
| 4 | 861 | 7,608 | 3,942 | 276 | 135 | 6,747 | 3,081 | -585 | -726 | 8.8 | 4.6 | 0.32 | 0.16 |
| 5 | 7,049 | 41,819 | 21,946 | 2,073 | 1,343 | 34,770 | 14,897 | -4,976 | -5,706 | 5.9 | 3.1 | 0.29 | 0.19 |
| 6 | 7,049 | 42,756 | 22,420 | 2,084 | 1,344 | 35,706 | 15,371 | -4,965 | -5,706 | 6.1 | 3.2 | 0.30 | 0.19 |
| 6 (long term) | 12,681 | 42,756 | 22,420 | 2,084 | 1,344 | 30,075 | 9,739 | -10,597 | -11,337 | 3.4 | 1.8 | 0.16 | 0.11 |
| **Central estimates, no rolling forward** | | | | | | | | | | | | | |
| 1 | 4,490 | 23,509 | 12,272 | 1,034 | 554 | 19,020 | 7,782 | -3,456 | -3,936 | 5.2 | 2.7 | 0.23 | 0.12 |
| 2 | 1,700 | 9,820 | 5,125 | 429 | 239 | 8,121 | 3,425 | -1,270 | -1,461 | 5.8 | 3.0 | 0.25 | 0.14 |
| 3 | 861 | 4,295 | 2,235 | 174 | 57 | 3,434 | 1,374 | -686 | -804 | 5.0 | 2.6 | 0.20 | 0.07 |
| 4 | 861 | 5,745 | 2,964 | 184 | 73 | 4,884 | 2,104 | -677 | -788 | 6.7 | 3.4 | 0.21 | 0.08 |
| 5 | 7,049 | 31,480 | 16,407 | 1,333 | 757 | 24,431 | 9,358 | -5,716 | -6,292 | 4.5 | 2.3 | 0.19 | 0.11 |
| 6 | 7,049 | 32,192 | 16,768 | 1,344 | 759 | 25,143 | 9,719 | -5,705 | -6,290 | 4.6 | 2.4 | 0.19 | 0.11 |
| 6 (long term) | 12,681 | 32,192 | 16,768 | 1,344 | 759 | 19,511 | 4,087 | -11,337 | -11,922 | 2.5 | 1.3 | 0.11 | 0.06 |
| **Central estimates, with rolling forward** | | | | | | | | | | | | | |
| 1 | 4,490 | 24,783 | 12,930 | 1,077 | 570 | 20,293 | 8,440 | -3,413 | -3,919 | 5.5 | 2.9 | 0.24 | 0.13 |
| 2 | 1,700 | 10,352 | 5,399 | 446 | 245 | 8,652 | 3,699 | -1,253 | -1,455 | 6.1 | 3.2 | 0.26 | 0.14 |
| 3 | 861 | 4,530 | 2,357 | 183 | 60 | 3,669 | 1,496 | -677 | -801 | 5.3 | 2.7 | 0.21 | 0.07 |
| 4 | 861 | 6,058 | 3,125 | 193 | 76 | 5,198 | 2,265 | -668 | -785 | 7.0 | 3.6 | 0.22 | 0.09 |
| 5 | 7,049 | 33,190 | 17,291 | 1,392 | 784 | 26,141 | 10,242 | -5,657 | -6,265 | 4.7 | 2.5 | 0.20 | 0.11 |
| 6 | 7,049 | 33,941 | 17,672 | 1,403 | 786 | 26,892 | 10,623 | -5,646 | -6,263 | 4.8 | 2.5 | 0.20 | 0.11 |
| 6 (long term) | 12,681 | 33,941 | 17,672 | 1,403 | 786 | 21,260 | 4,991 | -11,277 | -11,894 | 2.7 | 1.4 | 0.11 | 0.06 |
| **Lower estimates, no rolling forward** | | | | | | | | | | | | | |
| 1 | 4,490 | 17,347 | 8,919 | 491 | 155 | 12,858 | 4,430 | -3,999 | -4,335 | 3.9 | 2.0 | 0.11 | 0.03 |
| 2 | 1,700 | 7,243 | 3,722 | 200 | 66 | 5,543 | 2,022 | -1,500 | -1,633 | 4.3 | 2.2 | 0.12 | 0.04 |
| 3 | 861 | 3,193 | 1,648 | 103 | 20 | 2,332 | 787 | -758 | -840 | 3.7 | 1.9 | 0.12 | 0.02 |
| 4 | 861 | 4,272 | 2,187 | 101 | 24 | 3,411 | 1,326 | -759 | -837 | 5.0 | 2.5 | 0.12 | 0.03 |
| 5 | 7,049 | 23,237 | 11,932 | 627 | 224 | 16,188 | 4,883 | -6,422 | -6,825 | 3.3 | 1.7 | 0.09 | 0.03 |
| 6 | 7,049 | 23,770 | 12,202 | 634 | 224 | 16,721 | 5,153 | -6,415 | -6,825 | 3.4 | 1.7 | 0.09 | 0.03 |
| 6 (long term) | 12,681 | 23,770 | 12,202 | 634 | 224 | 11,089 | -479 | -12,047 | -12,457 | 1.9 | 1.0 | 0.05 | 0.02 |
| **Lower estimates, with rolling forward** | | | | | | | | | | | | | |
| 1 | 4,490 | 18,295 | 9,405 | 515 | 160 | 13,805 | 4,915 | -3,975 | -4,329 | 4.1 | 2.1 | 0.11 | 0.04 |
| 2 | 1,700 | 7,638 | 3,924 | 210 | 69 | 5,939 | 2,224 | -1,490 | -1,631 | 4.5 | 2.3 | 0.12 | 0.04 |
| 3 | 861 | 3,368 | 1,738 | 108 | 21 | 2,507 | 877 | -753 | -839 | 3.9 | 2.0 | 0.13 | 0.02 |
| 4 | 861 | 4,506 | 2,306 | 107 | 25 | 3,645 | 1,446 | -754 | -836 | 5.2 | 2.7 | 0.12 | 0.03 |
| 5 | 7,049 | 24,507 | 12,583 | 659 | 233 | 17,458 | 5,534 | -6,390 | -6,816 | 3.5 | 1.8 | 0.09 | 0.03 |
| 6 | 7,049 | 25,069 | 12,867 | 666 | 234 | 18,019 | 5,818 | -6,384 | -6,815 | 3.6 | 1.8 | 0.09 | 0.03 |
| 6 (long term) | 12,681 | 25,069 | 12,867 | 666 | 234 | 12,388 | 186 | -12,015 | -12,447 | 2.0 | 1.0 | 0.05 | 0.02 |

Table 12.10 (Sheet 2) **River Worfe : Summary of Costs and Benefits**
(£ 000 Q4 1997 expressed as present values)

| Option | 6% Discount Rate, 50 year time period | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Costs | Benefits | | | | Total NPV | | | | Benefit Cost Ratio | | | |
| | | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use | incl full non-use | incl local and 50% non-local non-use | incl local non-use | excl non-use |
| **Upper estimates, no rolling forward** | | | | | | | | | | | | | |
| 1 | 4,810 | 38,213 | 20,072 | 1,931 | 1,187 | 33,403 | 15,262 | -2,879 | -3,624 | 7.9 | 4.2 | 0.40 | 0.25 |
| 2 | 1,829 | 15,949 | 8,370 | 790 | 494 | 14,120 | 6,541 | -1,039 | -1,335 | 8.7 | 4.6 | 0.43 | 0.27 |
| 3 | 927 | 6,965 | 3,639 | 313 | 131 | 6,038 | 2,712 | -614 | -796 | 7.5 | 3.9 | 0.34 | 0.14 |
| 4 | 927 | 9,308 | 4,819 | 330 | 158 | 8,380 | 3,892 | -597 | -769 | 10.0 | 5.2 | 0.36 | 0.17 |
| 5 | 7,565 | 51,113 | 26,781 | 2,448 | 1,555 | 43,548 | 19,215 | -5,117 | -6,011 | 6.8 | 3.5 | 0.32 | 0.21 |
| 6 | 7,565 | 52,258 | 27,359 | 2,461 | 1,554 | 44,693 | 19,794 | -5,105 | -6,011 | 6.9 | 3.6 | 0.33 | 0.21 |
| 6 (long term) | 13,733 | 52,258 | 27,359 | 2,461 | 1,554 | 38,525 | 13,626 | -11,273 | -12,179 | 3.8 | 2.0 | 0.18 | 0.11 |
| **Upper estimates, with rolling forward** | | | | | | | | | | | | | |
| 1 | 4,810 | 41,157 | 21,604 | 2,052 | 1,249 | 36,347 | 16,794 | -2,759 | -3,561 | 8.6 | 4.5 | 0.43 | 0.26 |
| 2 | 1,829 | 17,176 | 9,007 | 837 | 518 | 15,347 | 7,178 | -992 | -1,311 | 9.4 | 4.9 | 0.46 | 0.28 |
| 3 | 927 | 7,506 | 3,921 | 337 | 140 | 6,579 | 2,994 | -590 | -787 | 8.1 | 4.2 | 0.36 | 0.15 |
| 4 | 927 | 10,029 | 5,191 | 353 | 168 | 9,102 | 4,264 | -574 | -759 | 10.8 | 5.6 | 0.38 | 0.18 |
| 5 | 7,565 | 55,060 | 28,833 | 2,607 | 1,644 | 47,494 | 21,268 | -4,958 | -5,921 | 7.3 | 3.8 | 0.34 | 0.22 |
| 6 | 7,565 | 58,294 | 29,457 | 2,620 | 1,643 | 48,728 | 21,891 | -4,945 | -5,922 | 7.4 | 3.9 | 0.35 | 0.22 |
| 6 (long term) | 13,733 | 56,294 | 29,457 | 2,620 | 1,643 | 42,560 | 15,724 | -11,113 | -12,090 | 4.1 | 2.1 | 0.19 | 0.12 |
| **Central estimates, no rolling forward** | | | | | | | | | | | | | |
| 1 | 4,810 | 30,286 | 15,773 | 1,261 | 640 | 25,476 | 10,963 | -3,549 | -4,170 | 6.3 | 3.3 | 0.26 | 0.13 |
| 2 | 1,829 | 12,647 | 6,583 | 519 | 272 | 10,817 | 4,754 | -1,310 | -1,557 | 6.9 | 3.6 | 0.28 | 0.15 |
| 3 | 927 | 5,544 | 2,884 | 223 | 71 | 4,617 | 1,956 | -704 | -856. | 6.0 | 3.1 | 0.24 | 0.08 |
| 4 | 927 | 7,413 | 3,822 | 231 | 88 | 6,486 | 2,895 | -696 | -839 | 8.0 | 4.1 | 0.25 | 0.09 |
| 5 | 7,565 | 40,577 | 21,111 | 1,645 | 901 | 33,012 | 13,546 | -5,920 | -6,664 | 5.4 | 2.8 | 0.22 | 0.12 |
| 6 | 7,565 | 41,496 | 21,577 | 1,658 | 903 | 33,931 | 14,012 | -5,907 | -6,663 | 5.5 | 2.9 | 0.22 | 0.12 |
| 6 (long term) | 13,733 | 41,496 | 21,577 | 1,658 | 90 | 27,763 | 7,844 | -12,075 | -13,643 | 3.0 | 1.6 | 0.12 | 0.01 |
| **Central estimates, with rolling forward** | | | | | | | | | | | | | |
| 1 | 4,810 | 32,623 | 16,981 | 1,339 | 670 | 27,813 | 12,171 | -3,472 | -4,140 | 6.8 | 3.5 | 0.28 | 0.14 |
| 2 | 1,829 | 13,621 | 7,085 | 549 | 284 | 11,792 | 5,256 | -1,280 | -1,545 | 7.4 | 3.9 | 0.30 | 0.16 |
| 3 | 927 | 5,975 | 3,107 | 240 | 76 | 5,048 | 2,180 | -687 | -851 | 6.4 | 3.4 | 0.26 | 0.08 |
| 4 | 927 | 7,988 | 4,118 | 247 | 93 | 7,061 | 3,191 | -680 | -834 | 8.6 | 4.4 | 0.27 | 0.10 |
| 5 | 7,565 | 43,715 | 22,734 | 1,752 | 950 | 36,149 | 15,168 | -5,813 | -6,615 | 5.8 | 3.0 | 0.23 | 0.13 |
| 6 | 7,565 | 44,705 | 23,235 | 1,766 | 952 | 37,139 | 15,670 | -5,800 | -6,614 | 5.9 | 3.1 | 0.23 | 0.13 |
| 6 (long term) | 13,733 | 44,705 | 23,235 | 1,766 | 952 | 30,971 | 9,502 | -11,967 | -12,782 | 3.3 | 1.7 | 0.13 | 0.07 |
| **Lower estimates, no rolling forward** | | | | | | | | | | | | | |
| 1 | 4,810 | 22,388 | 11,503 | 619 | 185 | 17,578 | 6,693 | -4,191 | -4,626 | 4.7 | 2.4 | 0.13 | 0.04 |
| 2 | 1,829 | 9,347 | 4,799 | 251 | 79 | 7,518 | 2,970 | -1,578 | -1,751 | 5.1 | 2.6 | 0.14 | 0.04 |
| 3 | 927 | 4,123 | 2,128 | 132 | 26 | 3,196 | 1,200 | -795 | -901 | 4.4 | 2.3 | 0.14 | 0.03 |
| 4 | 927 | 5,516 | 2,823 | 130 | 29 | 4,589 | 1,896 | -798 | -898 | 5.9 | 3.0 | 0.14 | 0.03 |
| 5 | 7,565 | 29,994 | 15,394 | 795 | 274 | 22,429 | 7,829 | -6,771 | -7,292 | 4.0 | 2.0 | 0.11 | 0.04 |
| 6 | 7,565 | 30,681 | 15,742 | 803 | 274 | 23,116 | 8,177 | -6,763 | -7,291 | 4.1 | 2.1 | 0.11 | 0.04 |
| 6 (long term) | 13,733 | 30,681 | 15,742 | 803 | 274 | 16,948 | 2,009 | -12,930 | -13,459 | 2.2 | 1.1 | 0.06 | 0.02 |
| **Lower estimates, with rolling forward** | | | | | | | | | | | | | |
| 1 | 4,810 | 24,126 | 12,395 | 663 | 195 | 19,316 | 7,584 | -4,147 | -4,615 | 5.0 | 2.6 | 0.14 | 0.04 |
| 2 | 1,829 | 10,072 | 5,170 | 269 | 83 | 8,243 | 3,341 | -1,560 | -1,746 | 5.5 | 2.8 | 0.15 | 0.05 |
| 3 | 927 | 4,444 | 2,293 | 142 | 28 | 3,517 | 1,366 | -785 | -899 | 4.8 | 2.5 | 0.15 | 0.03 |
| 4 | 927 | 5,945 | 3,042 | 139 | 31 | 5,018 | 2,115 | -788 | -896 | 6.4 | 3.3 | 0.15 | 0.03 |
| 5 | 7,565 | 32,324 | 16,588 | 853 | 291 | 24,759 | 9,023 | -6,713 | -7,274 | 4.3 | 2.2 | 0.11 | 0.04 |
| 6 | 7,565 | 33,065 | 16,963 | 861 | 291 | 25,500 | 9,398 | -6,704 | -7,274 | 4.4 | 2.2 | 0.11 | 0.04 |
| 6 (long term) | 13,733 | 33,065 | 16,963 | 861 | 291 | 19,332 | 3,230 | -12,872 | -13,442 | 2.4 | 1.2 | 0.06 | 0.02 |

**Table 12.11 Assessment of Tangibles (£000 Q4 1997)**

| Option | Agency Costs | Water Co. Costs | Economic Benefit | Net Present Value | Benefit Cost Ratio |
|---|---|---|---|---|---|
| 6% discount rate, 50 year time period | | | | | |
| **Do Nothing** | 0 | 0 | 0 | 0 | 0 |
| **Option 1** | 0 | 4,810 | 15,733 | 10,963 | 3.3 |
| **Option 2** | 0 | 1,829 | 6,583 | 4,754 | 3.6 |
| **Option 3** | 0 | 927 | 2,884 | 1,956 | 3.1 |
| **Option 4** | 0 | 927 | 3,822 | 2,895 | 4.1 |
| **Option 5** | 0 | 7,565 | 21,111 | 13,546 | 2.8 |
| **Option 6** | 0 | 7,565 | 21,577 | 14,012 | 2.9 |
| **Option 6 (long term)** | 9 | 13,724 | 21,577 | 7,844 | 1.6 |
| 7% discount rate, 30 year time period | | | | | |
| **Do Nothing** | 0 | 0 | 0 | 0 | 0 |
| **Option 1** | 0 | 4,490 | 12,272 | 7,782 | 2.7 |
| **Option 2** | 0 | 1,700 | 5,125 | 3,425 | 3.0 |
| **Option 3** | 0 | 861 | 2,235 | 1,374 | 2.6 |
| **Option 4** | 0 | 861 | 2,964 | 2,104 | 3.4 |
| **Option 5** | 0 | 7,049 | 16,407 | 9,358 | 2.3 |
| **Option 6** | 0 | 7,049 | 16,768 | 9,719 | 2.4 |
| **Option 6 (long term)** | 9 | 12,671 | 16,768 | 4,087 | 1.3 |

## 12.6 Assessment of Intangibles

The assessment of intangible benefits (or disbenefits) has been undertaken by a weighting and scoring system and is presented in Table 12.12. The intangibles considered in the table are:

1. Facilitation of Agency meeting objectives
2. Improved public relations and maintenance of credibility of Agency
3. Longer term benefits not quantified in economic analysis

Each of the intangible benefits has been allocated a weighting within the range from 5 to 0 (from most important to least important). Scores reflecting the ability of each option to deliver the intangible benefit have been allocated from 5 to 0 (from greatest ability to least ability).

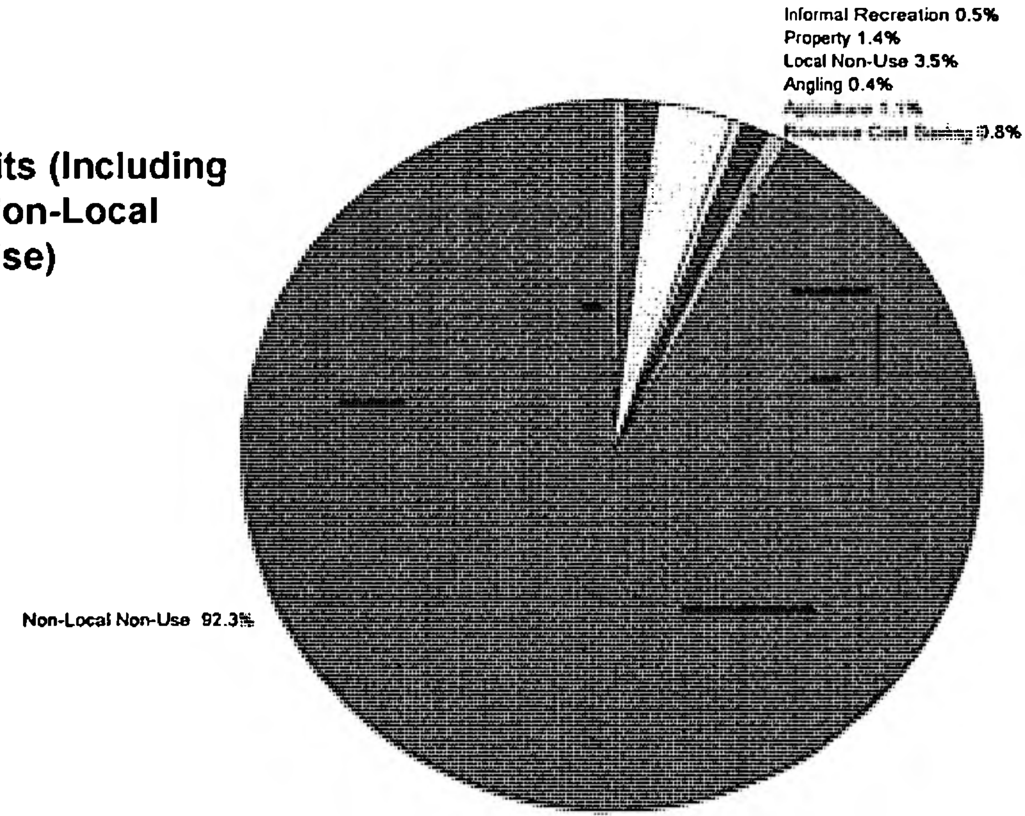
## 12.7 Risk Assessment

A risk assessment of the options has been undertaken and the results tabulated in a "Risk Register" (Table 12.13). The risks considered to be relevant in the appraisal are:

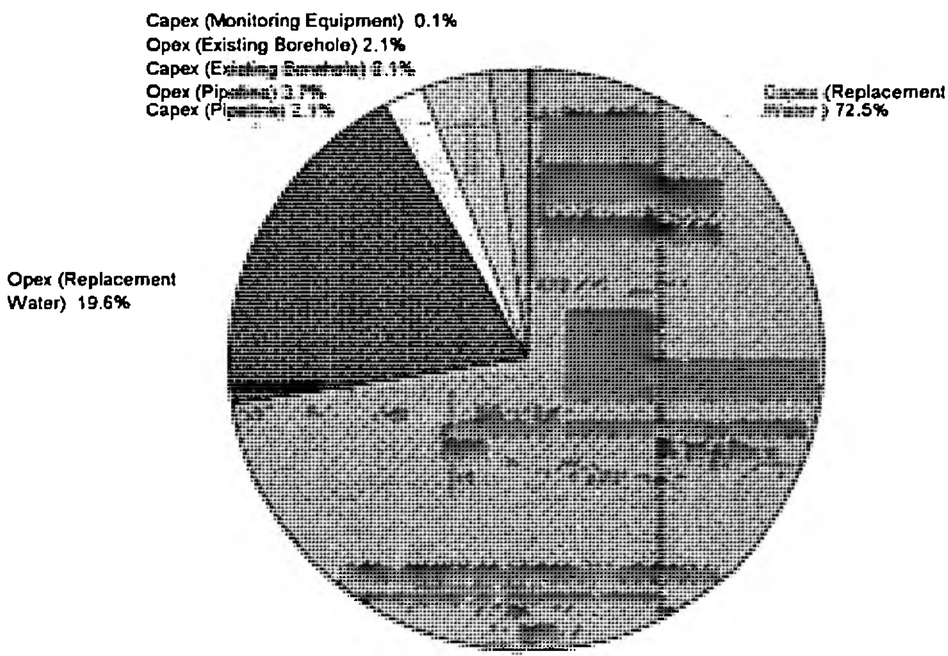
Risk 1 Operational failure of flow alleviation
Risk 2 Failure to provide anticipated benefits
Risk 3 Failure to supply a sustainable solution

Within the Risk Register the likelihood of the risk happening, and the consequent effect on the solution, are classified as "high", "medium" or "low".

## Benefits (Including 50% Non-Local Non-Use)




## Costs




Note: The area of the circles is proportional to the present value of the benefits or costs at a 6% discount rate

**River Worfe Option 6 (long term)**
**Present Value of Benefits and Costs**
**Figure 12.2**

## Table 12.12 Assessment of Intangible Benefits

| Intangible Benefit | Weighting Factor | Option 1 5 Ml/d release from Sheriffhales | | Option 2 2 Ml/d release from Lizard Mill | | Option 3 1 Ml/d release from Hell Bank | | Option 4 1 Ml/d release from Cramp Pool | | Option 5 8 Ml/d release Options 1 + 2 + 3 | | Option 6 8 Ml/d release Options 1 + 2 + 4 | | Option 6 (long term) Options 1 + 2 + 4 + additional costs | | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | points | weighted points | points | weighted points | points | weighted points | points | weighted points | points | weighted points | points | weighted points | points | weighted points | |
| 1 | 3 | 3 | 9 | 2 | 6 | 1 | 3 | 1 | 3 | 4 | 12 | 4 | 12 | 5 | 15 | Related to the extent of flow improvement |
| 2 | 3 | 3 | 9 | 2 | 6 | 1 | 3 | 1 | 3 | 4 | 12 | 4 | 12 | 5 | 15 | Related to the extent of flow improvement |
| 3 | 3 | 1 | 3 | 1 | 3 | 1 | 3 | 1 | 3 | 1 | 3 | 1 | 3 | 5 | 15 | Limited recovery of groundwater levels, except for Option 6 (long term) |
| Total weighted score | | | 21 | | 15 | | 9 | | 9 | | 27 | | 27 | | 45 | |

Intangible Benefit 1: Facilitation of Agency meeting objectives
Intangible Benefit 2: Improved public relations and maintenance of credibility of Agency
Intangible Benefit 3: Longer term benefits not quantified in economic analysis

## Table 12.13 Risk Register

| Identified Risk | Option 1 5 Ml/d release from Sheriffhales | | Option 2 2 Ml/d release from Lizard Mill | | Option 3 1 Ml/d release from Hell Bank | | Option 4 1 Ml/d release from Cramp Pool | | Option 5 8 Ml/d release Options 1 + 2 + 3 | | Option 6 8 Ml/d release Options 1 + 2 + 4 | | Option 6 (long term) Options 1 + 2 + 4 + additional costs | | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Likeli-hood | Effect | Likeli-hood | Effect | Likeli-hood | Effect | Likeli-hood | Effect | Likeli-hood | Effect | Likeli-hood | Effect | Likeli-hood | Effect | |
| Operational failure of flow alleviation | L | L | L | L | L | L | L | L | L | L | L | L | L | L | |
| Failure to provide anticipated benefits | M | M | M | M | M | M | M | M | M | M | M | M | L | L | Recovery of groundwater levels will be achieved sooner with Option 6 (long term) |
| Failure to supply a sustainable solution | M | M | M | M | M | M | M | M | M | M | M | M | L | L | |

Relative risks: H high M medium L low

## 12.8 Selection of Preferred Option

From the assessment of tangibles presented in Table 12.11 it can be seen that each of the individual options is justifiable in its own right, with Option 4 being preferable to 3. Therefore the combination of the three options (1, 2 and 4), designated as Option 6, represents the most cost effective solution in terms of maximum net present value (NPV).

However, without further allowance for the longer term reduction in groundwater abstractions, Options 1, 2 and 4 may not be sustainable or compatible with the long term objective of a recovery of groundwater levels. This is reflected in the assessment of intangibles and the risk register in Tables 12.12 and 12.13. Only Option 6 (long term) is shown as having a low risk of failing to provide the anticipated benefits and a low risk of not supplying a sustainable solution. Option 6 (long term) is consistent with the draft water resources plan of Severn Trent Water Limited which, as indicated in Section 12.1, was recently submitted to the Agency and includes proposals for a reduction of 17 Ml/d in deployable output from groundwater sources located in the Cosford unit over the AMP3 period.

**It is therefore concluded that Option 6 (long term), incorporating Options 1, 2 and 4 with a total compensation release from groundwater sources of 8 Ml/d and including an overall reduction in PWS groundwater abstractions of 17 Ml/d, should be selected as the preferred option.**

This solution will ensure that the river lengths which at present are subject to zero or low flow will be improved. It should provide a long term sustainable solution as reductions in abstraction licences for the Cosford groundwater unit have been agreed with the water company. The West Midland groundwater model, which is under development, will be used to address the suitability of the present abstraction requirement.

The interim remedial measures should restore baseflows to 13 km of watercourse whilst significantly increasing the flow over a further 21 km of river.

In the longer term, with reduced groundwater abstractions, rising groundwater levels should restore some baseflows to the river and its tributaries, with a subsequent reduction in the requirements for compensation releases.

Increased river flows in the catchment could enable some limited extra abstraction for agricultural use and there could also be more water available to support public water supply abstractions from the River Severn.

The designated trout fishery will be better able to support the wild population of brown trout as well as some introduced stock. Further habitat loss due to siltation will be avoided and some areas already degraded will be rejuvenated or restored to their former condition.

The assessed economic benefit takes account of the ecological improvements and greater water availability, in addition to the increase in the amenity and recreational value of the area surrounding the watercourses.

## 12.9 Tasks and Dependencies

| | |
|---|---|
| Investigations: | Agency Midlands Region, Upper Severn Area<br>Agency Midlands Region, Regional Office |
| Design and implementation: | Severn Trent Water Ltd |

**Programme for implementation of the preferred option:**

| | |
|---|---|
| 1998 | Submission of Business Plan<br>Construction of Sherriffhales pipeline<br>Installation of monitoring equipment |
| 1999 | Investigation and Design<br>Planning and Consents |
| 2000 | Construction<br>Investigation |
| 2001 | Construction (If required) |

## 12.10 Cost of Preferred Option

The estimated capital and operating costs of the preferred option are given in Table 12.14. The estimates of likely future capital costs are based on the assumption that the Construction Output Index (COPI) will rise by 4 per cent per annum. In the estimation of operating costs an annual increase of 2.5 per cent per annum in the Retail Price Index (RPI) has been assumed.

**Table 12.14 Estimated Costs of the Preferred Option (£ 000)**

| Year | Water Company | | Agency | |
|---|---|---|---|---|
| ending 31/03 | Capex | Opex | Capex | Opex |
| 1999 | 3,898 | 88 | 15[1] | 0 |
| 2000 | 0 | 90 | 0 | 0 |
| 2001 | 2,337 | 136 | 0 | 0 |
| 2002 | 0 | 153 | 0 | 0 |
| 2003 | 7,467[2] | 274[2] | 0 | 0 |

[1] comprises submission of business plan, the cost of which has not been included in the assessment of tangibles, and the installation of monitoring equipment

[2] long term replacement water costs could be deferred subject to supply/demand balance

# Appendix 1

## Details of Cost Estimates

# APPENDIX 1 DETAILS OF COST ESTIMATES

This Appendix includes the cost data made available by the Agency from Severn Trent Water Ltd and South Staffordshire Water Company Ltd. A summary table is also included which presents the cost estimates used in the assessments, based on the data provided. The following points should be noted in relation to the cost estimates:

1. In some instances costs were presented by the water companies for a more limited range of options than that considered in this report. In the absence of a more detailed disaggregation, we have pro rated the costs provided for each scheme by the figures for loss of water (for replacement water costs) and compensation flow (for PWS option costs) for each of the options.
2. We have assumed that the opex costs provided are annual costs for continuous operation. We have pro rated these by our estimate of the proportion of the time we expect the compensation flows to be required, based on the flow duration data provided by the Agency.
3. The capex data for Blakedown Brook appear to include the cost of the pipeline from the new STW (PWS option cost) as well as replacement water costs for the same volume. We can see no justification for replacement water costs for Option 1.
4. The river bed lining costs for Dover Beck/Oxton Dumble were confirmed verbally by the Agency.
5. The costs for river bed lining for Croxden Brook were provided by the Agency in a letter dated 8.9.98, together with details of a further option.
6. The capex data provided by Severn Trent Water Ltd appear over-estimated for some options which comprise a compensation release from an existing borehole (e.g. Battlefield / Catshill). From the limited information available the capex figures appear unrealistic and could not be reconciled with lesser figures for a new borehole of the same capacity. In many cases it would seem that a review of capex figures may be required. For the assessment in this report a nominal capex figure of £10k has been adopted where only minor works are required to existing pipework to provide a compensation release directly to a watercourse from an existing borehole.
7. The capex estimates provided by Severn Trent Water Ltd for some of the options which comprise a new borehole seem excessive (e.g the River Sherbourne where £1M for a single 1Ml/d borehole seems grossly excessive). This capital cost should in any event only apply to the new borehole for Option 3b, and not for the compensation releases from existing installations in the other options.
8. The Agency provided cost data based on existing compensation boreholes which indicates a capital cost of £120 - 140k, including pump installation, for a borehole delivering 1 - 2 Ml/d. The Agency also provided an indicative figure of £91k per Ml/d for larger scale installations based on the Shropshire Groundwater Scheme. These figures have been used as the basis for the capital costs of new boreholes in this assessment.
9. For all options with compensation releases, including releases from a new borehole, replacement water costs have been included in this assessment. This reflects the fact that the analysis is concerned not only with the interim solutions but also with the proposals for the long term reduction in groundwater levels. In four cases (Blakedown Brook, Hewell Grange Lake, River Sherbourne and River Worfe) the additional long term replacement water costs of further reductions in abstractions are included as a variant on the selected option.

**ENVIRONMENT AGENCY MIDLANDS REGION**

**AMP3 BENEFITS ASSESSMENT - ALLEVIATION OF LOW FLOWS**

**SUMMARY OF OPTIONS AND COSTS USED IN COST BENEFIT ANALYSIS**

| Site | EA Options | | | Replacement Water Costs | | | | PWS Option / Agency Borehole | | | | Other | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Option Ref | Compensation Flow Ml/d | % of time (no losses assumed) | Loss of Water Ml/d | Capex £000 | Opex (full year) £000 | Opex (part year) £000 | Compensation Flow Ml/d | Capex £000 | Opex (full year) £000 | Opex (part year) £000 | Agency Capex £000 | |
| Burntwood Pools / River Sow | 1 | 1 | 65% | 1 | 690 | 14 | 9 | 1 | 10 | 4 | 3 | | Release from existing borehole |
| | 2 | 2 | 75% | 2 | 1379 | 29 | 21 | 2 | 10 | 8 | 6 | | Release from existing borehole |
| | STW data | | | 1 | 690 | 14 | | | | | | | |
| | STW data | | | | | | | 1 | 200 | 4 | | | Excessive capex for existing borehole |
| Croxden Brook | 1a | 1 | 100% | 1 | 690 | 14 | 14 | 1 | 10 | 4 | 4 | 13* | From existing bh to pt A + bed lining |
| | 1b | 1 | 100% | 1 | 80 | 14 | 14 | 1 | 80 | 4 | 4 | 25* | From existing bh to pt B + bed lining |
| | 2 | 2 | 100% | 2 | 1379 | 29 | 29 | 2 | 10 | 8 | 8 | 13* | From existing bh to pt A + bed lining |
| | 3 | 2 | 100% | 2 | 1379 | 29 | 29 | 2 | 80 | 8 | 8 | 25* | From existing bh to pts A and B + bed lining |
| | 4 { | 1 | 100% | 2 | 1379 | 29 | 21 | 1 - 2 | 4620 | 8 | 6 | 13* | From existing bh to pt A + bed lining, with replacement |
| | { | 2 | 50% | | | | | | | | | | PWS supply from new borehole |
| | STW data | | | 1 | 690 | 14 | | | | | | | |
| | STW data | | | | | | | 1 | 200 | 4 | | | Excessive capex for existing borehole |
| Dover Beck / Oxton Dumble | 1 re-lining | | | | | | | | | | | 45* | Other costs for bed lining (1.5 Ml/d) |
| | 2 re-lining | | | | | | | | | | | 60* | Other costs for bed lining (2.5 Ml/d) |
| | 3 | 1 | 80% | 1 | 690 | 14 | 11 | 1 | 120 | 11 | 9 | | New borehole |
| | 4 1+3 | 1 | 80% | 1 | 690 | 14 | 11 | 1 | 120 | 11 | 9 | 45* | |
| | 5 2+3 | 1 | 80% | 1 | 690 | 14 | 11 | 1 | 120 | 11 | 9 | 60* | |
| | STW data | | | 1 | 690 | 14 | | | | | | | |
| | STW data | | | | | | | 1 | 300 | 11 | | | Excessive capex for new borehole |
| River Noe and River Ashop | 1 | 10 | | | | | | | 200 | | | 41 | Fish passes, release facilities and PHABSIM study |
| | 2 | 15 | | | | | | | 200 | | | 41 | Fish passes, release facilities and PHABSIM study |
| Rainworth Water | 1a | 1 | 80% | 1 | 690 | 14 | 11 | 1 | 25 | 0 | 0 | 10 | Reinstall pump set in existing borehole and g'water study |
| | 1b | 2 | 80% | 2 | 1379 | 29 | 23 | 2 | 50 | 0 | 0 | 10 | Reinstall pump set in existing borehole and g'water study |
| | 2a | 1 | 80% | 1 | 690 | 14 | 11 | 1 | 120 | 11 | 9 | 10 | New borehole and g'water study |
| | 2b | 2 | 80% | 2 | 1379 | 29 | 23 | 2 | 200 | 22 | 18 | 10 | New borehole and g'water study |
| | STW data | | | 2 | 1379 | 29 | | | | | | | |
| | STW data | | | | | | | 2 | 50 | | | | PWS option costs |
| | STW data | | | | | | | 1 | 300 | 11 | | | Excessive capex for new borehole |
| Battlefield/ Catshill Brooks | 1 | 1 | 80% | 1 | 690 | 14 | 11 | 1 | 10 | 8 | 6 | | Release from existing borehole |
| | 2 | 1 | 80% | 1 | 690 | 14 | 11 | 1 | 10 | 6 | 6 | | Release from existing borehole |
| | 3 1+2 | 2 | 80% | 2 | 1379 | 29 | 23 | 2 | 20 | 15 | 12 | | |
| | STW data | | | 2 | 1379 | 29 | | | | | | | |
| | STW data | | | | | | | 2 | 1000 | 15 | | | Excessive capex for existing borehole |
| Blakedown Brook | 1 | 3 | 100% | 0 | 0 | 0 | 0 | 3 | 1000 | 30 | 30 | | STW effluent pipeline |
| | 2a SSWC | 2 | 80% | 2 | 500 | 0 | 0 | 2 | 200 | 6 | 5 | | Release from existing SSWC borehole |
| | 2b SSWC | 2 | 80% | 2 | 500 | 0 | 0 | 2 | 200 | 6 | 5 | | Release from new SSWC borehole |
| | 3 | 1 | 80% | 1 | 690 | 14 | 11 | 1 | 120 | 6 | 5 | | Release from new Agency borehole* |
| | 4 1+2b | 5 | | 2 | 500 | 0 | 0 | 5 | 1200 | 36 | 35 | | |
| | 5 1+2b+3 | 6 | | 3 | 1190 | 14 | 11 | 6 | 1320 | 42 | 40 | | |
| Long Term | 5 1+2b+3 | | | 10 | 4688 | 71 | 71 | | 1320 | 42 | 40 | 15 | Agency cost of monitoring equipment included. Long term opex cost of PWS option will reduce |
| | STW data | | | 5 | 3448 | 71 | | | | | | | |
| | SSWC data | | | 5 | 1250 | 0 | | | | | | | SSWC advise negligible additional opex |
| | STW data | | | | | | | 3 | 1000 | 30 | | | EA option 1 |
| | SSWC data | | | | | | | 2 | 200 | 6 | | | EA option 2a |
| Bow Brook | 1 | 2 | 80% | 2 | 1379 | 29 | 23 | 2 | 10 | 15 | 12 | 15 | } Release from existing borehole |
| | 2 | 2 | 50% | 2 | 1379 | 29 | 14 | 2 | 10 | 15 | 8 | 15 | } plus installation of monitoring equipment |
| | STW data | | | 2 | 1379 | 29 | | | | | | | |
| | STW data | | | | | | | 2 | 400 | 15 | | | Excessive capex for existing borehole |
| Hewell Grange Lake | 1 | 0.62 | 72% | 0.62 | 427 | 9 | 6 | 0.62 | 10 | 14 | 10 | | Release from existing borehole |
| | 2 | 0.52 | 59% | 0.52 | 359 | 7 | 4 | 0.52 | 10 | 12 | 7 | | Release from existing borehole |
| | 3 | 0.47 | 41% | 0.47 | 324 | 7 | 3 | 0.47 | 10 | 11 | 4 | | Release from existing borehole |
| | 4 | 0.45 | 20% | 0.45 | 310 | 6 | 1 | 0.45 | 10 | 10 | 2 | | Release from existing borehole |
| Long Term | 1 | | | 1 | 690 | 9 | 6 | | 10 | 14 | 10 | | Long term opex cost of PWS option will reduce and that of replacement water increase |
| | STW data | | | 1 | 690 | 14 | | | | | | | |
| | STW data | | | | | | | 1 | 200 | 23 | | | Excessive capex for existing borehole |
| River Sherbourne | 1 | 1 | 50% | 1 | 690 | 14 | 7 | 1 | 10 | 8 | 4 | | Release from existing borehole |
| | 2 | 1 | 50% | 1 | 690 | 14 | 7 | 1 | 10 | 8 | 4 | | Release from existing borehole |
| | 3a | 1 | 50% | 1 | 690 | 14 | 7 | 1 | 10 | 8 | 4 | | Release from existing pipeline |
| | 3b | 1 | 50% | 1 | 690 | 14 | 7 | 1 | 120 | 8 | 4 | | Release from new Agency borehole* |
| | 4 1+2 | 2 | 50% | 2 | 1379 | 29 | 14 | 2 | 20 | 16 | 8 | | |
| | 5 1+2+3a | 3 | 50% | 3 | 2069 | 43 | 21 | 3 | 30 | 24 | 12 | | |
| | 6 1+2+3b | 3 | 50% | 3 | 2069 | 43 | 21 | 3 | 140 | 24 | 12 | | |
| Long Term | 6 1+2+3b | | | 10.15 | 6999 | 145 | 133 | | 140 | 24 | 12 | 15 | Agency cost of monitoring equipment included. Long term opex cost of PWS option will reduce and that of replacement water increase |
| | STW data | | | 10.15 | 6999 | 145 | | | | | | | |
| | STW data | | | | | | | 1 | 1000 | 8 | | | Excessive capex for new borehole |
| River Worfe | 1 | 5 | 75% | 5 | 3448 | 71 | 54 | 5 | 300 | 43 | 32 | | Pipeline from existing borehole |
| | 2 | 2 | 78% | 2 | 1379 | 29 | 22 | 2 | 10 | 17 | 13 | | Release from existing borehole |
| | 3 | 1 | 80% | 1 | 690 | 14 | 11 | 1 | 10 | 9 | 7 | | Release from existing borehole |
| | 4 | 1 | 80% | 1 | 690 | 14 | 11 | 1 | 10 | 9 | 7 | | Release from existing borehole |
| | 5 1+2+3 | 8 | | 8 | 5516 | 114 | 87 | 8 | 320 | 68 | 52 | | |
| | 6 1+2+4 | 8 | | 8 | 5516 | 114 | 87 | 8 | 320 | 68 | 52 | | |
| Long Term | 6 1+2+4 | | | 16.90 | 11653 | 242 | 190 | | 320 | 68 | 52 | 10 | Agency cost of monitoring equipment included. Long term opex cost of PWS option will reduce and that of replacement water increase |
| | STW data | | | 16.90 | 11653 | 242 | | | | | | | |
| | STW data | | | | | | | 4 | 300 | 34 | | | Pipeline from existing borehole |
| New Stategic Resource | STW data | | | 41.0 | 28270 | 586 | | | | | | | |

Note: Selected options are shown thus

* Agency costs to be recharged to STW Ltd under AMP3

ENVIRONMENT AGENCY

Our Ref: JR/PSH

Date: 16 March 1998

1565

JG/RMW

20/3/98

Gibb Environmental
Gibb House
London Road
Reading
Berkshire RG6 1BL

FAO J Buckland

Dear Jon

**AMP 3 – COST FROM PNS COMPANY AND EA**

Enclosed is the costs provided by the water companies for the low flood alleviation scheme. These are taken from the Cost of Quality Submitting to OFWAT and do not cross match with the Agency options. To enable the Cost/Benefit to be calculated, work will be required on these figures and I hope that the following information will enable this to be completed with the minimum of problems.

1. River Worfe

   PWS compensation relates to EA option 1. For option 2, 3 and 4 there will be no capital requirement but the OPEX figure will be modified to relate to the amount of water being pumped.

2. Blakedown

   PWS compensations of 5Ml/d and 2Ml/d relate to Option 1 and 2. No figures stated for option 3, but if figures required could use the same PWS option for Burntwood.

3. Dover Beck

   PWS compensation relates to option 3 only.

All other sites look straight forward, if you wish to discuss please contact me.

Yours sincerely

**J Ratcliffe**
**Senior Hydrologist - Planning**

G:\wordproc\w97\2nd\monthlib\mar98\058jr

**The Environment Agency**
Sapphire East, 550 Streetsbrook Road, Solihull, B91 1QT
DX 702280 Solihull 3 Tel: 0121-711 2324 Fax: 0121-711-5824

| SITE | LOSS OF WATER ML/D | REPLACEMENT WATER CAPEX COST £000 | REPLACEMENT WATER OPEX COST £000 | PWS OPTION COMP ML/D | PWS OPTION CAPEX £000 | PWS OPTION OPEX £000 | PWS TOTAL CAPEX £000 | PWS TOTAL OPEX £000 | EA OPTION | COMP ML/D | COST OF LINING |
|---|---|---|---|---|---|---|---|---|---|---|---|
| RIVER WORFE | 9 | 6205.61 | 128.63 | 4 | 300.00 | 34.00 | 6505.61 | 162.63 | 1 | 5 | |
| | | | | | | | | | 2 | 2 | |
| | | | | | | | | | 3 | 1 | |
| | | | | | | | | | 4 | 1 | |
| BLAKEDOWN BROOK/HURCOTT SSSI | 8 | 5516.10 | 114.34 | 5 | 1000.00 | 30.00 | 6516.10 | 144.34 | 1 | 3 | |
| | 5 | 1250.00 | 0.00 | 2 | 200.00 | 3.00 | 1450.00 | 3.00 | 2 | 2 | |
| | | | | | | | | | 3 | 1 | |
| BATTLEFIELD/CATSHILL BROOKS | 4 | 2758.05 | 57.17 | 2 | 1000.00 | 15.00 | 3758.05 | 72.17 | 1 | 1 | |
| | | | | | | | | | 2 | 1 | |
| BOW BROOK | 4 | 2758.05 | 57.17 | 2 | 400.00 | 15.00 | 3158.05 | 72.17 | 1 | 2 | |
| HEWELL GRANGE LAKE | 6 | 4137.07 | 85.76 | 1 | 200.00 | 23.00 | 4337.07 | 108.76 | 1 | 0.62 | |
| | | | | | | | | | 2 | 0.52 | |
| | | | | | | | | | 3 | 0.47 | |
| | | | | | | | | | 4 | 0.45 | |
| RIVER SHERBOURE | 2 | 1379.02 | 28.59 | 1 | 1000.00 | 8.00 | 2379.02 | 36.59 | 1 | 1 | |
| | | | | | | | | | 2 | 1 | |
| | | | | | | | | | 3a | 1 | |
| | | | | | | | | | 3b | 1 | |
| BURNTWOOD/RIVER SOW | 1 | 689.51 | 14.29 | 1 | 200.00 | 4.00 | 889.51 | 18.29 | 1 | 1 | |
| | | | | | | | | | 2 | 2 | |
| CROXDEN BROOK | 1 | 689.51 | 14.29 | 1 | 200.00 | 4.00 | 889.51 | 18.29 | 1 | 1 | 45.5 |
| | | | | | | | | | 2 | 2 | |
| | | | | | | | | | 3 | 2 | |
| DOVER BECK/OXTON DUMBLE | 3 | 2068.54 | 42.88 | 1 | 300.00 | 11.00 | 2368.54 | 53.88 | 1 | 1.5 | 45.5 |
| | | | | | | | | | 2 | 2.5 | |
| | | | | | | | | | 3 | 1 | |
| RAINWORTH WATER | 3 | 2068.54 | 42.88 | 2 | 50.00 | 0.00 | 2418.54 | 53.88 | 1a | 1 | |
| | | | | | 300.00 | 11.00 | | | 1b | 2 | |
| | | | | | | | | | 2a | 1 | |
| | | | | | | | | | 2b | 2 | |
| JAGGERS CLOUGH | 0 | 0.00 | 0.00 | | | | | | | | |
| TOTAL | 46 | 29520 | 586.00 | | | | 34670.00 | 744.00 | | | |
| NEW STRATEGIC RESOURE | 40 | 28270.00 | 586.00 | | | | | | | | |

# SECTION 6: COMMENTARY AND MATERIAL ASSUMPTIONS FOR TABLE D4.3

## Water service - Work programme to deliver non-core quality functions

## 6.1 Environmental Drivers

### 6.1.1 SSSI - Role of Company abstraction clearly identified

**Line 1 Leamonsley Brook Low Flow Alleviation**

This scheme is substantially complete. Costs shown are for the remaining final element of the scheme to divert source water back to the distribution system via an alternative route.

### 6.1.2 SSSI - Role of Company abstraction not yet calculated

**Line 2 Hurcott and Podmore Pools SSSI (Blakedown Brook)**

Hurcott and Podmore Pools have been identified by English Nature as a Site of Special Scientific Interest which is affected by the Company's groundwater abstractions. Appendix B is the proforma prepared by English Nature outlining the case for inclusion of this site in AMP3.

The Company has agreed with the Environment Agency (EA) that it is willing to reduce average abstraction from a combination of three groundwater abstraction sites (Hagley, Churchill and Cookley) by 5 Ml/d. The exact quantity and location of the reduction in abstraction will be determined following completion of a groundwater modelling exercise currently being undertaken by the EA. The reduction is viewed as the long term solution to the problems at Hurcott and Podmore Pools SSSI. In the short term it will be necessary to make a compensation discharge of 1-2 Ml/d to Blakedown Brook. This can be achieved by either diverting flow from Churchill Pumping Station or by drilling a new support borehole close to the Brook.

Authorised DMP

Capital expenditure has been calculated on the basis of the following two elements: -

Costs associated with providing 5 Ml/d of resource elsewhere at a cost of £250,000 per megalitre.

Costs associated with diverting flow from Churchill via a new pipeline (approximately 2.5 km long). These amount to approx. £200,000, although this will be dependant upon the final agreed location for discharge. Should negotiations with the EA confirm the need for a new borehole to provide compensation flows, then costs for this may be as high as £500k.

The total capital expenditure has been calculated as £1,450,000.

Operating expenditure for the compensation discharge has been calculated on the basis of pumping 2 Ml/d for 180 days per year. This is in the region of £3,000 per year. The additional operating cost of abstracting 5 Ml/d from an alternative source or sources will be insignificant.

### 6.1.3 Over-abstraction - Problem Sites

**Line 3&4 Smestow Brook, Wombourne and Middle Stour Catchment, Stourbridge**

These sites have been identified by the Environment Agency and English Nature as requiring further investigation. Capital expenditure of £50,000 per site has been included for this purpose as advised by the Environment Agency. Further expenditure will be required once the effect of the Company's abstraction has been established and measures to resolve the problem agreed.

Our ref: JR/MM
Your ref:

Date: 8 September 1998

ENVIRONMENT AGENCY

Gibb Environmental
Gibb House
London Road
READING
Berkshire
RG6 1BL
FAO: Mr Widgery

5050

NJW

11/9/98

Dear Nigel

**AMP3 - COST BENEFIT ASSESSMENT**

We have been in discussions with both the water companies who have direct involvement with the ALF's schemes and have been able to refine/update the cost information provided to you for the Draft Final Reports. This will enable the cost/benefit ratio to be reworked and complete the information requirements needed for the Business Cases for submission to DETR.

This information is as follows:-

1) Burntwood Pools/River Sow - No change
   The option which is being put forwarded in the Business Case is Option 1.

2) Croxden Brook
   The cost of lining the brook under Other Capex are:-
   Option 1 = £13k
   Option 2&3 = £25k

A further Option is now to be considered. It is that STW construct a new borehole which will be situated away from the brook course so that its cone of depression will not influence flow in the brook. STW have provided a cost for this with the associated pumps and pipework of £ ?. The reliable sustainable yield of the aquifer is 8.4 Ml/d. At present the deployable output from Greatgates borehole is 6.5Ml/d all of which is required for supply purposes. The New Option would allow:

i) Compensation to brook at Greatgates borehole 1Ml/d
ii) STW, deployable output from new borehole (8.4-1.0) = 7.4Ml/d

Could you please work this into the existing report.

Cont/d..

3. Dover Beck/Oxton Dumble - No changes required.

4. River Hoe and River Ashop - Rework with £100k as cost for each fish pass.

5. Rainworth Water - No changes required, Option 2a looks to be the solution being accepted. STW plc data modified to 2, 1379, 29.

6. Battlefield/Catshill Brooks - No changes. STW plc data modified to 2, 1379, 29.

7. Blakedown Brook

| | | | |
|---|---|---|---|
| STW plc data | 5, 3448, 71 | | |
| SSWC plc data | 5, 1250, 0 | | |
| STW plc data | | 3, 1000, 30 | EA Option 1 |
| SSWC plc data | | 2, 200, 3 | EA Option 2, new borehole |

It should be noted that Option 2a and 2b should be put against SSWC name as they would be part of SSWC participation in the alleviation of low flows.

8. Hewell Grange Point

Gibbs to review % time (no losses assumed) as the figures do not appear to match calculations.

STW plc data 1, 690, 14.

At present River Sherbourne and River Worfe are still being reviewed as to how most replacement water cost should be considered in the short and long term solutions. I hope to have agreed data in the next 5 working days.

If you wish to discuss this new information, please contact me. Also if additional funding is required, please let me have breakdown of costs.

Yours sincerely

John Ratcliffe [signature]

**JOHN RATCLIFFE**
**Senior Hydrologist (Resource Planning)**

Our ref: JR/ED
Your ref:

**ENVIRONMENT AGENCY**

**Date:** 11 September 1998

Gibb Environmental
Gibb House
London Road
Reading
Berkshire
RG6 1BL

5071

NJW

14/9

**FAO Mr N Widgery**

Dear Nigel

**AMP3 – COST BENEFIT ASSESSMENT**

Further to my letter of 8 September 1998, the following information will complete the data input/modification.

2 **Croxden Brook**

The cost of a new borehole to produce 6.7 ml/d has been estimated by the EA based on STW plc data as £4.62M but having the same running cost as the existing Greatgates site.

10 **River Sherbourne**

Discussion with STW plc has resulted in an agreed reduction in the licences so that the figures are STW 10.15, 7003, 142.

11 **River Worfe**

Discussion with STW plc has resulted in an agreed reduction in licences so that these figures are STW 18.43, 12710, 258. Of this total 10.0 Ml/d has been made available via the proposed licence at Ukington and the cost will be incurred under AMP2.

In the cases of Blackdown, Sherbourne and Worfe, the licence reduction will not affect supplies at present, but if required I can find out from the supply/demand balance when the replacement resources may be needed.

Yours sincerely

John Ratcliffe

**J RATCLIFFE**
**Senior Hydrologist (Resource Planning)**

Extension 3233

**Environment Agency**
Sapphire East, 550 Streetsbrook Road, Solihull, B91 1QT
DX 702280 Solihull 3 Tel: 0121-711 2324 Fax: 0121-711-5824

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# FAX REQUEST FORM

ENVIRONMENT AGENCY

To: Gibb Date.

FAO: Nigel [illegible] Dept.

Fax No. 0118 966 9554 No.of pages

From: [illegible] Tel No/Ext

Fax No. Public Network

Subject: Cost distribution on AMPs Scheme

Message:

GIBB ENVIRONMENTAL

DOCUMENT No 5460

TO [illegible] C.C

DATE RECEIVED 14/10

FILE

Note: 1. Manuscript amendments agreed with Agency 9 and 11/11/98
2. Costs for submission of business plan not included in the cost benefit analysis.

| | | STW REPLACEMENT COST CAPEX | | STW COMPENSATION OPTION CAPEX | STW COMPENSATION OPTION OPEX | EA COMPENSATION OPTION CAPEX | EA COMPENSATION OPTION OPEX |
|---|---|---|---|---|---|---|---|
| SITE | **DOVER BECK AND OXTON DUMBLE** | | | | | | |
| 1998 | SUBMISSION OF BUSINESS PLAN | | | | | | 4 |
| 1999 | INVESTIGATION AND DESIGN | | | | | | |
| | PLANNING AND CONSENTS | | | | | | |
| 2000 | CONSTRUCTION PART 1 | | | | | 60 | 0 |
| 2001 | CONSTRUCTION PART 2 | 690 | | 120 | 9 | | 1 |
| SITE | **HEWELL GRANGE** | | | | | | |
| 1998 | SUBMISSION OF BUSINESS PLAN | | | | | | 4 |
| 1999 | INVESTIGATION AND DESIGN | | | | | | |
| | PLANNING AND CONSENTS | | | | | | |
| 2000 | CONSTRUCTION | 690 | | 10 ~~130~~ | 10 | | |
| | INVESTIGATION | | | | | | |
| SITE | **BURNTWOOD POOLS AND RIVER SOW** | | | | | | |
| 1998 | SUBMISSION OF BUSINESS PLAN | | | | | | 4 |
| 1999 | INVESTIGATION AND DESIGN | | | | | | |
| | PLANNING AND CONSENTS | | | | | | |
| 2000 | CONSTRUCTION | 690 | | 10 | 3 | | |
| SITE | **BLAKEDOWN BROOK** | | | | | | |
| 1998 | SUBMISSION OF BUSINESS PLAN | | | | | | 4 |
| 1999 | CONSTRUCTION OF ROUNDHILL PIPELINE | | | 1000 | 30 | | 15 |
| | INVESTIGATION AND DESIGN | | | | | | |
| | PLANNING AND CONSENTS | | | | | | |
| 2000 | CONSTRUCTION PART 1 | 690 | | | 30 | 120 | 5 |
| 2001 | CONSTRUCTION PART 2 | 500 | | 200 | 5<br>30 | | 5 |
| | LONGTERM | 3509 | | | | | |
| SITE | **RIVER SHERBOURNE** | | | | | | |
| 1998 | SUBMISSION OF BUSINESS PLAN | | | | | | 4 |
| 1990 | ~~INVESTIGATION AND DESIGN~~ INSTALLATION OF MONITORING EQ | | | | | | 15 |
| | PLANNING AND CONSENTS | | | | | | |
| 2000 | CONSTRUCTION PART 1 | 1379 | | 10 | 4 | 120 | 4 |
| 2001 | CONSTRUCTION PART 2 | 690 | | 10 | 8 | | 4 |
| | LONGTERM | 4930 | | | | | |

| | | STW | | STW | | EA | |
|---|---|---|---|---|---|---|---|
| | | REPLACEMENT COST | | COMPENSATION OPTION | | COMPENSATION OPTION | |
| | | CAPEX | | CAPEX | OPEX | CAPEX | OPEX |
| SITE | RIVER WORFE | | | | | | |
| 1998 | SUBMISSION OF BUSINESS PLAN | | | | | | 4 |
| | CONSTRUCTION OF SHEIFFHALES PIPELINE | 3448 | | 300 | 32 | | |
| | INSTALLATION OF MONITORY EQUIPMENT | | | | | 10 | |
| 1999 | INVESTIGATION AND DESIGN | | | | | | |
| | PLANNING AND CONSENTS | | | | | | |
| 2000 | CONSTRUCTION | 2068 | | 10 | 39 | | |
| | INVESTIGATION | | | | | | |
| 2001 | CONSTRUCTION(IF REQUIRED) | | | 10 | 52 | | |
| | LONGTERM | 6137 | | | | | |
| SITE | BOW BROOK | | | | | | |
| 1998 | SUBMISSION OF BUSINESS PLAN | | | | | 4 | |
| | INSTALLATION OF MONITORY EQUIPMENT | | | | | 15 | |
| 1999 | INVESTIGATION AND DESIGN | | | | | | |
| | PLANNING AND CONSENTS | | | | | | |
| 2000 | CONSTRUCTION | 1377 | | 10 | 12 | | |
| SITE | BATTLEFIELD BROOK | | | | | | |
| 1998 | SUBMISSION OF BUSINESS PLAN | | | | | | 4 |
| 1999 | INVESTIGATION AND DESIGN | | | | | | |
| | PLANNING AND CONSENTS | | | | | | |
| 2000 | CONSTRUCTION | 690 | | 10 | 6 ~~8~~ | | |
| | INVESTIGATION | | | | | | |
| 2001 | CONSTRUCTION(IF REQUIRED) | 690 | | 10 | 12 ~~16~~ | | |
| SITE | RIVERS NOE AND ASHOP | | | | | | |
| 1998 | SUBMISSION OF BUSINESS PLAN | | | | | | 4 |
| | PHABSIM INVESTIGATION | | | | | | 41 |
| 1999 | INVESTIGATION AND DESIGN | | | | | | |
| | PLANNING AND CONSENTS | | | | | | |
| 2000 | CONSTRUCTION | | | 200 ~~100~~ | | | |
| SITE | RAINWORTH WATER | | | | | | |
| 1998 | SUBMISSION OF BUSINESS PLAN | | | | | | 4 |
| 1999 | GROUNDWATER INVESTIGATION | | | | | | 10 |
| 2000 | INVESTIGATION AND DESIGN | | | | | | |
| | PLANNING AND CONSENTS | | | | | | |
| 2001 | CONSTRUCTION | 1379 | | 200 | 18 | | |
| SITE | CROXDEN BROOK | | | | | | |
| 1998 | SUBMISSION OF BUSINESS PLAN | | | | | | 4 |
| 1999 | INVESTIGATION AND DESIGN | | | | | | |
| | PLANNING AND CONSENTS | | | | | | |
| 2000 | CONSTRUCTION | 690 | | 20 | 4 | 25 | 6 |

Our ref: JR/JA
Your ref:

ENVIRONMENT AGENCY

Date: 3 December 1998

Gibbs Limited
Gibb House
London Road
Reading
Berkshire
RG6 1BL
FAO: Mr N Widgery

Dear Nigel

**AMP3 BENEFIT ASSESSMENTS**

With reference to your letter of 24 November and enclosures, I have the following comments:

Final Report, we need 15 copies, one which is unbound.

Business Cases, I agreed to the design of the cover sheet and Table of Contents as illustrated.

With reference to the Final Report here are my comments:

1. In all cases when the expenditure for the Environment Agency is shown red in the enclosed spreadsheet this indicates that the Agency will be carrying out the works required under this section but will be recharging their costs to the Water Companies. This is not as it is set out in the Table 'Estimated Costs of the Preferred Option (£000)'. Where necessary would you please modify these tables, maybe with a note and number.

| | | |
|---|---|---|
| 2. | Croxden Brook | Table 3.1, Option 4. The description is incorrect. The new borehole is for supply to public water company. The existing boreholes at Great Gates will be used to supply the compensation feed to the brook. |
| 3. | Croxden Brook | Para 3.8. 4 paragraph<br>Inflow of compensation water will not affect the pools on Croxden Brook. |
| 4. | Croxden Brook | Table 4.4 EA bedlining costs would be recharged to STW under AMP3 |
| 5. | Dover Beck | Table 4.13<br>Agency Capex £67 would be recharged to STW under AMP3. |
| 6. | Rainworth Water | Para 6.5 2 paragraph |

Cont/d..

**Environment Agency**
Sapphire East, 550 Streetsbrook Road, Solihull, B91 1QT
DX 702280 Solihull 3 Tel: 0121-711 2324 Fax: 0121-711-5824

| | |
|---|---|
| | Should have some comment on the benefits of extra water flowing through SSSI. This being the reason for choice of option 2. |
| 7. Battlefield | Para 7.9<br>2000 Construction – Wildmoor outflow<br>2001 Construction (if required) Washingstocks outflow |
| 8. Blakedown | Table 8.15<br>Capex 135 Opex 5 would be recharged to Severn Trent under AMP3.<br>$4268^3$ – what does 3 mean. |
| 9. Hewell Grange | Para 10.8. 4 para<br>Full capacity not full supply level as it cannot supply anything. |
| 10. R Sherbourne | Table 11.10<br>Copex £135 and Opex 4 will be recharged to Severn Trent under AMP3 |

Yours sincerely

John Ratcliffe

**J RATCLIFFE**
**Senior Hydrologist (Resource Planning)**

| | | STW | | STW | | EA | |
|---|---|---|---|---|---|---|---|
| | | REPLACEMENT COST | | COMPENSATION OPTION | | COMPENSATION OPTION | |
| | | CAPEX | | CAPEX | OPEX | CAPEX | OPEX |
| **SITE** | **DOVER BECK AND OXTON DUMBLE** | | | | | | |
| 1998 | SUBMISSION OF BUSINESS PLAN | | | | | | 4 |
| 1999 | INVESTIGATION AND DESIGN | | | | | | |
| | PLANNING AND CONSENTS | | | | | | |
| 2000 | CONSTRUCTION PART 1 | | | | | 60 | 0 |
| 2001 | CONSTRUCTION PART 2 | 690 | | | 9 | 120 | |
| **SITE** | **HEWELL GRANGE** | | | | | | |
| 1998 | SUBMISSION OF BUSINESS PLAN | | | | | | 4 |
| 1999 | INVESTIGATION AND DESIGN | | | | | | |
| | PLANNING AND CONSENTS | | | | | | |
| | GROUNDWATER INVESTIGATION | | | | | | |
| 2000 | CONSTRUCTION | 690 | | 10 | 9 | | |
| | INVESTIGATION | | | | | | |
| **SITE** | **BURNTWOOD POOLS AND RIVER SOW** | | | | | | |
| 1998 | SUBMISSION OF BUSINESS PLAN | | | | | | 4 |
| 1999 | INVESTIGATION AND DESIGN | | | | | | |
| | PLANNING AND CONSENTS | | | | | | |
| 2000 | CONSTRUCTION | 690 | | 10 | 3 | | |
| **SITE** | **BLAKEDOWN BROOK** | | | | | | |
| 1998 | SUBMISSION OF BUSINESS PLAN | | | | | | 4 |
| 1999 | CONSTRUCTION OF ROUNDHILL PIPELINE | | | 1000 | 30 | | 15 |
| | INVESTIGATION AND DESIGN | | | | | | |
| | PLANNING AND CONSENTS | | | | | | |
| | GROUNDWATER INVESTIGATION | | | | | | |
| 2000 | CONSTRUCTION PART 1 | 690 | | | 30 | 120 | 5 |
| 2001 | CONSTRUCTION PART 2(SSWC) | 500 | | 200 | 5 | | 5 |
| | | | | | 30 | | |
| | LONGTERM | 3508 | | | | | |
| **SITE** | **RIVER SHERBOURNE** | | | | | | |
| 1998 | SUBMISSION OF BUSINESS PLAN | | | | | | 4 |
| 1999 | INVESTIGATION AND DESIGN | | | | | | 15 |
| | PLANNING AND CONSENTS | | | | | | |
| 2000 | CONSTRUCTION PART 1 | 1379 | | 10 | 4 | 120 | 4 |
| 2001 | CONSTRUCTION PART 2 | 690 | | 10 | 8 | | 4 |
| | LONGTERM | 4930 | | | | | |

| | | STW | | STW | | EA | |
|---|---|---|---|---|---|---|---|
| | | REPLACEMENT COST | | COMPENSATION OPTION | | COMPENSATION OPTION | |
| | | CAPEX | | CAPEX | OPEX | CAPEX | OPEX |
| **SITE** | **RIVER WORFE** | | | | | | |
| 1998 | SUBMISSION OF BUSINESS PLAN | | | | | | 4 |
| | CONSTRUCTION OF SHEIFFHALES PIPELINE | 3148 | | 300 | 32 | | |
| | INSTALLATION OF MONITORY EQUIPMENT | | | | | 10 | |
| 1999 | INVESTIGATION AND DESIGN | | | | 32 | | |
| | PLANNING AND CONSENTS | | | | | | |
| 2000 | CONSTRUCTION | 2068 | | 10 | 39 | | |
| | INVESTIGATION | | | | | | |
| 2001 | CONSTRUCTION(IF REGUIRED) | | | 10 | 52 | | |
| | LONGTERM | 6137 | | | | | |
| **SITE** | **BOW BROOK** | | | | | | |
| 1998 | SUBMISSION OF BUSINESS PLAN | | | | | | 4 |
| | INSTALLATION OF MONITORY EQUIPMENT | | | | | 15 | |
| 1999 | INVESTIGATION AND DESIGN | | | | | | |
| | PLANNING AND CONSENTS | | | | | | |
| 2000 | CONSTRUCTION | 1379 | | 10 | 12 | | |
| **SITE** | **BATTLEFIELD BROOK** | | | | | | |
| 1998 | SUBMISSION OF BUSINESS PLAN | | | | | | 4 |
| 1999 | INVESTIGATION AND DESIGN | | | | | | |
| | PLANNING AND CONSENTS | | | | | | |
| 2000 | CONSTRUCTION | 690 | | 10 | 8 | | |
| | INVESTIGATION | | | | | | |
| 2001 | CONSTRUCTION(IF REGUIRED) | 690 | | 10 | 16 | | |
| **SITE** | **RIVERS NOE AND ASHOP** | | | | | | |
| 1998 | SUBMISSION OF BUSINESS PLAN | | | | | | 4 |
| | PHABSIM INVESTIGATION | | | | | | 41 |
| 99 | INVESTIGATION AND DESIGN | | | | | | |
| | PLANNING AND CONSENTS | | | | | | |
| 2000 | CONSTRUCTION | | | 200 | | | |
| **SITE** | **RAINWORTH WATER** | | | | | | |
| 1998 | SUBMISSION OF BUSINESS PLAN | | | | | | 4 |
| 1999 | GROUNDWATER INVESTIGATION | | | | | | 10 |
| 2000 | INVESTIGATION AND DESIGN | | | | | | |
| | PLANNING AND CONSENTS | | | | | | |
| 2001 | CONSTRUCTION | 1379 | | | 18 | 200 | |
| **SITE** | **CROXDEN BROOK** | | | | | | |
| 1998 | SUBMISSION OF BUSINESS PLAN | | | | | | 4 |
| 1999 | INVESTIGATION AND DESIGN | | | | | | |
| | PLANNING AND CONSENTS | | | | | | |
| 2000 | CONSTRUCTION | 690 | | 80 | 4 | 25 | 0 |

## Appendix 2

## Burntwood Pools / River Sow

<u>**Burntwood Pools / River Sow**</u>

| | | |
|---|---|---|
| **Stafford Borough Council** | - | **Paul Windmill**<br>**01785 223181** |
| **Staffordshire Borough Council** | - | **Rebecca Gibson (Council Tax)**<br>**01785 249701** |
| **Staffordshire Wildlife Trust** | - | **Mike Deegan**<br>**01189 508534** |
| **Environment Agency** | - | **Dave Gribble**<br>**01785 211300** |

## General

| | | |
|---|---|---|
| **Ramblers Association** | - | **0171 582 6878** |
| **Countryside Commission** | - | **0171 831 3510** |
| **Office National Statistics** | - | **0171 233 9233** |
| **Halifax Building Society's Statistical Service** | | **01422 333 333** |
| **Talking Pages** | - | **0800 600 900** |

## Burntwood Pools

At the present time there are two options to be considered to enhance flows on the upper reaches of the River Sow. In both cases the compensation release will be made from existing boreholes and will discharge to the river upstream of the fishing pool adjacent to Fairoak Grange. Option 1 is for a release of 1 Ml/d and Option 2 for a release of 2 Ml/d.

The gauging station at Walkmill will be used to regulate the compensation. This trigger will be when Q50 (4.061 Ml/d) has been reached. Similarly a second trigger will be used to stop the release. In the case of Option 1 the flow will be 5.061 Ml/d and Option 2 it will be 6.061 Ml/d.

Enclosed are copies of:-

| | | | |
|---|---|---|---|
| A | Duration/Frequency Graph | Walkmill | 1990-1997 |
| B | Duration/Frequency Table | Walkmill | 1990-1997 |
| C | Mean Daily flow against time | Walkmill | 1990-1997 |

There are very few current meter runs upstream of the Walkmill GS, but for a limited period in 1983 flow readings were measured at the outflow from Burntwood pools (record enclosed). There is also information that the brook between Burntwood pools an 1 Km downstream dry up during 1997. We have no dates to confirm the length of this period.

The abstraction which is thought to be causing the reduction is baseflow started in 1980, I enclose a summary of the average daily abstraction for each year of its operation.

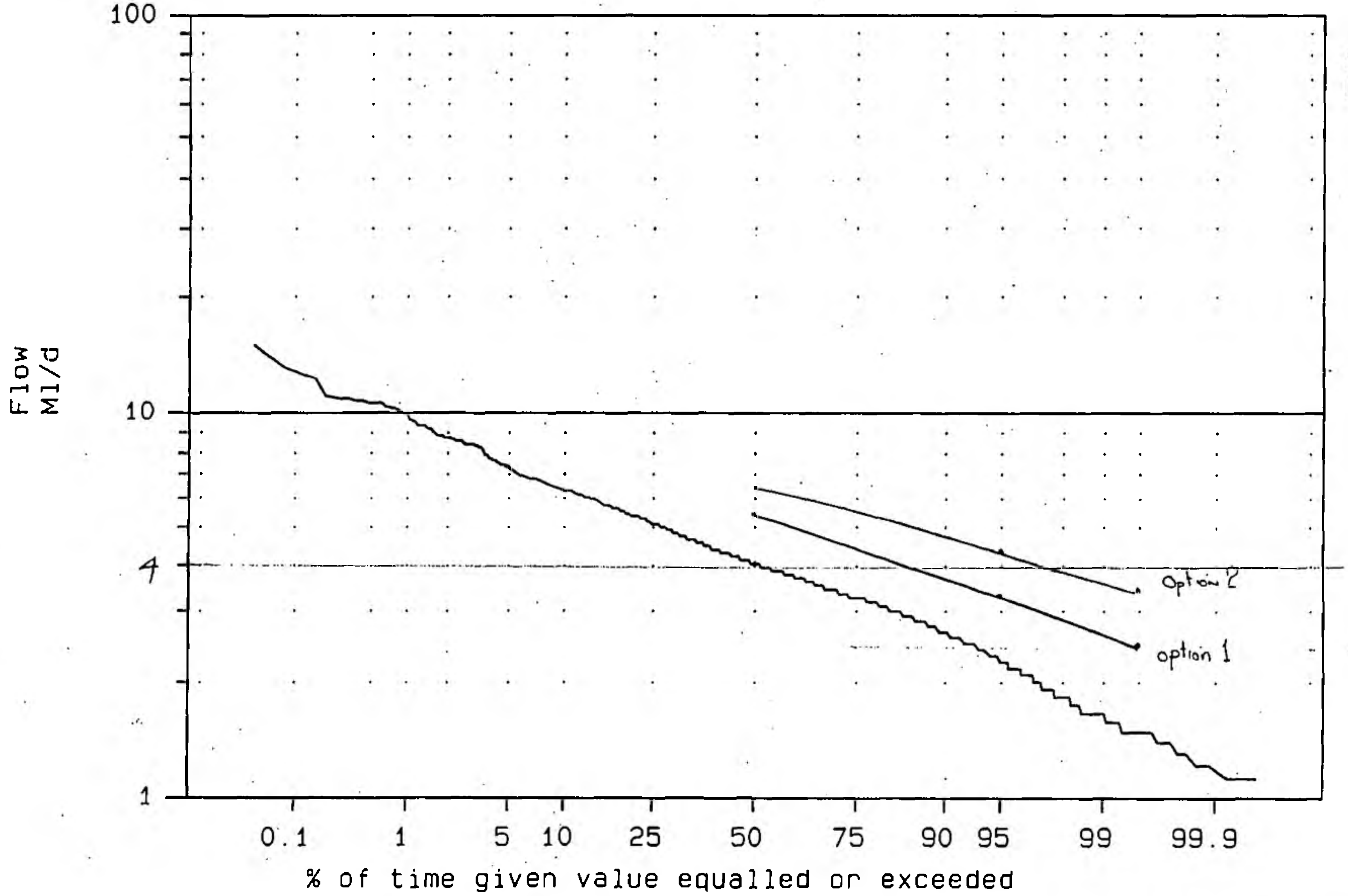
After discussion with Agency staff it is considered that both option 1 and 2 would cause the rewatering of 3.0Km of water course and provide significant increase in flow for a further 11.0 Km. This would be upto the discharge from Severn Trent Water WTW at Eccleshall.

E. A. Midlands - Headquarters Hydrometry　　　Duration/Frequency Graph

| Auth.: 4840 | Name: WALKMILL | Locat.: SOW |
|---|---|---|

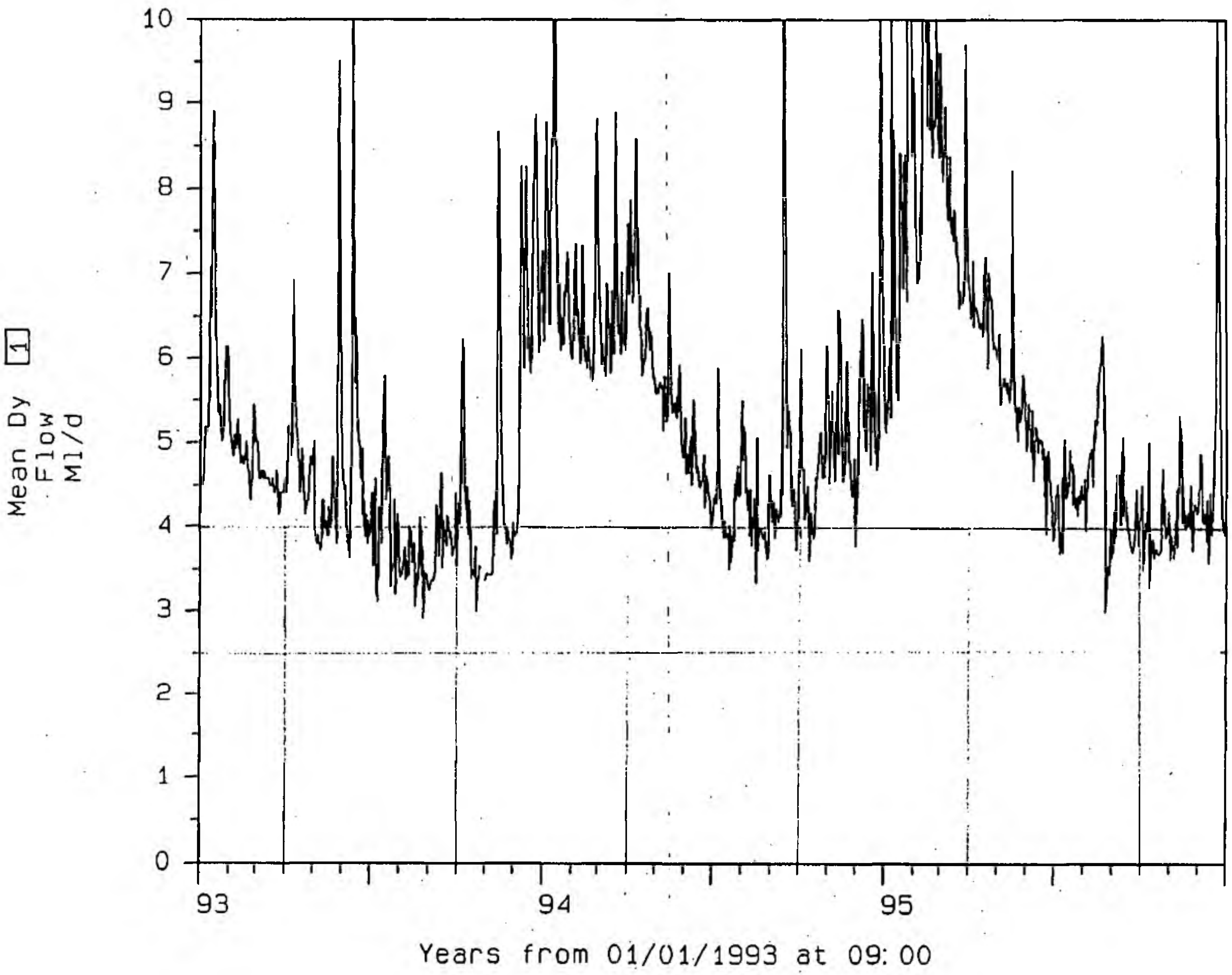
Period of Analysis : 1990 to 1997 (7 complete years used)

Season:
Clndr year



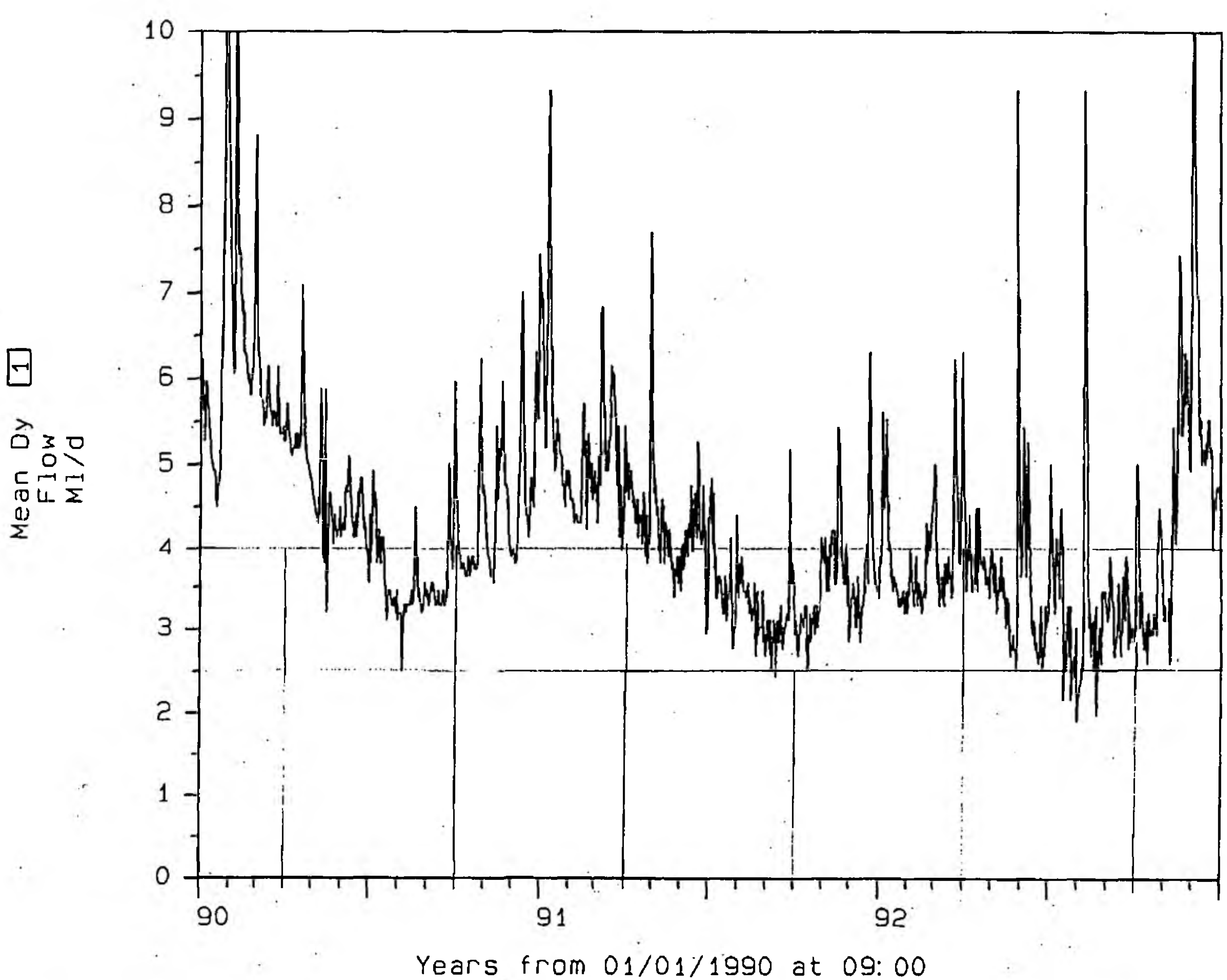

[illegible] put borehole feed of [illegible] /d

| Auth.: 4840 | Name: WALKMILL | Locat.: SOW |
|---|---|---|

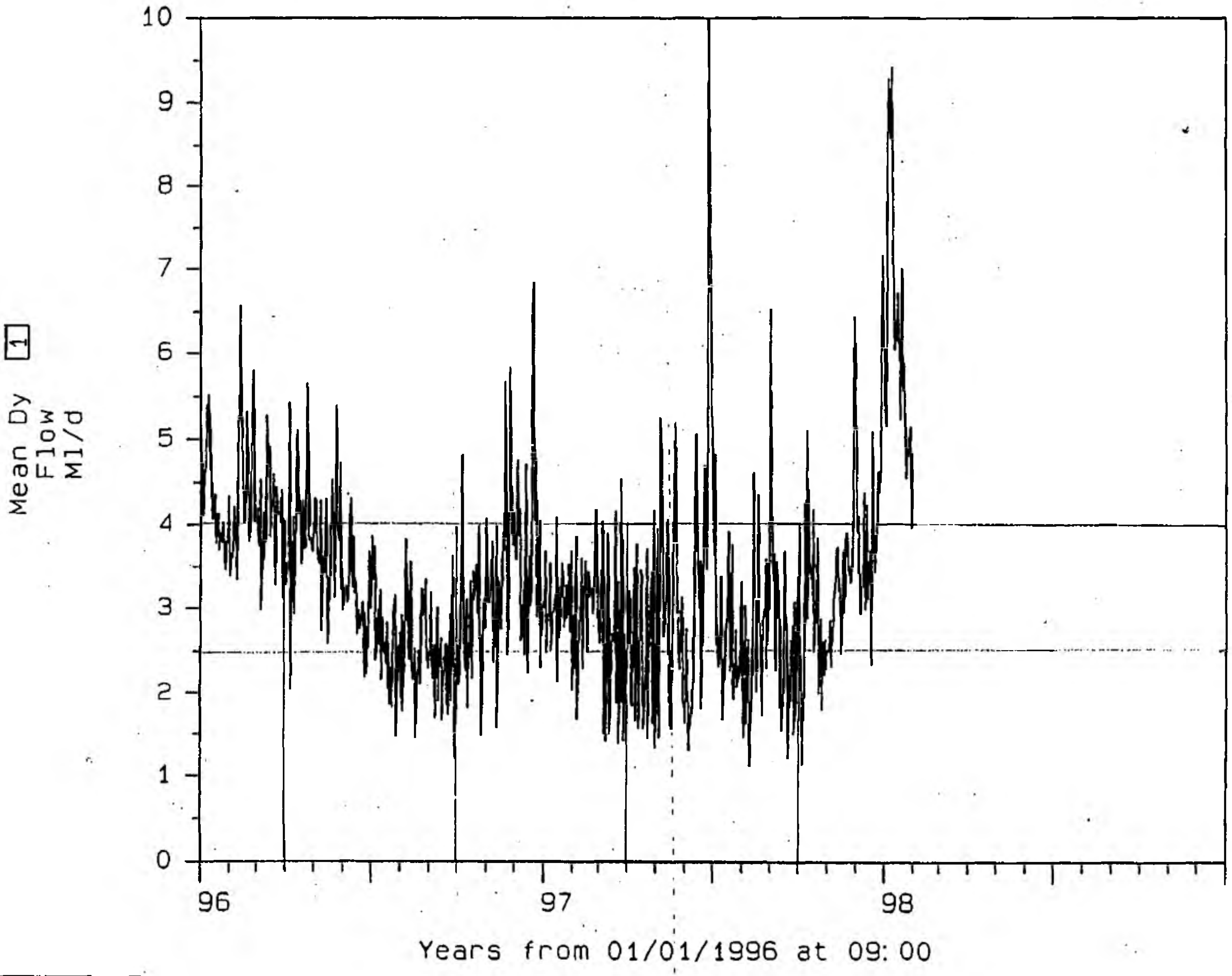


E. A. Midlands - Headquarters Hydrometry HYDROLOG Archive Report

| Auth.: 4840 | Name: WALKMILL | Locat.: SOW |
| --- | --- | --- |

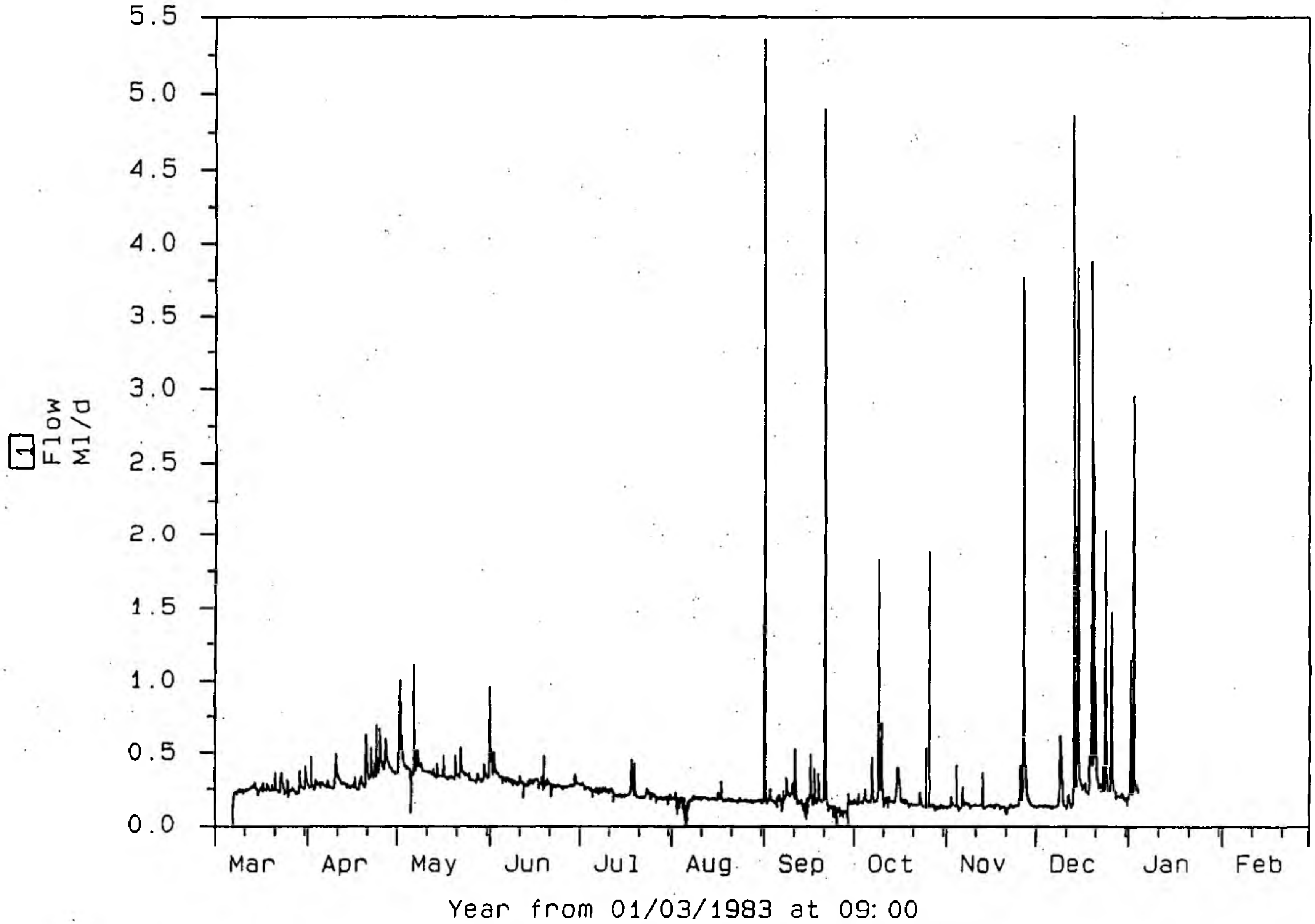


| Auth.: 4840 | Name: WALKMILL | Locat.: SOW |
|---|---|---|



E. A. Midlands - Headquarters Hydrometry HYDROLOG Archive Report

| Auth.: 4853 | Name: BURNTWOOD POOLS | Locat.: SOW |
|---|---|---|




Burntwood Pond [illegible] started [illegible] pu[illegible] 198[illegible] It was being used at [illegible] higher rate for the first 4 y[illegible]

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| LIC_NO: | 03/28/02/0126 | SITE NAME: | BURNTWOOD | | | | | | | | |
| SOURCE: | F41 | SITE: | 1 | NGR: | SJ | E: | 747 | N: | 341 | CUST: | 420 |
| LICENCE DETAILS: | | TREATMENT: | | | | | | | | | |
| ZONE: | STOKE | GROUP: | | | | | | | | | |
| DISTRICT: | STOKE | HOLDER: | STW LTD | | | | | | | | |
| HOUR: | 0.13 | DAY: | 3.05 | YEAR: | 1.81 | UPDATE YEAR: | | | | | |
| TYPE: | N | TIE: | N | SIC: | 170 | METER: | 57 | | | | |

| | | | | | |
|---|---|---|---|---|---|
| 1976: | | 1984: | 0.72 | 1992: | 0.95 |
| 1977: | | 1985: | 0.02 | 1993: | 0.79 |
| 1978: | | 1986: | 0.91 | 1994: | 0.81 |
| 1979: | | 1987: | 1.48 | 1995: | 0.94 |
| 1980: | 1.91 | 1988: | 1.39 | 1996: | 0.93 |
| 1981: | 1.24 | 1989: | 1.04 | 1997: | |
| 1982: | 1.68 | 1990: | 1.02 | 1998: | |
| 1983: | 1.3 | 1991: | 0.75 | NITRATE: | |

NOTES:

Add a record | Find a record using a keyword | View Database in table format | Quit ACCESS

Print

Consider reduction in Lic to compensate Jugbank.

Yearly 1.81 say to 1.00

Washout Burntwood, what Q

utput from HYDROLOG Data Management System V2.50(C) 1991-97 Hydro-Logic Ltd
ong Term Statistics Printed on 29/01/1998 at 15:11 hrs

**E. A. Midlands - Headquarters Hydrometry**

ath. Ref. : **4840**
oc. Desc. : **SOW**
eport Type : **Duration/Frequency**
arameter : **Flow**
nits : **Ml/d**

Station Name : **WALKMILL**
Catchment Ref.: **UT**
Grid Ref. : **SJ 793298**
Gauge Zero : **89.201 MAOD**
Catchment Area: **10.600 Sq Km**

eriod : **01/07/1989 to 31/12/1997** Start of Day : **09:00 GMT**

nalysis period : **Calendar Year**

DAILY MEAN VALUE EXCEEDED STATED AMOUNT FOR GIVEN PERCENTAGE OF TIME

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0% | | 9.677 | 8.726 | 8.294 | 7.603 | 7.258 | 6.998 | 6.826 | 6.653 | 6.480 |
| 10% | 6.307 | 6.221 | 6.134 | 6.048 | 5.962 | 5.789 | 5.702 | 5.616 | 5.530 | 5.443 |
| 20% | 5.443 | 5.357 | 5.270 | 5.270 | 5.184 | 5.098 | 5.011 | 5.011 | 4.925 | 4.838 |
| 30% | 4.838 | 4.752 | 4.752 | 4.666 | 4.666 | 4.579 | 4.579 | 4.493 | 4.493 | 4.406 |
| 40% | 4.406 | 4.320 | 4.320 | 4.320 | 4.234 | 4.234 | 4.147 | 4.147 | 4.147 | 4.061 |
| 50% | 4.061 | 4.061 | 3.974 | 3.974 | 3.888 | 3.888 | 3.888 | 3.888 | 3.802 | 3.802 |
| 60% | 3.802 | 3.715 | 3.715 | 3.715 | 3.629 | 3.629 | 3.542 | 3.542 | 3.456 | 3.456 |
| 70% | 3.456 | 3.456 | 3.370 | 3.370 | 3.283 | 3.283 | 3.283 | 3.197 | 3.197 | 3.197 |
| 80% | 3.110 | 3.110 | 3.024 | 3.024 | 2.938 | 2.938 | 2.851 | 2.851 | 2.765 | 2.678 |
| 90% | 2.678 | 2.592 | 2.506 | 2.506 | 2.419 | 2.333 | 2.160 | 1.987 | 1.814 | 1.642 |

SUMMARY STATISTICS FOR ANALYSIS PERIOD

| | | | | | |
|---|---|---|---|---|---|
| Maximum Daily Mean Value | = | **15.034** | Minimum Daily Mean Val. | = | **1.123** |
| LTA Daily Mean (Lin Calc) | = | **4.341** | Median Daily Mean Value | = | **4.061** |
| LTA Daily Mean (Log Calc) | = | **4.079** | Log Standard Deviation | = | **0.354** |
| Actual 95% Daily Mean | = | **2.333** | Calc 95% Daily Mean | = | **2.280** |

(Log-Normal distribution assumed)

Number of values used = **2557**
First year used = **1990**
Last year used = **1997**
Number of years used = **7 out of 8**

Only complete calendar years of data used

utput from HYDROLOG Data Management System V2.50(C) 1991-97 Hydro-Logic Ltd
ong Term Statistics Printed on 29/01/1998 at 15:12 hrs

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**E. A. Midlands - Headquarters Hydrometry**

uth. Ref. : **4840**
c. Desc. : **SOW**
eport Type : **Duration/Frequency**
arameter : **Flow**
its : **Ml/d**

Station Name : **WALKMILL**
Catchment Ref.: **UT**
Grid Ref. : **SJ 793298**
Gauge Zero : **89.201 MAOD**
Catchment Area: **10.600 Sq Km**

eriod : **01/07/1989 to 31/12/1997** Start of Day : **09:00 GMT**

nalysis period : **Calendar Year**

DATA FREQUENCY ANALYSIS

| aily Mean lue(DMV) | DMV as % of LTA | % values exceeding | Range of values of DMV From | To | No. in Range |
|---|---|---|---|---|---|
| 15.034 | 346.334 | 0.000 | > 15.034 | | 0 |
| 14.000 | 322.523 | 0.039 | 14.000 - | 15.034 | 1 |
| 12.000 | 276.448 | 0.156 | 12.000 - | 14.000 | 3 |
| 11.000 | 253.411 | 0.235 | 11.000 - | 12.000 | 2 |
| 9.900 | 228.069 | 0.978 | 9.900 - | 11.000 | 19 |
| 8.900 | 205.032 | 1.564 | 8.900 - | 9.900 | 15 |
| 8.100 | 186.602 | 3.363 | 8.100 - | 8.900 | 46 |
| 7.300 | 168.172 | 4.849 | 7.300 - | 8.100 | 38 |
| 6.600 | 152.046 | 8.017 | 6.600 - | 7.300 | 81 |
| 5.900 | 135.920 | 14.157 | 5.900 - | 6.600 | 157 |
| 5.300 | 122.098 | 21.744 | 5.300 - | 5.900 | 194 |
| 4.800 | 110.579 | 30.309 | 4.800 - | 5.300 | 219 |
| 4.300 | 99.060 | 43.410 | 4.300 - | 4.800 | 335 |
| 3.900 | 89.846 | 53.969 | 3.900 - | 4.300 | 270 |
| 3.500 | 80.631 | 67.775 | 3.500 - | 3.900 | 353 |
| 3.200 | 73.719 | 76.965 | 3.200 - | 3.500 | 235 |
| 2.900 | 66.808 | 85.843 | 2.900 - | 3.200 | 227 |
| 2.600 | 59.897 | 90.458 | 2.600 - | 2.900 | 118 |
| 2.300 | 52.986 | 94.994 | 2.300 - | 2.600 | 116 |
| 2.100 | 48.378 | 96.285 | 2.100 - | 2.300 | 33 |
| 1.900 | 43.771 | 97.771 | 1.900 - | 2.100 | 38 |
| 1.700 | 39.163 | 98.553 | 1.700 - | 1.900 | 20 |
| 1.500 | 34.556 | 99.296 | 1.500 - | 1.700 | 19 |
| 1.400 | 32.252 | 99.648 | 1.400 - | 1.500 | 9 |
| 1.200 | 27.645 | 99.922 | 1.200 - | 1.400 | 7 |
| 1.123 | 25.876 | 99.961 | 1.123 - | 1.200 | 1 |
| | | | <= | 1.123 | 1 |

SUMMARY STATISTICS FOR ANALYSIS PERIOD

aximum Daily Mean Value = **15.034**
TA Daily Mean (Lin Calc) = **4.341**
ctual 95% Daily Mean = **2.333**

Minimum Daily Mean Val. = **1.123**
Median Daily Mean Value = **4.061**
Modal Daily Mean Value = **3.756**
(Class Interval 5% of median value)

umber of values used = **2557**
irst year used = **1990**
st year used = **1997**
umber of years used = 7 out of **8**

# Appendix 3

# Croxden Brook

## Croxden Brook

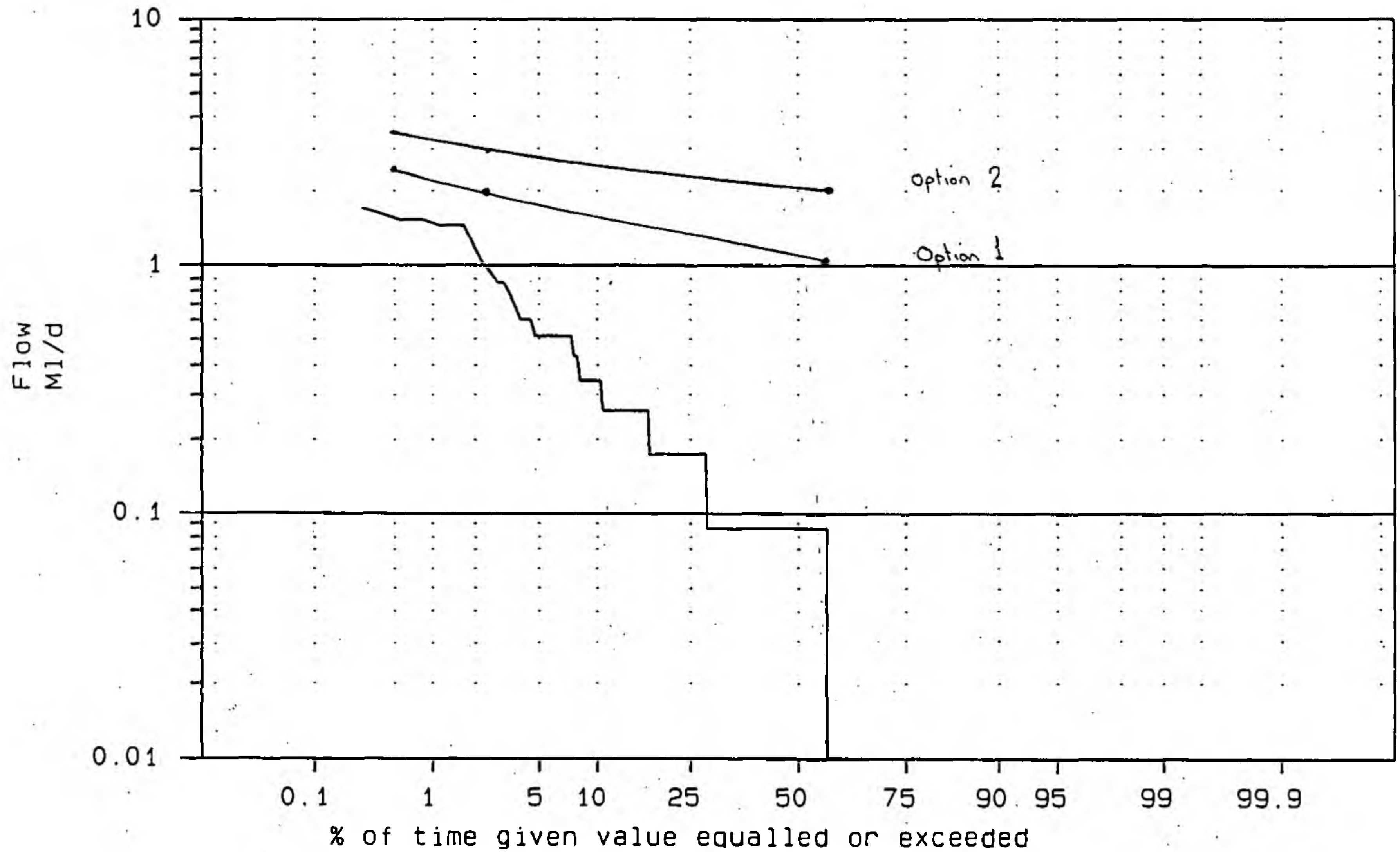
| | | |
|---|---|---|
| **Halifax Property Services** | - | **01785 259321** |
| **Stafford Borough Council** | - | **Rebecca Gibson**<br>**01785 223181** |
| **Environment Agency** | - | **Ann Dacey**<br>**01543 444 141** |
| **Mailing Office for Croxton** | - | **01889 562346** |
| **Mailing Office for Cheadle** | - | **01538 752 101** |
| **Uttoxeter County Council** | - | **01889 564 085** |
| **East Staffordshire County Council** | - | **01283 50 80 00** |
| **Staffordshire Moorlands District Council** | - | **01538 48 34 93** |
| **Heritage Centre** | - | **Mr Nickson**<br>**01889 567 176** |
| **English Heritage** | - | **0171 973 3000** |
| **The Raddle Pub, Hollington** | - | **01889 507 278** |
| **Local Ramblers Association Member** | - | **Mr Loadwich**<br>**01785 284 359** |
| **District Secretary** | - | **Mr D Hewitt**<br>**01889 563 474** |

## General

| | | |
|---|---|---|
| **Ramblers Association** | **-** | **0171 582 6878** |
| **Countryside Commission** | **-** | **0171 831 3510** |
| **Office National Statistics** | **-** | **0171 233 9233** |
| **Halifax Building Society's Statistical Service** | | **01422 333 333** |
| **Talking Pages** | **-** | **0800 600 900** |

| Auth.: 4130 | Name: GREAT GATE | Locat.: CROXDEN BK |
|---|---|---|

Period of Analysis : 1997




Season:
Clndr year

## Croxden Brook

During 1993 a trial compensation release was undertaken into the Winnothdale Brook to see how well the watercourse could transfer water to the downstream gauging station at Greatgate. This trial identified a problem with water leaking through the brook bed before it reached the gauging station. The Agency in conjunction with Severn Trent Water is to define the length of brook coarse which requires lining, with the expectation that this cost will be part of the AMP3 submission.

Therefore for the purpose of the benefit assessment it should be considered that all water released as compensation will remain in the watercourse till its confluence with Nothill Brook.

The options to be considered are

1 A compensation release of 1.0 Ml/d at all times at release point A
2 A compensation release of 2.0 Ml/d at all times at release point A
3 A compensation release of 1.0 Ml/d at release part A and 1.0 Ml/d at release part B. Both releases to be in operation 365 days/annum.

Note see enclosed map.

The gauging station at Greatgates has now had its record processed for the period 1995-1997. No trigger flow has been put forward as the MLF's artificial influences suggest a Q95 of 4.0 Ml/d $\pm$ 0.67 and the actual flow record doesn't contain a flow of this magnitude. Therefore for this analysis it should be assumed that the compensation release will be in operation 365 days/annum.

Enclosed are copies of:-

A Duration/Frequency Graph Greatgates 1997
B The above with 1995 comparison
C The above with 1996 comparison
D Mean daily flow against time

The following length of water course will be improved by the various options

| | | |
|---|---|---|
| Option 1 | rewater | 0.7 Km |
| | significant increase in flow | 3.0 Km |
| Option 2 | rewater | 0.7 Km |
| | significant increase in flow | 3.0 Km |
| Option 3 | rewater | 0.7 Km |
| | significant increase in flow | 3.0 Km |

Output from HYDROLOG Data Management System V2.50(C) 1991-97 Hydro-Logic Ltd
SUMMARY REPORT Printed on 10/02/1998 at 13:47 hrs 

E. A. Midlands - Headquarters Hydrometry

Auth. Ref. : 4130
Loc. Desc. : CROXDEN BK
Report Type : Daily Means For Yr.
Parameter : Flow
Units : Ml/d

Period : 1996

Station Name : GREAT GATE
Catchment Ref.:
Grid Ref. :
Gauge Zero : 0.000 MAOD
Catchment Area: 0.000 Sq Km

Start of Day : 09:00 GMT

| Day | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Day |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.120 | 0.815E | 0.774 | 0.737 | 0.768M | 0.611 | 0.429 | 0.380E | 0.289 | 0.164 | 0.073 | 0.141 | 1 |
| 2 | 1.111 | 0.827E | 0.786 | 0.749 | 0.758 | 0.606 | 0.431 | 0.387E | 0.289 | 0.150 | 0.079 | 0.158 | 2 |
| 3 | 1.035 | 0.846E | 0.789 | 0.749 | 0.747 | 0.602 | 0.490 | 0.342E | 0.290 | 0.261 | 0.099 | 0.406 | 3 |
| 4 | 1.017 | 0.852E | 0.796 | 0.733M | 0.715 | 0.581 | 0.433 | 0.358E | 0.302 | 0.233 | 0.119 | 0.229 | 4 |
| 5 | 1.129 | 0.888E | 0.819 | | 0.715 | 0.581 | 0.426 | 0.350E | 0.226 | 0.193 | 0.098 | 0.164 | 5 |
| 6 | 1.142 | 0.895E | 0.822 | | 0.715 | 0.583 | 0.515 | 0.437E | 0.213 | 0.192 | 0.093 | 0.128 | 6 |
| 7 | 1.139 | 0.889E | 0.801 | | 0.713 | 0.668 | 0.532 | 0.355E | 0.205 | 0.185 | 0.061 | 0.102 | 7 |
| 8 | 1.106 | 0.856E | 0.800 | | 0.686 | 0.622 | 0.519 | 0.322E | 0.205 | 0.191 | 0.048 | 0.104 | 8 |
| 9 | 1.114 | 0.927E | 0.807 | | 0.688 | 0.599 | 0.537 | 0.352 | 0.205 | 0.190 | 0.043 | 0.103 | 9 |
| 10 | 1.022 | 0.931 | 0.874 | | 0.709 | 0.587 | 0.528 | 0.385 | 0.203 | 0.182 | 0.041 | 0.083 | 10 |
| 11 | 0.985 | 1.012 | 0.870 | | 0.681 | 0.639 | 0.384 | 0.345 | 0.209 | 0.182 | 0.041 | 0.055 | 11 |
| 12 | 0.945 | 1.056 | 0.789 | | 0.631 | 0.570 | 0.364 | 0.331 | 0.207 | 0.182 | 0.029 | 0.023 | 12 |
| 13 | 0.910 | 0.843 | 0.936 | | 0.642 | 0.462 | 0.354E | 0.317 | 0.198 | 0.182 | 0.022 | 0.022 | 13 |
| 14 | 0.890 | 0.807 | 1.216 | | 0.635 | 0.443 | 0.338E | 0.320 | 0.193 | 0.182 | 0.010 | 0.014 | 14 |
| 15 | 0.888 | 0.814 | 0.961 | | 0.646 | 0.433 | 0.331E | 0.328 | 0.193 | 0.182 | 0.006 | 0.006 | 15 |
| 16 | 0.860 | 0.800 | 0.891 | | 0.647 | 0.478 | 0.349E | 0.321 | 0.199 | 0.182 | 0.022 | 0.006 | 16 |
| 17 | 0.808 | 0.961 | 0.872 | | 0.647 | 0.483 | 0.326E | 0.331 | 0.205 | 0.167 | 0.042 | 0.006 | 17 |
| 18 | 0.803 | 1.178 | 0.861 | | 0.678 | 0.501 | 0.396E | 0.311 | 0.205 | 0.167 | 0.022 | 0.133 | 18 |
| 19 | 0.785 | 0.876 | 0.889 | | 0.678 | 0.477 | 0.354E | 0.274 | 0.256 | 0.109 | 0.081 | 0.237 | 19 |
| 20 | 0.814 | 0.814 | 0.867 | | 0.613 | 0.471 | 0.356E | 0.280 | 0.216 | 0.177 | 0.051 | 0.160 | 20 |
| 21 | 0.821 | 0.824 | 0.950 | | 0.591 | 0.471 | 0.404E | 0.262 | 0.201 | 0.097 | 0.022 | 0.124 | 21 |
| 22 | 0.804 | 0.845 | 0.949 | | 0.664 | 0.471 | 0.414E | 0.285 | 0.194 | 0.095 | 0.013 | 0.117 | 22 |
| 23 | 0.819E | 0.865 | 0.982 | | 0.817 | 0.464 | 0.414E | 0.290 | 0.193 | 0.094 | 0.045 | 0.114 | 23 |
| 24 | 0.838E | 0.894 | 0.919 | | 0.768 | 0.471 | 0.380E | 0.296 | 0.198 | 0.089 | 0.122 | 0.118 | 24 |
| 25 | 0.850E | 0.907 | 0.878 | | 0.655 | 0.471 | 0.354E | 0.283 | 0.195 | 0.099 | 0.275 | 0.112 | 25 |
| 26 | 0.852E | 0.847 | 0.862 | | 0.649 | 0.476 | 0.393E | 0.357 | 0.197 | 0.074 | 0.105 | 0.104 | 26 |
| 27 | 0.834E | 0.800 | 0.824 | | 0.611 | 0.404 | 0.402E | 0.292 | 0.175 | 0.096 | 0.055 | 0.116 | 27 |
| 28 | 0.830E | 0.764 | 0.822 | | 0.619 | 0.426 | 0.618E | 0.273 | 0.178 | 0.164 | 0.152 | 0.094 | 28 |
| 29 | 0.827E | 0.768 | 0.807 | | 0.647 | 0.396 | 0.475E | 0.277 | 0.181 | 0.069 | 0.296 | 0.108 | 29 |
| 30 | 0.829E | | 0.778 | | 0.671 | 0.419 | 0.446E | 0.282 | 0.159 | 0.068 | 0.182 | 0.085 | 30 |
| 31 | 0.832E | | 0.780 | | 0.616 | | 0.418E | 0.278 | | 0.108 | | 0.076 | 31 |
| Mean | 0.928 | 0.876 | 0.863 | 0.742 | 0.678 | 0.516 | 0.423 | 0.323 | 0.213 | 0.152 | 0.078 | 0.111 | |
| Maximum | 1.142 | 1.178 | 1.216 | 0.749 | 0.817 | 0.668 | 0.618 | 0.437 | 0.302 | 0.261 | 0.296 | 0.406 | |
| Day of Max. | 6 | 18 | 14 | 2 | 23 | 7 | 28 | 6 | 4 | 3 | 29 | 3 | |
| Min | 0.785 | 0.764 | 0.774 | 0.733 | 0.591 | 0.396 | 0.326 | 0.262 | 0.159 | 0.068 | 0.006 | 0.006 | |
| Day of Min. | 19 | 28 | 1 | 4 | 21 | 29 | 17 | 21 | 30 | 30 | 15 | 16 | |
| Total (TCM) | 29 | 25 | 27 | 3 | 20 | 15 | 13 | 10 | 6 | 5 | 2 | 3 | |
| Runoff (mm) | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | |

Above summary is for Daily Means of Flow
Data Codes : E - Edited ? - Suspect U - Unchecked M - Missing

E. A. Midlands - Headquarters Hydrometry

Auth. Ref. : 4130
Loc. Desc. : CROXDEN BK
Report Type : Daily Means For Yr.
Parameter : Flow
Units : Ml/d

Period : 1997

Station Name : GREAT GATE
Catchment Ref.:
Grid Ref. :
Gauge Zero : 0.000 MAOD
Catchment Area: 0.000 Sq Km

Start of Day : 09:00 GMT

| Day | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Day |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.080 | 0.037E | 0.511 | 0.097 | 0.029 | 0.041 | 0.379 | 0.045 | 0.055 | 0.034 | 0.000E | 0.038 | 1 |
| 2 | 0.078 | 0.035E | 0.520 | 0.098 | 0.023 | 0.041 | 0.331 | 0.041 | 0.048 | 0.037 | 0.000E | 0.008E | 2 |
| 3 | 0.070 | 0.033E | 0.485 | 0.090 | 0.038 | 0.040 | 0.328 | 0.040 | 0.122 | 0.037 | 0.000E | 0.001E | 3 |
| 4 | 0.065 | 0.031E | 0.485 | 0.085 | 0.039 | 0.039 | 0.294 | 0.038 | 0.034 | 0.028 | 0.000E | 0.000E | 4 |
| 5 | 0.065 | 0.020E | 0.488 | 0.063 | 0.111 | 0.035 | 0.261 | 0.035 | 0.031 | 0.027 | 0.000E | 0.000E | 5 |
| 6 | 0.067 | 0.018 | 0.306 | 0.057 | 0.050 | 0.041 | 0.251 | 0.034 | 0.020 | 0.003 | 0.000E | 0.001E | 6 |
| 7 | 0.064 | 0.023 | 0.268 | 0.055 | 0.094 | 0.041 | 0.242 | 0.032 | 0.011 | 0.054 | 0.017E | 0.004E | 7 |
| 8 | 0.071E | 0.015 | 0.253 | 0.055 | 0.091 | 0.041 | 0.249 | 0.029 | 0.013 | 0.146 | 0.054 | 0.008E | 8 |
| 9 | 0.031E | 0.016 | 0.229 | 0.055 | 0.077 | 0.065 | 0.249 | 0.030 | 0.014 | 0.067 | 0.026 | 0.018E | 9 |
| 10 | 0.030E | 0.029 | 0.212 | 0.054 | 0.085 | 0.084 | 0.241 | 0.039 | 0.020 | 0.032 | 0.043 | 0.035 | 10 |
| 11 | 0.029E | 0.048 | 0.192 | 0.042 | 0.081 | 0.089 | 0.243 | 0.061 | 0.026 | 0.050 | 0.026 | 0.097 | 11 |
| 12 | 0.028E | 0.058 | 0.165 | 0.035 | 0.092 | 0.086 | 0.245 | 0.034 | 0.016E | 0.031 | 0.020 | 0.087 | 12 |
| 13 | 0.027E | 0.060 | 0.160 | 0.034 | 0.089 | 0.076 | 0.248 | 0.038 | 0.009E | 0.026 | 0.017 | 0.091 | 13 |
| 14 | 0.027E | 0.052 | 0.272 | 0.034 | 0.088 | 0.073 | 0.285 | 0.025 | 0.010E | 0.068 | 0.003 | 0.098 | 14 |
| 15 | 0.026E | 0.044 | 0.181 | 0.034 | 0.096 | 0.075 | 0.309 | 0.017 | 0.007E | 0.067 | 0.000 | 0.130 | 15 |
| 16 | 0.025E | 0.049 | 0.154 | 0.034 | 0.103 | 0.078 | 0.308 | 0.015 | 0.007E | 0.054 | 0.000 | 0.139 | 16 |
| 17 | 0.024E | 0.084 | 0.148 | 0.045 | 0.116 | 0.081 | 0.289 | 0.011 | 0.003E | 0.035 | 0.000E | 0.182 | 17 |
| 18 | 0.024E | 0.083 | 0.167 | 0.043 | 0.130 | 0.081 | 0.257 | 0.020 | 0.003E | 0.032 | 0.005E | 1.507 | 18 |
| 19 | 0.023E | 0.146 | 0.176 | 0.035 | 0.181 | 0.081 | 0.242 | 0.017 | 0.001E | 0.027 | 0.029 | 0.774 | 19 |
| 20 | 0.020 | 0.541 | 0.149 | 0.033 | 0.216 | 0.136 | 0.243 | 0.017 | 0.002E | 0.023 | 0.048 | 0.603 | 20 |
| 21 | 0.045 | 0.387 | 0.165 | 0.033 | 0.163 | 0.194 | 0.247 | 0.051 | 0.002E | 0.019 | 0.019 | 0.504 | 21 |
| 22 | 0.063E | 0.326 | 0.160 | 0.039 | 0.159 | 0.187 | 0.255 | 0.045 | 0.003E | 0.009 | 0.004 | 0.550 | 22 |
| 23 | 0.060E | 0.434 | 0.159 | 0.033 | 0.153 | 0.199 | 0.273 | 0.096 | 0.004E | 0.005 | 0.004 | 1.233 | 23 |
| 24 | 0.057E | 0.624 | 0.155 | 0.032 | 0.139 | 0.146 | 0.179 | 0.140 | 0.005 | 0.004 | 0.004 | 1.079 | 24 |
| 25 | 0.055E | 0.527 | 0.136 | 0.075 | 0.151 | 0.248 | 0.086 | 0.074 | 0.008 | 0.001 | 0.003 | 0.918 | 25 |
| 26 | 0.052E | 0.854 | 0.134 | 0.067 | 0.136 | 0.331 | 0.081 | 0.034 | 0.011 | 0.000E | 0.008 | 0.902 | 26 |
| 27 | 0.049E | 0.669 | 0.127 | 0.046 | 0.135 | 0.299 | 0.079 | 0.076 | 0.016 | 0.000E | 0.009 | 1.470 | 27 |
| 28 | 0.047E | 0.648 | 0.110 | 0.068 | 0.135 | 0.528 | 0.068 | 0.128 | 0.018 | 0.000E | 0.100 | 1.701 | 28 |
| 29 | 0.044E | | 0.103 | 0.033 | 0.111 | 0.502 | 0.051 | 0.083 | 0.024 | 0.000E | 0.090 | 1.477 | 29 |
| 30 | 0.042E | | 0.101 | 0.034 | 0.056 | 0.423 | 0.048 | 0.075 | 0.032 | 0.000E | 0.055 | 1.590 | 30 |
| 31 | 0.040E | | 0.101 | | 0.041 | | 0.047 | 0.163 | | 0.000E | | 1.556 | 31 |
| Mean | 0.046 | 0.210 | 0.225 | 0.051 | 0.103 | 0.146 | 0.223 | 0.051 | 0.019 | 0.030 | 0.019 | 0.542 | |
| Maximum | 0.080 | 0.854 | 0.520 | 0.098 | 0.216 | 0.528 | 0.379 | 0.163 | 0.122 | 0.146 | 0.100 | 1.701 | |
| Day of Max. | 1 | 26 | 2 | 2 | 20 | 28 | 1 | 31 | 3 | 8 | 28 | 28 | |
| Min | 0.020 | 0.015 | 0.101 | 0.032 | 0.023 | 0.035 | 0.047 | 0.011 | 0.001 | 0.000 | 0.000 | 0.000 | |
| Day of Min. | 20 | 8 | 31 | 24 | 2 | 5 | 31 | 17 | 19 | 27 | 1 | 5 | |
| Total (TCM) | 1 | 6 | 7 | 2 | 3 | 4 | 7 | 2 | 1 | 1 | 1 | 17 | |
| Runoff (mm) | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | |

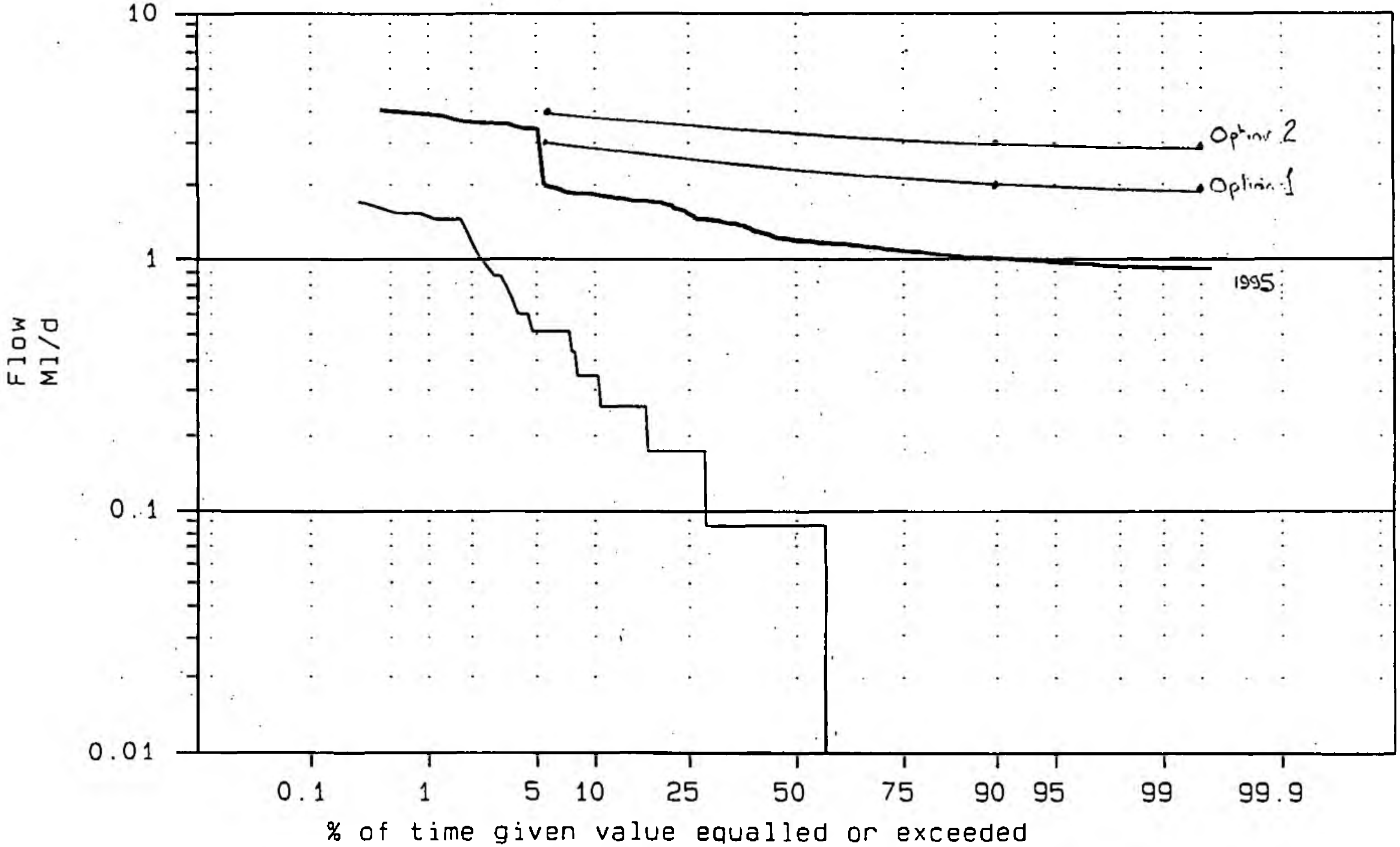
Above summary is for Daily Means of Flow

Data Codes : E - Edited ? - Suspect U - Unchecked M - Missing

E. A. Midlands - Headquarters Hydrometry | Duration/Frequency Graph

| Auth.: 4130 | Name: GREAT GATE | Locat.: CROXDEN BK |
|---|---|---|

Period of Analysis : 1997




Year:
1995

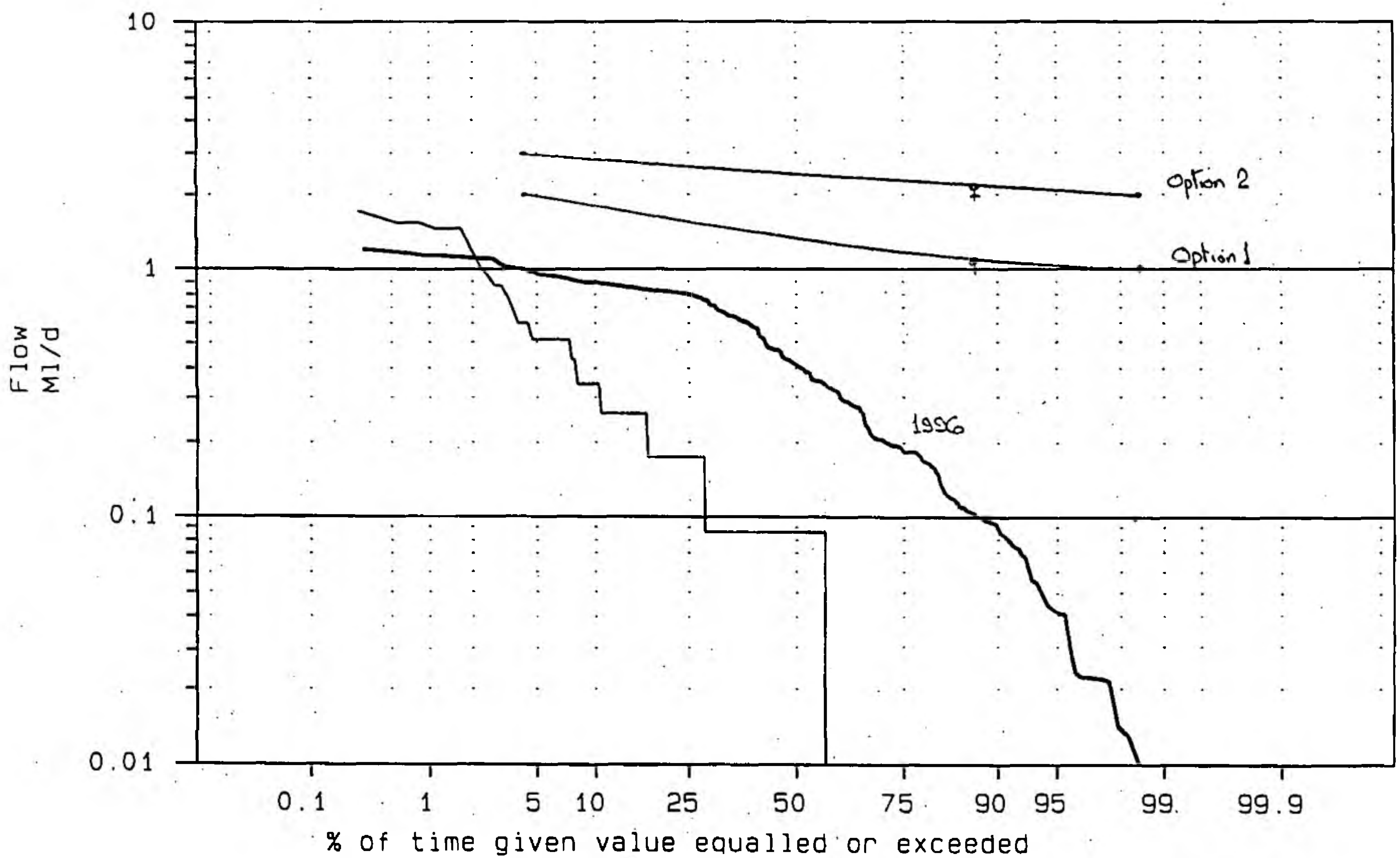
Season:
Clndr year

No.of days
238

| | | | | | |
|---|---|---|---|---|---|
| 0.000 | 0.000 | 66.301 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 66.575 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 66.849 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 67.123 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 67.397 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 67.671 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 67.945 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 68.219 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 68.493 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 68.767 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 69.041 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 69.315 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 69.589 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 69.863 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 70.137 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 70.411 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 70.685 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 70.959 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 71.233 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 71.507 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 71.781 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 72.055 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 72.329 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 72.603 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 72.877 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 73.151 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 73.425 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 73.699 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 73.973 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 74.247 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 74.521 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 74.795 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 75.068 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 75.342 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 75.616 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 75.890 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 76.164 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 76.438 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 76.712 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 76.986 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 77.260 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 77.534 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 77.808 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 78.082 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 78.356 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 78.630 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 78.904 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 79.178 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 79.452 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 79.726 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 80.000 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 80.274 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 80.548 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 80.822 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 81.096 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 81.370 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 81.644 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 81.918 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 82.192 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 82.466 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 82.740 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 83.014 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 83.288 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 83.562 | 0.000 - | 0.000 | 1 |

| Auth.: 4130 | Name: GREAT GATE | Locat.: CROXDEN BK |
|---|---|---|

Period of Analysis : 1997




Year:
1996

Season:
Clndr year

No.of days
338

Output from HYDROLOG Data Management System V2.50(C) 1991-97 Hydro-Logic Ltd
Long Term Statistics Printed on 11/02/1998 at 11:18 hrs

E. A. Midlands - Headquarters Hydrometry

Auth. Ref. : 4130
Loc. Desc. : CROXDEN BK
Report Type : Duration/Frequency
Parameter : Flow
Units : Ml/d

Station Name : GREAT GATE
Catchment Ref.:
Grid Ref. :
Gauge Zero : 0.000 MAOD
Catchment Area: 0.000 Sq Km

Period : 23/02/1995 to 04/02/1998 Start of Day : 09:00 GMT

Analysis period : Calendar Year

DAILY MEAN VALUE EXCEEDED STATED AMOUNT FOR GIVEN PERCENTAGE OF TIME

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0% | | 1.469 | 1.210 | 0.864 | 0.605 | 0.518 | 0.518 | 0.518 | 0.432 | 0.346 |
| 10% | 0.346 | 0.259 | 0.259 | 0.259 | 0.259 | 0.259 | 0.259 | 0.259 | 0.173 | 0.173 |
| 20% | 0.173 | 0.173 | 0.173 | 0.173 | 0.173 | 0.173 | 0.173 | 0.173 | 0.173 | 0.086 |
| 30% | 0.086 | 0.086 | 0.086 | 0.086 | 0.086 | 0.086 | 0.086 | 0.086 | 0.086 | 0.086 |
| 40% | 0.086 | 0.086 | 0.086 | 0.086 | 0.086 | 0.086 | 0.086 | 0.086 | 0.086 | 0.086 |
| 50% | 0.086 | 0.086 | 0.086 | 0.086 | 0.086 | 0.086 | 0.086 | 0.086 | 0.000 | 0.000 |
| 60% | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 70% | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 80% | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 90% | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

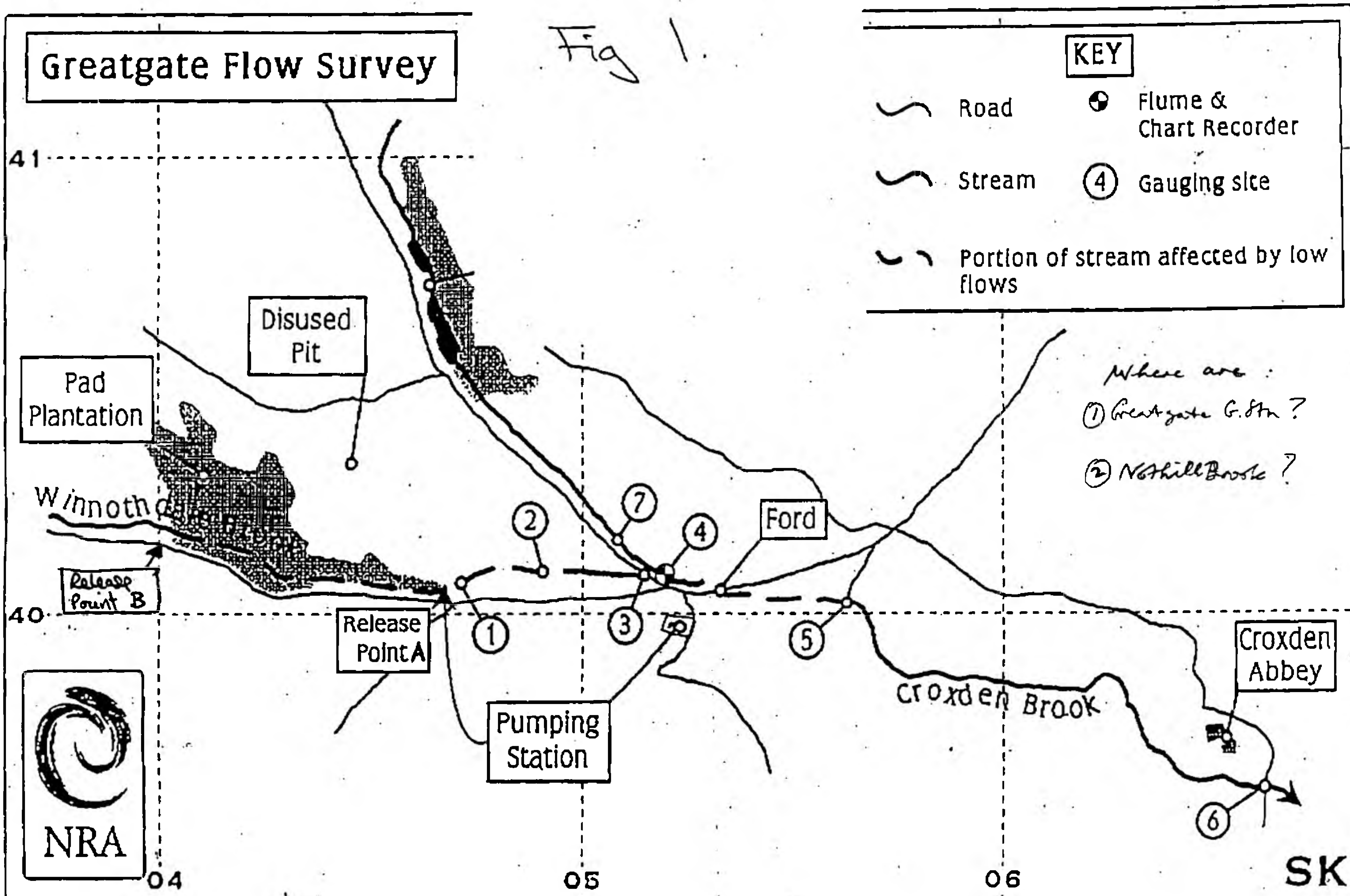
SUMMARY STATISTICS FOR ANALYSIS PERIOD

Maximum Daily Mean Value = 1.728
LTA Daily Mean (Lin Calc) = 0.136
LTA Daily Mean (Log Calc) = 0.160
Actual 95% Daily Mean = 0.000

Minimum Daily Mean Val. = 0.000
Median Daily Mean Value = 0.086
Log Standard Deviation = 0.779
Calc 95% Daily Mean = 0.045
(Log-Normal distribution assumed)

Number of values used = 365
First year used = 1997
Last year used = 1997
Number of years used = 1 out of 1

Only complete calendar years of data used


Greatgate Flow Survey
Fig 1.
KEY
Road
Stream
Portion of stream affected by low flows
Flume & Chart Recorder
4 Gauging site
Where are:
(1) Greatgate G.Stn ?
(2) Nothill Brook ?
Disused Pit
Pad Plantation
Winnothdale Brook
Release Point B
Release Point A
Pumping Station
Ford
Croxden Brook
Croxden Abbey
41
40
04
05
06
SK
NRA

# Appendix 4

## Dover Beck

## Dover Beck

| | | |
|---|---|---|
| **Epperstone Park Hatcheries** | **-** | **01159 664410** |
| **Grimesmoor Farm** | **-** | **Roger Burton** |
| **Gelding District Council** | | **0115 967 0067** |
| **Newark & Sherwood District Council** | | **01636 605111** |

# General

| | | |
|---|---|---|
| **Ramblers Association** | **-** | **0171 582 6878** |
| **Countryside Commission** | **-** | **0171 831 3510** |
| **Office National Statistics** | **-** | **0171 233 9233** |
| **Halifax Building Society's Statistical Service** | | **01422 333 333** |
| **Talking Pages** | **-** | **0800 600 900** |

## Dover Beck

In the last month the Agency has commissioned the flow augmentation borehole at Oxton Golf Club. This will rewater the Dover Beck from where the borehole water enters the beck to Beanford immediately downstream of Oxton Bogs. Downstream of this point through Thorndale Plantation all flow is lost.

The Agency will identify the length of watercourse which is leaking and arrange to let a contract a scheme to line the affecting beck course. This investigation will be concentrated on the length of beck between Thorndale Plantation and Calverton Lido. Once this lining has been installed any outflow from the Agency borehole should be transferred onward to the River Trent.

The three options which should be considered for this alleviation site are:-

| | |
|---|---|
| Option 1 | The sealing of the beck bed between Thorndale and Calverton Lido which will produce a 1.0 Ml/d flow below Oxton Bogs when borehole is in operation. This is allowing a loss within Salterford Dam and Oxton Bogs of 1.5 Ml/d. |
| Option 2 | The sealing of the beck bed will produce a 2.5 Ml/d flow below Oxton Bogs when borehole is in operation. (assuming zero loss above Oxton Bogs). |
| Option 3 | A compensation release into Oxton Dumble of 1Ml/d adjacent to NGR SK 6460 5300. |

The gauging station at Lowdham will be used to regulate the compensation release. This will stop the pumps at both sites (Oxton Golf Club and Oxton Dumble) when Q20 is exceeded and restarted them when the flow is below Q20 (15.03 Ml/d)

Enclosed are copies of:-

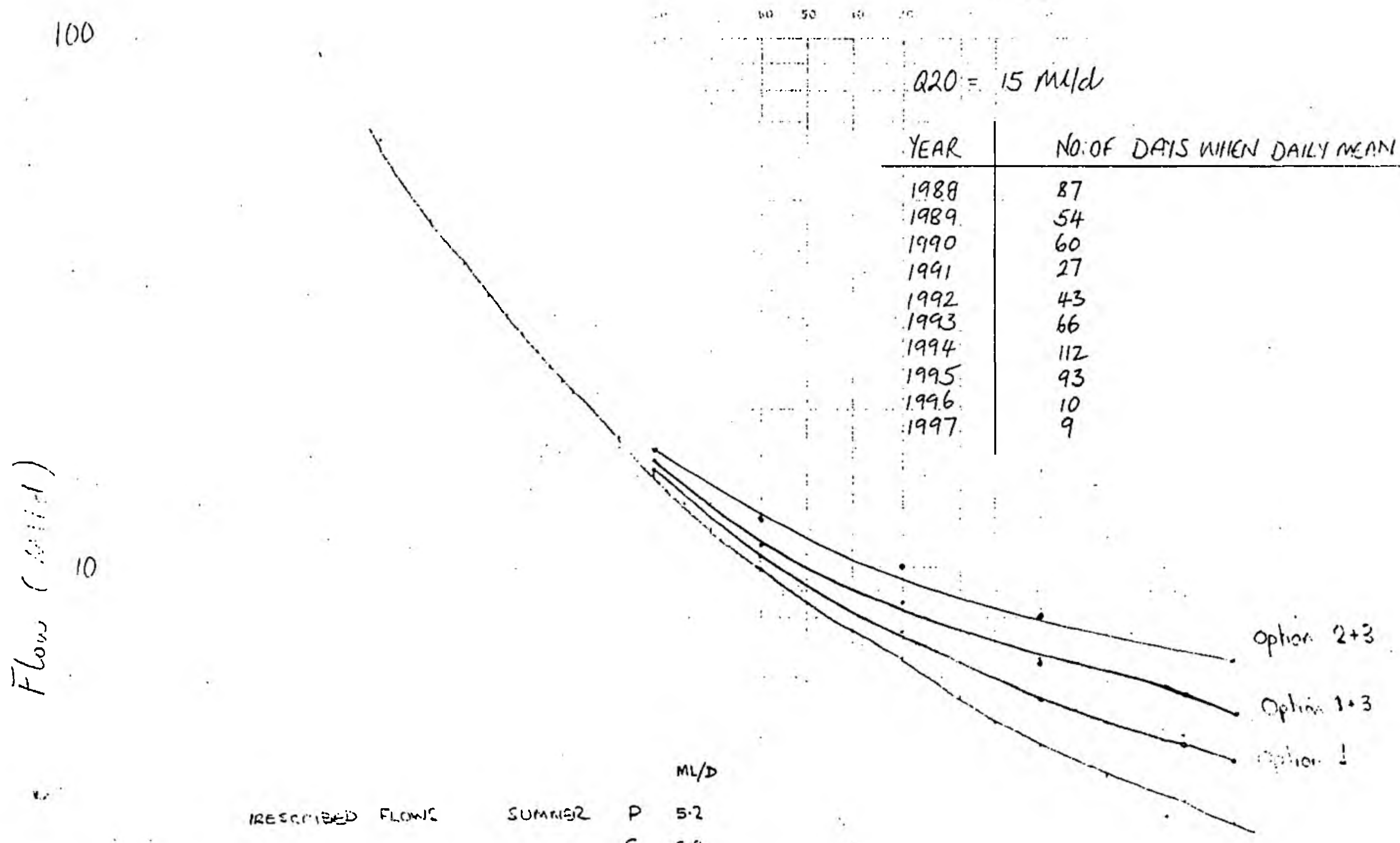
A Duration/Frequency Graph Lowdham
B Duration/Frequency Table Lowdham
C Mean Daily flow against time

Also enclosed is a separate diagram of the Dover Beck produced by Howard Humphreys which indicates the length which has been observed to be dry. This, in conjunction with Area staff knowledge enabled an estimation of the lengths being rewatered and the watercourse provided significant increases in flow. There are:-

| | | |
|---|---|---|
| Option 1 | rewater | ~~3.5~~ 2.5 Km |
| | provide extra water | 8 Km |
| Option 2 | rewater | ~~4.5~~ 3.5 Km |
| | provide extra water | 8 Km |
| Option 3 | rewater | 3.5 Km |
| | provide extra water | 8 Km |

If Option 1 + Option 3 considered or Option 2 + Option 3
then rewater would be 6.0 Km
provide extra water 8.0 Km

DOVER BECK AT LOWDHAM

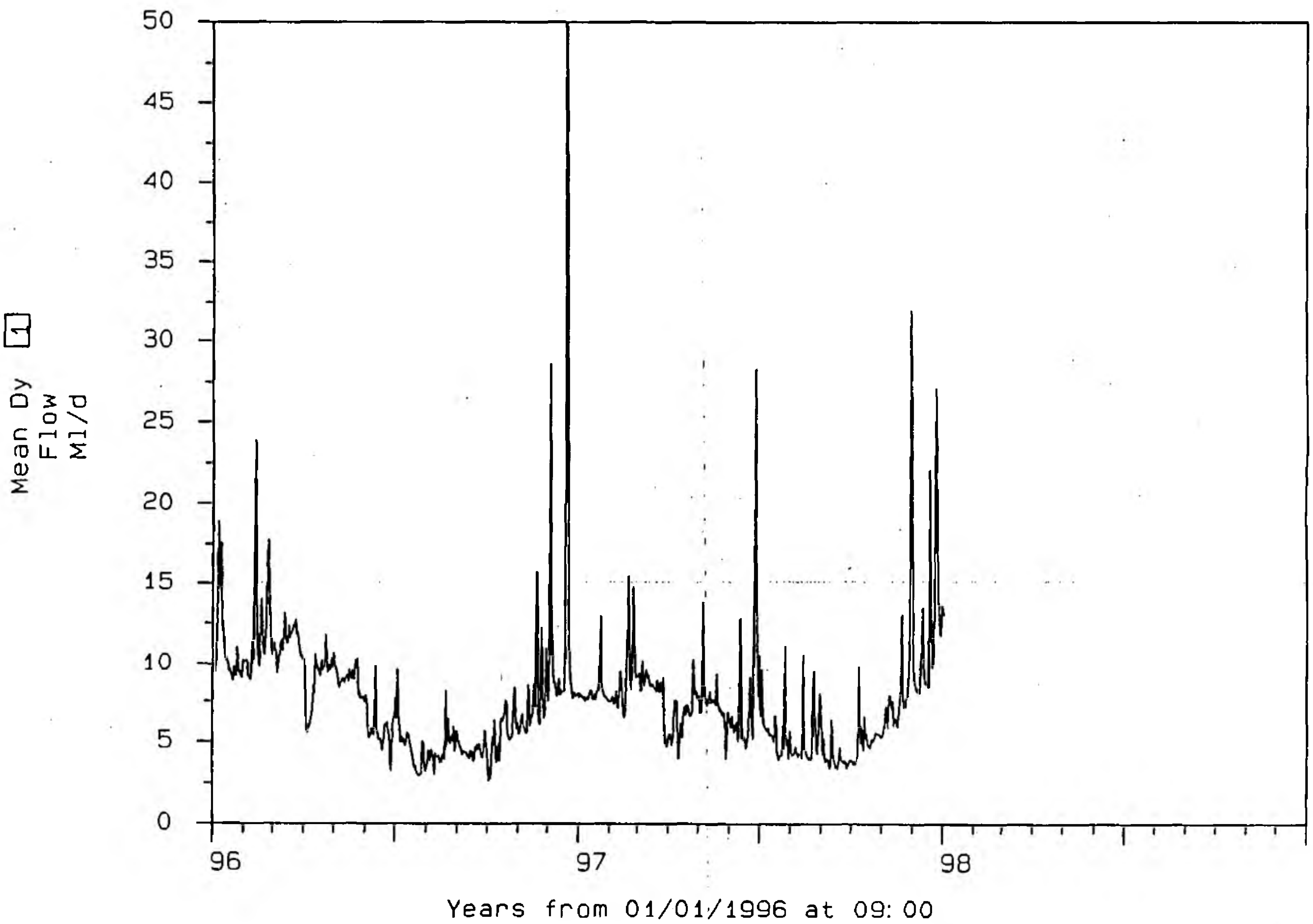



Q20 = 15 Ml/d

| YEAR | No: OF DAYS WHEN DAILY MEAN > Q20 |
|---|---|
| 1988 | 87 |
| 1989 | 54 |
| 1990 | 60 |
| 1991 | 27 |
| 1992 | 43 |
| 1993 | 66 |
| 1994 | 112 |
| 1995 | 93 |
| 1996 | 10 |
| 1997 | 9 |

| | | | ML/D |
|---|---|---|---|
| PRESCRIBED FLOWS | SUMMER | P | 5·2 |
| | | S | 6·9 |
| | WINTER | P | 6·6 |

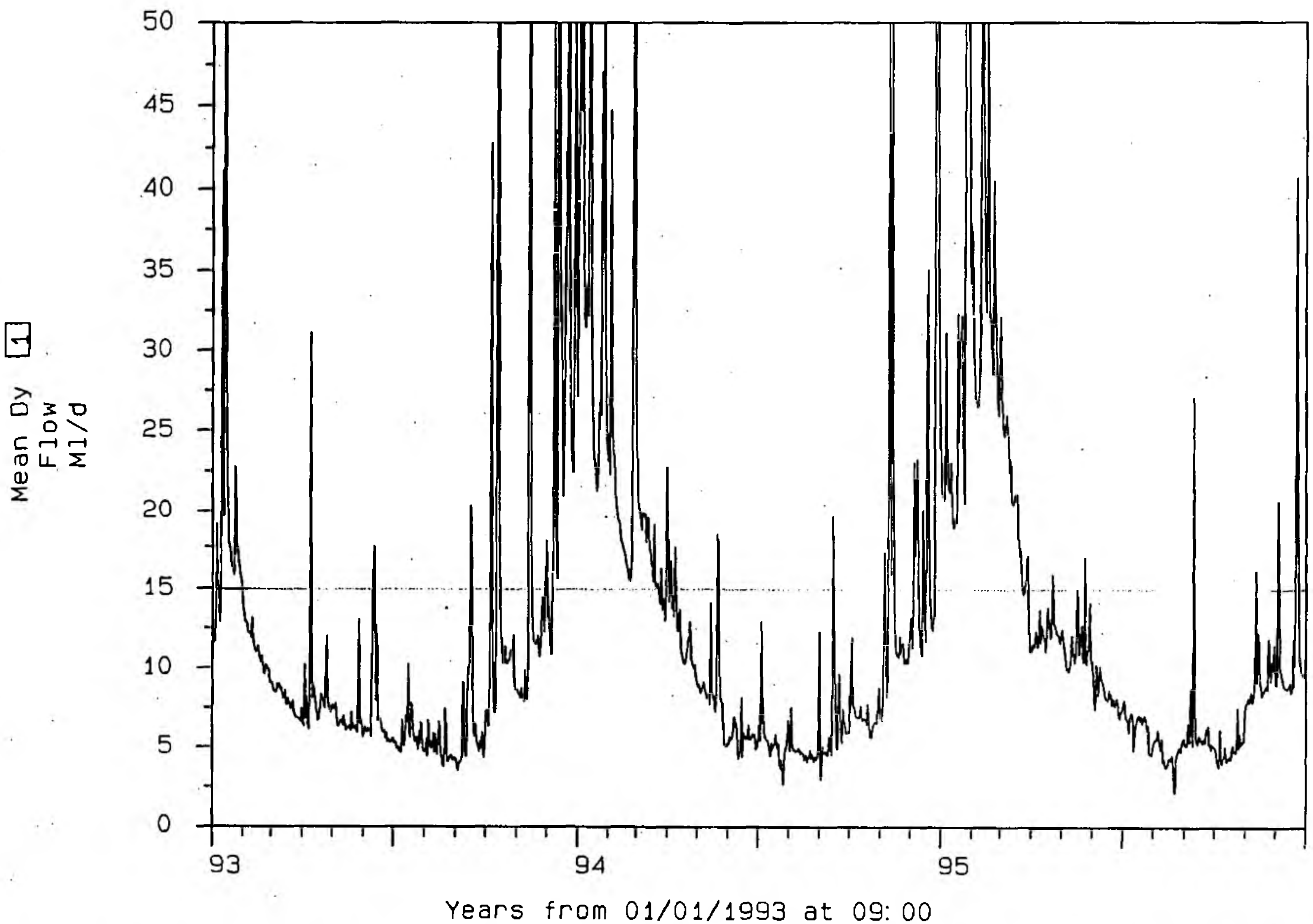
| Auth.: 4060 | Name: LOWDHAM | Locat.: DOVER BECK |
|---|---|---|



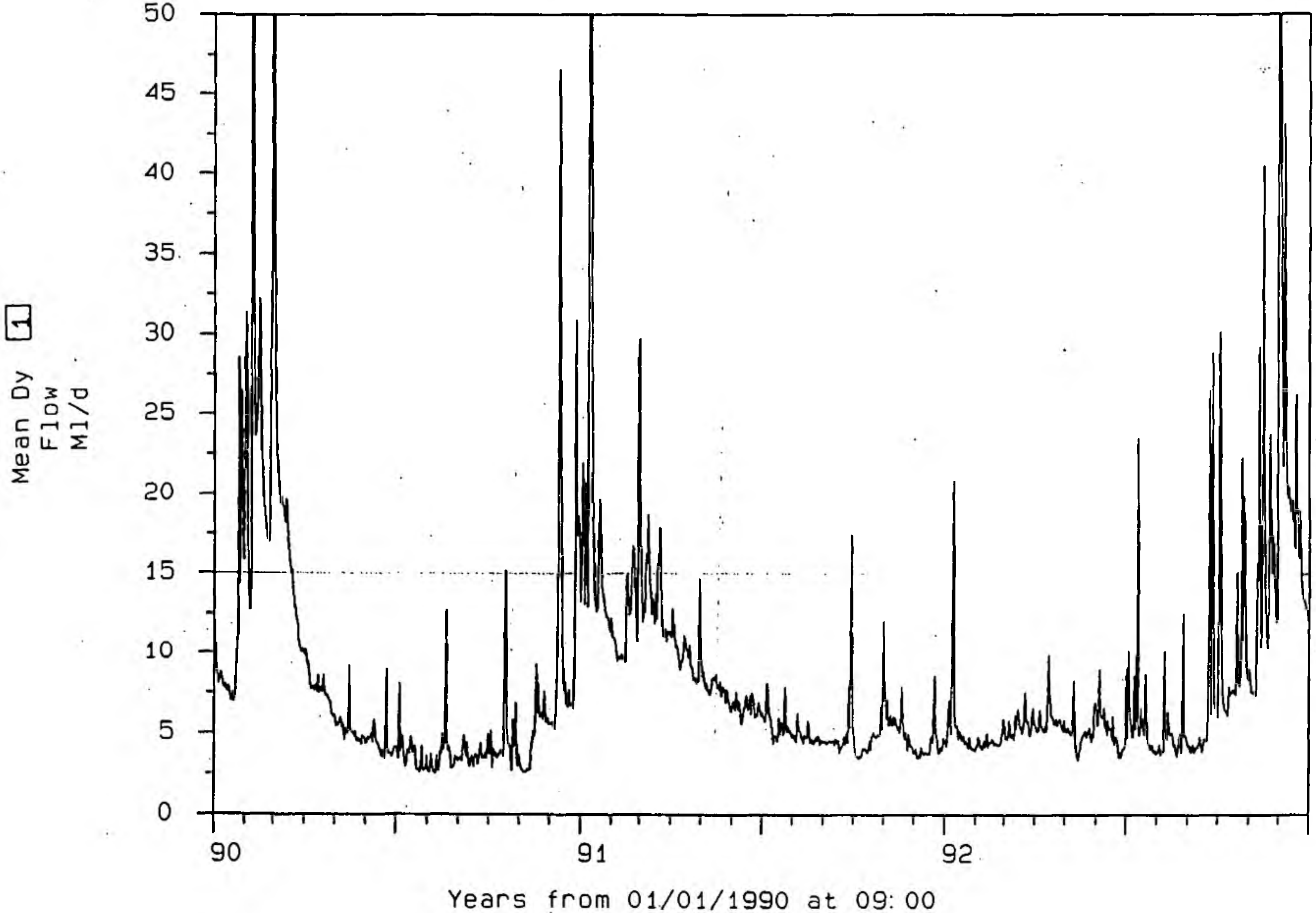
E. A. Midlands - Headquarters Hydrometry

HYDROLOG Archive Report

| Auth.: 4060 | Name: LOWDHAM | Locat.: DOVER BECK |
|---|---|---|

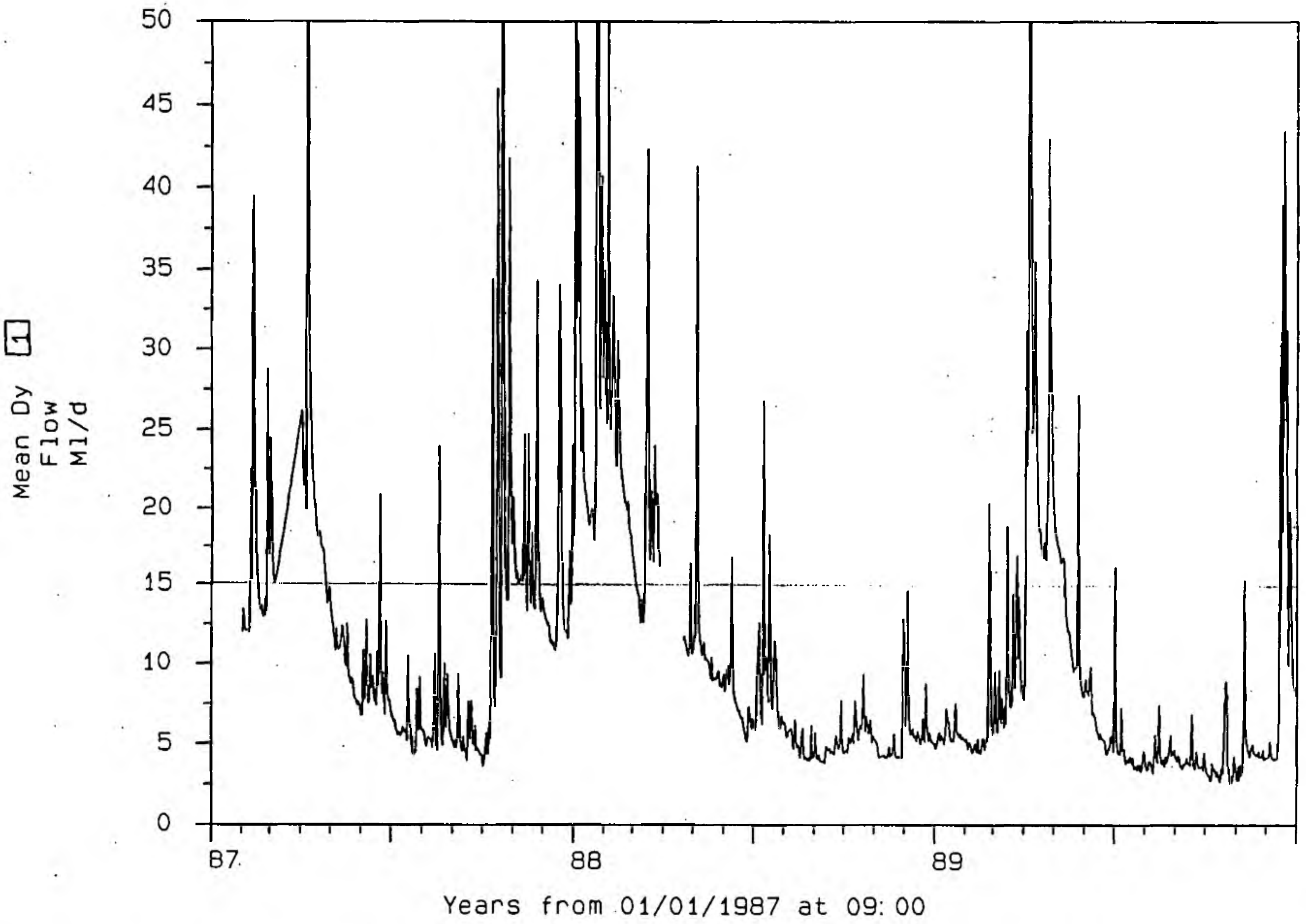


| Auth.: 4060 | Name: LOWDHAM | Locat.: DOVER BECK |
|---|---|---|



E. A. Midlands - Headquarters Hydrometry HYDROLOG Archive Report

| Auth.: 4060 | Name: LOWDHAM | Locat.: DOVER BECK |
|---|---|---|



Output from HYDROLOG Data Management System V2.50(C) 1991-97 Hydro-Logic Ltd
Long Term Statistics                                   Printed on 29/01/1998 at 12:18 hrs

**E. A. Midlands - Headquarters Hydrometry**

Auth. Ref. : 4060
Loc. Desc. : **DOVER BECK**
Report Type : **Duration/Frequency**
Parameter : **Flow**
Units : **Ml/d**

Station Name : **LOWDHAM**
Catchment Ref.: **LT**
Grid Ref. : **SK 653479**
Gauge Zero : **28.690 MAOD**
Catchment Area: **69.000 Sq Km**

Period : **01/03/1972 to 31/12/1997** Start of Day : **09:00 GMT**

Analysis period : **Calendar Year**

DAILY MEAN VALUE EXCEEDED STATED AMOUNT FOR GIVEN PERCENTAGE OF TIME

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0% | | 64.714 | 46.483 | 38.102 | 33.264 | 30.586 | 28.080 | 26.006 | 24.278 | 22.896 |
| 10% | 21.600 | 20.650 | 19.786 | 19.094 | 18.230 | 17.712 | 17.107 | 16.502 | 16.070 | 15.552 |
| 20% | 15.034 | 14.602 | 14.256 | 13.910 | 13.565 | 13.219 | 12.874 | 12.528 | 12.269 | 12.010 |
| 30% | 11.750 | 11.578 | 11.318 | 11.059 | 10.800 | 10.627 | 10.454 | 10.282 | 10.195 | 10.022 |
| 40% | 9.850 | 9.763 | 9.590 | 9.418 | 9.245 | 9.158 | 8.986 | 8.899 | 8.726 | 8.640 |
| 50% | 8.554 | 8.381 | 8.294 | 8.208 | 8.122 | 7.949 | 7.862 | 7.776 | 7.776 | 7.690 |
| 60% | 7.517 | 7.517 | 7.344 | 7.258 | 7.171 | 7.085 | 6.998 | 6.912 | 6.826 | 6.739 |
| 70% | 6.566 | 6.480 | 6.394 | 6.307 | 6.134 | 6.048 | 5.962 | 5.875 | 5.789 | 5.616 |
| 80% | 5.530 | 5.357 | 5.270 | 5.184 | 5.011 | 4.925 | 4.838 | 4.752 | 4.666 | 4.493 |
| 90% | 4.406 | 4.320 | 4.234 | 4.147 | 3.974 | 3.888 | 3.715 | 3.629 | 3.456 | 3.110 |

SUMMARY STATISTICS FOR ANALYSIS PERIOD

Maximum Daily Mean Value = **208.138**
LTA Daily Mean (Lin Calc) = **11.960**
LTA Daily Mean (Log Calc) = **9.347**
Actual 95% Daily Mean = **3.888**

Minimum Daily Mean Val. = **2.160**
Median Daily Mean Value = **8.554**
Log Standard Deviation = **0.633**
Calc 95% Daily Mean = **3.298**
(Log-Normal distribution assumed)

Number of values used = **6939**
First year used = **1973**
Last year used = **1997**
Number of years used = **19** out of **25**

Only complete calendar years of data used

# DOVER BECK: LOW FLOW CONDITIONS

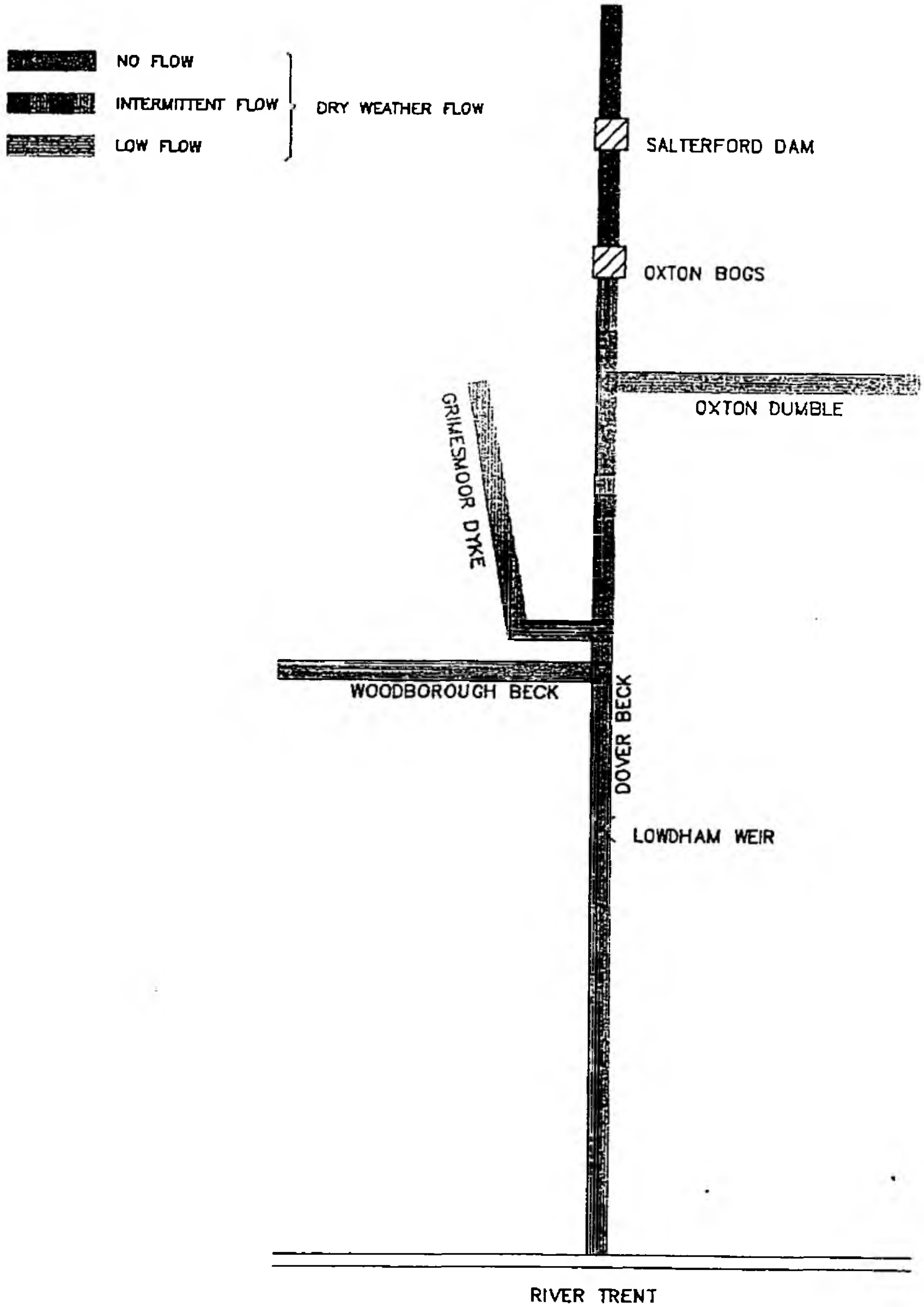



figure 6

# Appendix 5

## River Ashop and River Noe

## Jaggers Clough

| | | |
|---|---|---|
| Environment Agency | - | Keith Easton<br>01159  455722 |
| | - | Mat Linley<br>01159 455722 |
| | - | Stuart King<br>01773 520511 |
| | - | Jim Lyons<br>01159 455722 |
| Peak Forest Angling Club | | Mr Marwood<br>01949 815000 |

## General

| | | |
|---|---|---|
| **Ramblers Association** | - | **0171 582 6878** |
| **Countryside Commission** | - | **0171 831 3510** |
| **Office National Statistics** | - | **0171 233 9233** |
| **Halifax Building Society's Statistical Service** | | **01422 333 333** |
| **Talking Pages** | - | **0800 600 900** |

DERWENT VALLEY RESERVOIR COMPENSATION ARRANGEMENTS

River Alport and Ashop

There is no compensation requirement at the abstraction point from these two rivers into Derwent Reservoir. So that the river Ashop downstream of the confluence can be brought back as a salmonic fishery and enhance the appearance of the river, can you please consider the affect of compensation releases from the impounding structures. The options to be considered are discharge releases of 15 Ml/d and 10 Ml/d. The length of river to be rewatered would be 3Km.

River Noe

At present there is no compensation release at the River Noe diversion to Ladybower Reservoir. It was initially considered that the compensation release at Jagger Clough should be split between Jagger Clough and River Noe diversion. This has now been discounted. The water course below Jagger Clough is producing a reliable fishery and should not be modified. Therefore it has been decided that the Ladybower compensation release of 57Ml/d should be considered for variation. For this benefit assessment the modification to be considered is

| | | | |
|---|---|---|---|
| Option 1 | Compensation | Ladybower Res (York Br) | 47 Ml/d |
| | | River Noe diversion | 10 Ml/d |
| Option 2 | Compensation | Ladybower Res (York Br) | 42 Ml/d |
| | | River Noe diversion | 15 Ml/d |

This is expected to improve the visual appearance of the River Noe as well as providing an additional salmonic fishery. The rewatered length of river would be 2km.

Enclosed is a copy of Severn Trent Water plc environmental assessment of the river Derwent, Drought Order which you will find helpful in relationship to the York Br compensation flows.

Note in all cases the compensation release will be for 365 days/annum.

# Appendix 6

# Rainworth Water

# Rainworth Water

| | | |
|---|---|---|
| Robert Thomas Farms | - | 01623 792239 |
| Mark Strawson | - | 01623 870421 |
| J W Parker & Sons | - | 01623 861074 |
| J Mawer | - | 01623 870953 |
| Jack Singleton<br>Bailiff at L Lake | - | 01623 796536 |
| Centre Parcs | | Anne Goodhead<br>01623 827400 |
| Notts County Council | | Roger Alderson<br>0115 982 3823 |
| Bilsthorpe Post Office | | 01623 870243 |
| Newark & Sherwood District Council | | 01636 605111 |
| L Lake | | Mrs Derbyshire<br>01623 490731 |

# General

| | | |
|---|---|---|
| **Ramblers Association** | - | **0171 582 6878** |
| **Countryside Commission** | - | **0171 831 3510** |
| **Office National Statistics** | - | **0171 233 9233** |
| **Halifax Building Society's Statistical Service** | | **01422 333 333** |
| **Talking Pages** | - | **0800 600 900** |

ENVIRONMENT AGENCY

**Rainworth Water**

English Nature identified 'L' Lake as a site of Wetland SSSI vulnerable to Licensed surface and Groundwater abstraction. It is thought that the lake itself is situated on perched groundwater, but the woodland adjacent to the outfall stream could be influenced by public water abstraction from groundwater.

It has therefore been identified as a site where trials will be undertaken within the AMP3 Log up period to investigate this section of watercourse. The options being considered for the trial are:-

Option 1. Review Licence 70/3, and see if it would be practical too reinstall a pump set at the existing borehole. This would provide a compensation release of either 1 or 2 Ml/d and this release would be triggered by flows upstream of the Rainworth Water confluence with the Gallows Hole Dyke.

Option 2. A new borehole upstream of 'L' Lake on the Northside Tributary, which will provide 1 or 2 Ml/d with the same triggers as Option 1.

Therefore there are 4 options to be considered

| | | |
|---|---|---|
| Option | 1a | 1Ml/d |
| | 1b | 2Ml/d |
| Option | 2a | 1Ml/d |
| | 2b | 2Ml/d |

After discussion with Area it was discussed that the trigger site would be just upstream of the Rainworth Water confluence with the Gallows Hole Dyke. This site will have to be calibrated but for the requirement of this benefit assent would you consider the compensation releases by trigger by two flow levels, Q20 and Q50. This will enable the sensitivity of this parameter to be reviewed. If it is imperative that you have a Duration/Frequency Graph, please let me know.

The length of watercourse which will benefit from the compensate release are:-

| | | |
|---|---|---|
| Option 1. | Rewater | 1.5 Km |
| | Increase flow | 8.5 Km |
| Option 2 | Rewater | 2.0 Km |
| | Increase flow | 8.5 Km |

g:\wordproc\grd\112.jr

# Appendix 7

# Battlefield Brook

# Battlerfield Brook

| | | |
|---|---|---|
| **Ramblers Association** | - | **0171 582 6878** |
| **Bromsgrove District Council** | - | **01527 873 232** |
| **Local Ramblers Contact** | - | **Mrs Woodbury 01527 873 441** |
| **Tourist Information**<br>**Bromsgrove** | - | **01527 831809** |
| **Environment Agency** | - | **Glenn Hoban 0121 711 2324**<br>**John Ratcliffe 0121 711 2324**<br>**Mike Averill 01562 863 887** |

# General

| | | |
|---|---|---|
| **Ramblers Association** | **-** | **0171 582 6878** |
| **Countryside Commission** | **-** | **0171 831 3510** |
| **Office National Statistics** | **-** | **0171 233 9233** |
| **Halifax Building Society's Statistical Service** | | **01422 333 333** |
| **Talking Pages** | **-** | **0800 600 900** |

## Battlefield Brook

Because of low flow within the Battlefield Brook, in 1992 the NRA (The Agency) set out to alleviate the problem downstream of Saunder Park (Bromsgrove). To enable this to be achieved the Agency had a new borehole drilled (NRG SO94807050) and installed a knife edge plate weir to monitor flow within the brook (Natural and borehole) (NGR SO95307070). This ensured that the watercourse from the borehole discharge to its confluence with the Spadesbourne Brook would base flow of 1.0 Ml/d. In practice this was not always achieved, the monitoring status Q95 is . Ml/d.

This scheme did not address low flow problems upstream of Saunders Park to Catshill and the Catshill Brook itself. The proposed next alleviation is to be undertaken of the Battlefield Brook but at present has not been developed to include the Catshill Brook.

The Options to be considered are:

1 To use existing Severn Trent Water plc borehole at Wildmoor (NGR SO958752) to provide 1 Ml/d compensation release.

2 To use existing Severn Trent Water plc borehole at Washingstocks (NGR SO960730) to provide 1 Ml/d compensation release.

Both the above would be triggered by the gauging station in Saunders Park, with the trigger flow being Q20 (3.6 Ml/d). For the benefit appraisals you should produce figures for Option 1, Option 2 and Option 1 + 2. To assist with the above enclosed are

A) Duration/Frequency Graph
B) Duration/Frequency Listing
C) Details produced by Howard Humphreys of low flow conditions on Battlefield Brook.

The lengths which will benefit from these compensation flows are:

| | | | |
|---|---|---|---|
| i) | Option 1 | rewatered 6Km | increased flow 6.2Km |
| ii) | Option 2 | rewatered 2.5Km | increased flow 6.2Km |
| iii) | Option 1+2 | rewatered 6Km | increased flow 6.2Km |

Although the benbcfits have been calculated to Saunders Park eg 6Km from Wildmoor borehole, it is considered that an additional length of the brook, down to Sugar Brook would be enhanced by these extra flows as well as providing dilution for the effluent from Bromsgrove (NGR SO95806820) which has a DWF of 9.9 Ml/d.

Output from HYDROLOG Data Management System V2.50(C) 1991-97 Hydro-Logic Ltd
Long Term Statistics Printed on 04/03/1998 at 11:40 hrs

E. A. Midlands - Headquarters Hydrometry

Auth. Ref. : 26004
Loc. Desc. :
Report Type : Duration/Frequency
Parameter : Flow
Units : Ml/d

Station Name : BATTLEFIELD BROOK
Catchment Ref.: US
Grid Ref. : SO954706
Gauge Zero : 0.000 MAOD
Catchment Area: 0.000 Sq Km

Period : 18/08/1992 to 09/07/1997 Start of Day : 09:00 GMT

Analysis period : Calendar Year

DAILY MEAN VALUE EXCEEDED STATED AMOUNT FOR GIVEN PERCENTAGE OF TIME

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0% | | 19.699 | 16.675 | 14.515 | 12.528 | 10.973 | 9.590 | 8.640 | 7.517 | 7.171 |
| 10% | 6.739 | 6.134 | 5.616 | 5.270 | 5.011 | 4.579 | 4.320 | 4.147 | 3.974 | 3.802 |
| 20% | 3.629 | 3.370 | 3.197 | 3.024 | 2.938 | 2.851 | 2.678 | 2.592 | 2.419 | 2.246 |
| 30% | 2.246 | 2.074 | 1.987 | 1.987 | 1.901 | 1.814 | 1.642 | 1.555 | 1.555 | 1.555 |
| 40% | 1.469 | 1.469 | 1.382 | 1.382 | 1.296 | 1.210 | 1.210 | 1.210 | 1.210 | 1.123 |
| 50% | 1.123 | 1.037 | 1.037 | 1.037 | 1.037 | 0.950 | 0.950 | 0.950 | 0.950 | 0.864 |
| 60% | 0.864 | 0.864 | 0.864 | 0.864 | 0.864 | 0.778 | 0.778 | 0.778 | 0.778 | 0.778 |
| 70% | 0.778 | 0.691 | 0.691 | 0.691 | 0.691 | 0.691 | 0.691 | 0.691 | 0.605 | 0.605 |
| 80% | 0.605 | 0.605 | 0.605 | 0.605 | 0.605 | 0.605 | 0.605 | 0.518 | 0.518 | 0.518 |
| 90% | 0.518 | 0.518 | 0.432 | 0.432 | 0.346 | 0.259 | 0.173 | 0.173 | 0.086 | 0.086 |

SUMMARY STATISTICS FOR ANALYSIS PERIOD

Maximum Daily Mean Value = 31.363
LTA Daily Mean (Lin Calc) = 2.634
LTA Daily Mean (Log Calc) = 1.407
Actual 95% Daily Mean = 0.259

Minimum Daily Mean Val. = 0.000
Median Daily Mean Value = 1.123
Log Standard Deviation = 1.075
Calc 95% Daily Mean = 0.240
(Log-Normal distribution assumed)

Number of values used = 1096
First year used = 1994
Last year used = 1996
Number of years used = 3 out of 3

Only complete calendar years of data used

## BATTLEFIELD BROOK
## LOW FLOW CONDITIONS

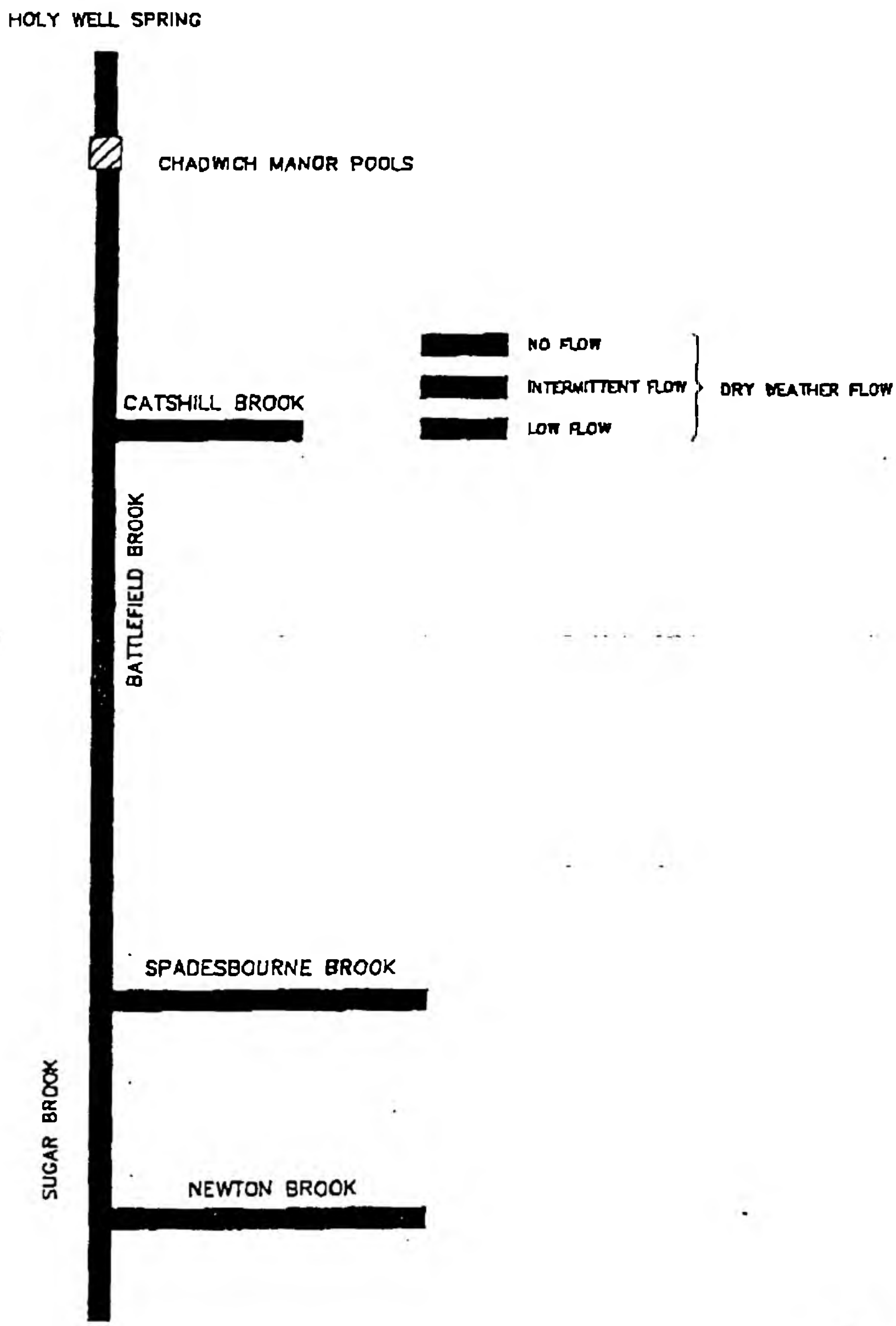
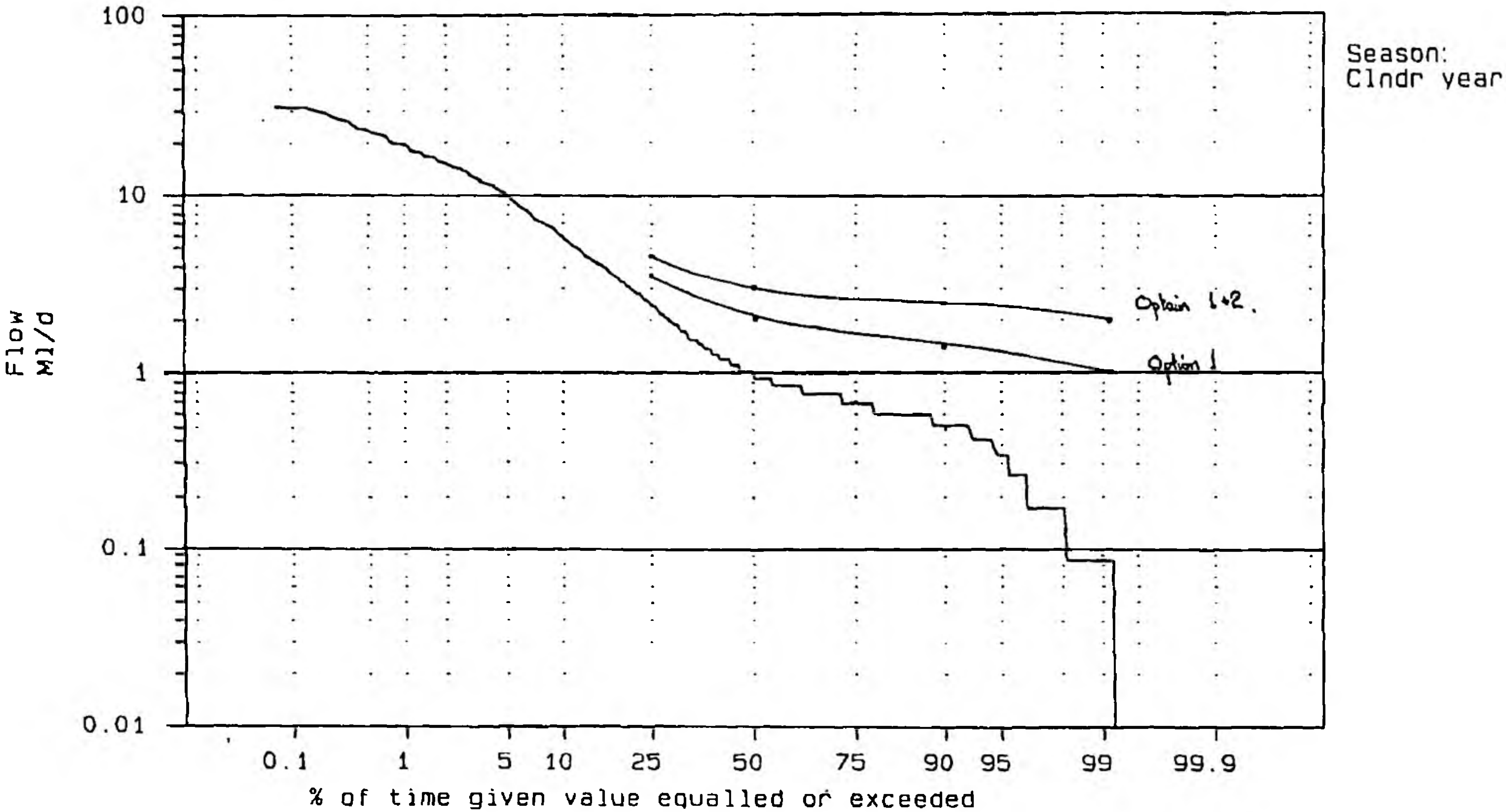



Figure 9

E. A. Midlands - Headquarters Hydrometry — Duration/Frequency Graph

| Auth.: 26004 | Name: BATTLEFIELD BROOK | Locat.: |
|---|---|---|

Period of Analysis : 1994 to 1997 (4 complete years used)



Output from HYDROLOG Data Management System V2.50(C) 1991-97 Hydro-Logic Ltd
Long Term Statistics Printed on 18/03/1998 at 09:57 hrs

E. A. Midlands - Headquarters Hydrometry

Auth. Ref. : 26004
Loc. Desc. :
Report Type : Duration/Frequency
Parameter : Flow
Units : Ml/d

Station Name : BATTLEFIELD BROOK
Catchment Ref.: US
Grid Ref. : SO954706
Gauge Zero : 0.000 MAOD
Catchment Area: 0.000 Sq Km

Period : 18/08/1992 to 19/02/1998 Start of Day : 09:00 GMT

Analysis period : Calendar Year

DAILY MEAN VALUE EXCEEDED STATED AMOUNT FOR GIVEN PERCENTAGE OF TIME

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0% | | 19.354 | 15.293 | 12.960 | 11.578 | 9.677 | 8.554 | 7.430 | 6.998 | 6.566 |
| 10% | 5.789 | 5.357 | 5.011 | 4.579 | 4.320 | 4.061 | 3.974 | 3.715 | 3.456 | 3.283 |
| 20% | 3.110 | 2.938 | 2.851 | 2.678 | 2.592 | 2.419 | 2.246 | 2.160 | 2.074 | 1.987 |
| 30% | 1.901 | 1.814 | 1.728 | 1.642 | 1.555 | 1.555 | 1.469 | 1.469 | 1.382 | 1.296 |
| 40% | 1.296 | 1.210 | 1.210 | 1.210 | 1.123 | 1.123 | 1.123 | 1.037 | 1.037 | 1.037 |
| 50% | 1.037 | 0.950 | 0.950 | 0.950 | 0.950 | 0.864 | 0.864 | 0.864 | 0.864 | 0.864 |
| 60% | 0.864 | 0.864 | 0.864 | 0.778 | 0.778 | 0.778 | 0.778 | 0.778 | 0.778 | 0.778 |
| 70% | 0.778 | 0.778 | 0.691 | 0.691 | 0.691 | 0.691 | 0.691 | 0.691 | 0.691 | 0.605 |
| 80% | 0.605 | 0.605 | 0.605 | 0.605 | 0.605 | 0.605 | 0.605 | 0.605 | 0.605 | 0.518 |
| 90% | 0.518 | 0.518 | 0.518 | 0.432 | 0.432 | 0.346 | 0.259 | 0.173 | 0.173 | 0.086 |

SUMMARY STATISTICS FOR ANALYSIS PERIOD

Maximum Daily Mean Value = 31.363
LTA Daily Mean (Lin Calc) = 2.415
LTA Daily Mean (Log Calc) = 1.335
Actual 95% Daily Mean = 0.346

Minimum Daily Mean Val. = 0.000
Median Daily Mean Value = 1.037
Log Standard Deviation = 1.010
Calc 95% Daily Mean = 0.254
(Log-Normal distribution assumed)

Number of values used = 1461
First year used = 1994
Last year used = 1997
Number of years used = 4 out of 4

Only complete calendar years of data used

E. A. Midlands - Headquarters Hydrometry

Auth. Ref. : 26005
Loc. Desc. : BROMSGROVE
Report Type : Daily Totals For Yr.
Parameter : Cum. Vol
Units : mm

Station Name : BATTLEFIELD BK B/H
Catchment Ref.: US
Grid Ref. : SO948705

Period : 1994

Start of Day : 09:00 GMT

| Day | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Day |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.217 | 0.218 | 0.218 | 0.220 | 0.223 | 0.220 | 0.000 | 1 |
| 2 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.223 | 0.219 | 0.218 | 0.220 | 0.223 | 0.221 | 0.000 | 2 |
| 3 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.222 | 0.219 | 0.218 | 0.221 | 0.222 | 0.221 | 0.000 | 3 |
| | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.222 | 0.219 | 0.219 | 0.220 | 0.222 | 0.221 | 0.000 | 4 |
| 5 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.221 | 0.219 | 0.219 | 0.220 | 0.222 | 0.221 | 0.000 | 5 |
| 6 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.221 | 0.219 | 0.219 | 0.220 | 0.222 | 0.221 | 0.000 | 6 |
| 7 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.221 | 0.219 | 0.219 | 0.220 | 0.222 | 0.220 | 0.000 | 7 |
| 8 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.221 | 0.219 | 0.219 | 0.220 | 0.222 | 0.220 | 0.000 | 8 |
| 9 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.221 | 0.219 | 0.219 | 0.220 | 0.221 | 0.015 | 0.000 | 9 |
| 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.221 | 0.219 | 0.201 | 0.219 | 0.221 | 0.000 | 0.000 | 10 |
| 11 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.221 | 0.219 | 0.015 | 0.220 | 0.221 | 0.000 | 0.000 | 11 |
| 12 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.221 | 0.219 | 0.220 | 0.219 | 0.221 | 0.000 | 0.000 | 12 |
| 13 | 0.000 | 0.000 | 0.000 | 0.000 | 0.183 | 0.221 | 0.219 | 0.219 | 0.219 | 0.221 | 0.000 | 0.000 | 13 |
| 14 | 0.000 | 0.000 | 0.000 | 0.000 | 0.223 | 0.221 | 0.219 | 0.219 | 0.035 | 0.221 | 0.000 | 0.000 | 14 |
| 15 | 0.000 | 0.000 | 0.000 | 0.000 | 0.223 | 0.221 | 0.219 | 0.219 | 0.000 | 0.221 | 0.000 | 0.000 | 15 |
| 16 | 0.000 | 0.000 | 0.000 | 0.000 | 0.223 | 0.221 | 0.219 | 0.219 | 0.000 | 0.221 | 0.000 | 0.000 | 16 |
| 17 | 0.000 | 0.000 | 0.000 | 0.000 | 0.223 | 0.220 | 0.219 | 0.220 | 0.000 | 0.221 | 0.000 | 0.000 | 17 |
| 18 | 0.000 | 0.000 | 0.000 | 0.000 | 0.222 | 0.220 | 0.219 | 0.220 | 0.000 | 0.221 | 0.000 | 0.000 | 18 |
| 19 | 0.000 | 0.000 | 0.000 | 0.000 | 0.222 | 0.220 | 0.211 | 0.220 | 0.000 | 0.221 | 0.000 | 0.000 | 19 |
| 20 | 0.000 | 0.000 | 0.000 | 0.000 | 0.223 | 0.220 | 0.000 | 0.220 | 0.000 | 0.221 | 0.000 | 0.000 | 20 |
| 21 | 0.000 | 0.000 | 0.000 | 0.000 | 0.223 | 0.220 | 0.004 | 0.220 | 0.000 | 0.221 | 0.000 | 0.000 | 21 |
| 22 | 0.000 | 0.000 | 0.000 | 0.000 | 0.223 | 0.220 | 0.218 | 0.220 | 0.000 | 0.221 | 0.000 | 0.000 | 22 |
| 23 | 0.000 | 0.000 | 0.000 | 0.000 | 0.223 | 0.220 | 0.217 | 0.220 | 0.000 | 0.221 | 0.000 | 0.000 | 23 |
| 24 | 0.000 | 0.000 | 0.000 | 0.000 | 0.223 | 0.220 | 0.217 | 0.220 | 0.000 | 0.220 | 0.000 | 0.000 | 24 |
| 25 | 0.000 | 0.000 | 0.000 | 0.000 | 0.022 | 0.220 | 0.217 | 0.220 | 0.000 | 0.221 | 0.000 | 0.000 | 25 |
| 26 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.220 | 0.216 | 0.220 | 0.000 | 0.221 | 0.000 | 0.000 | 26 |
| 27 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.219 | 0.216 | 0.220 | 0.000 | 0.221 | 0.000 | 0.000 | 27 |
| 28 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.219 | 0.217 | 0.220 | 0.000 | 0.221 | 0.000 | 0.000 | 28 |
| 29 | 0.000 | | 0.000 | 0.000 | 0.000 | 0.219 | 0.217 | 0.220 | 0.000 | 0.221 | 0.000 | 0.000 | 29 |
| 30 | 0.000 | | 0.000 | 0.000 | 0.000 | 0.219 | 0.218 | 0.220 | 0.174 | 0.221 | 0.000 | 0.000 | 30 |
| 31 | 0.000 | | 0.000 | | 0.000 | | 0.218 | 0.220 | | 0.221 | | 0.000 | 31 |
| Mean | 0.000 | 0.000 | 0.000 | 0.000 | 0.086 | 0.220 | 0.204 | 0.212 | 0.102 | 0.221 | 0.059 | 0.000 | |
| Maximum | 0.000 | 0.000 | 0.000 | 0.000 | 0.223 | 0.223 | 0.219 | 0.220 | 0.221 | 0.223 | 0.221 | 0.000 | |
| Day of Max. | 1 | 1 | 1 | 1 | 14 | 2 | 10 | 20 | 3 | 1 | 3 | 1 | |
| Min | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.217 | 0.000 | 0.015 | 0.000 | 0.220 | 0.000 | 0.000 | |
| Day of Min. | 1 | 1 | 1 | 1 | 1 | 1 | 20 | 11 | 15 | 24 | 10 | 1 | |
| Total | 0.000 | 0.000 | 0.000 | 0.000 | 2.654 | 6.612 | 6.323 | 6.583 | 3.067 | 6.860 | 1.779 | 0.000 | |

Above summary is for Daily Totals of Cum. Vol
Data Codes : E - Edited ? - Suspect U - Unchecked M - Missing

E. A. Midlands - Headquarters Hydrometry

Auth. Ref. : 26005
Loc. Desc. : BROMSGROVE
Report Type : Daily Totals For Yr.
Parameter : Cum. Vol.
Units : mm

Station Name : BATTLEFIELD BK B/H
Catchment Ref. : US
Grid Ref. : SO948705

Period : 1996

Start of Day : 09:00 GMT

| Day | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Day |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.000 | 0.000 | 0.000 | 0.278 | 0.274 | 0.276 | 0.271 | 0.267 | 0.270 | 0.272 | 0.000 | 0.000 | 1 |
| 2 | 0.000 | 0.000 | 0.000 | 0.276 | 0.274 | 0.276 | 0.271 | 0.268 | 0.270 | 0.260 | 0.000 | 0.000 | 2 |
| 3 | 0.000 | 0.000 | 0.000 | 0.275 | 0.274 | 0.276 | 0.272 | 0.268 | 0.270 | 0.270 | 0.000 | 0.000 | 3 |
| | 0.000 | 0.000 | 0.000 | 0.275 | 0.275 | 0.275 | 0.272 | 0.269 | 0.270 | 0.268 | 0.000 | 0.000 | 4 |
| 5 | 0.000 | 0.000 | 0.000 | 0.274 | 0.275 | 0.275 | 0.261 | 0.269 | 0.270 | 0.267 | 0.000 | 0.000 | 5 |
| 6 | 0.000 | 0.000 | 0.000 | 0.274 | 0.275 | 0.275 | 0.272 | 0.268 | 0.258 | 0.267 | 0.000 | 0.000 | 6 |
| 7 | 0.000 | 0.000 | 0.000 | 0.274 | 0.276 | 0.130 | 0.272 | 0.268 | 0.269 | 0.266 | 0.000 | 0.000 | 7 |
| 8 | 0.000 | 0.000 | 0.000 | 0.274 | 0.275 | 0.000 | 0.271 | 0.269 | 0.269 | 0.266 | 0.000 | 0.000 | 8 |
| 9 | 0.000 | 0.000 | 0.000 | 0.274 | 0.275 | 0.000 | 0.271 | 0.258 | 0.269 | 0.267 | 0.000 | 0.000 | 9 |
| 10 | 0.000 | 0.000 | 0.000 | 0.274 | 0.275 | 0.000 | 0.271 | 0.270 | 0.268 | 0.267 | 0.000 | 0.000 | 10 |
| 11 | 0.000 | 0.000 | 0.000 | 0.274 | 0.275 | 0.000 | 0.271 | 0.270 | 0.268 | 0.267 | 0.000 | 0.000 | 11 |
| 12 | 0.000 | 0.000 | 0.000 | 0.274 | 0.274 | 0.187 | 0.270 | 0.270 | 0.268 | 0.267 | 0.000 | 0.000 | 12 |
| 13 | 0.000 | 0.000 | 0.000 | 0.273 | 0.274 | 0.276 | 0.270 | 0.270 | 0.268 | 0.267 | 0.000 | 0.000 | 13 |
| 14 | 0.000 | 0.000 | 0.000 | 0.274 | 0.274 | 0.275 | 0.269 | 0.270 | 0.268 | 0.267 | 0.000 | 0.000 | 14 |
| 15 | 0.000 | 0.000 | 0.000 | 0.274 | 0.274 | 0.274 | 0.269 | 0.270 | 0.268 | 0.267 | 0.000 | 0.000 | 15 |
| 16 | 0.000 | 0.000 | 0.000 | 0.274 | 0.274 | 0.274 | 0.269 | 0.270 | 0.267 | 0.267 | 0.000 | 0.000 | 16 |
| 17 | 0.000 | 0.000 | 0.000 | 0.274 | 0.274 | 0.273 | 0.268 | 0.270 | 0.256 | 0.256 | 0.000 | 0.000 | 17 |
| 18 | 0.000 | 0.000 | 0.000 | 0.274 | 0.274 | 0.273 | 0.268 | 0.270 | 0.267 | 0.266 | 0.000 | 0.000 | 18 |
| 19 | 0.000 | 0.000 | 0.000 | 0.274 | 0.275 | 0.273 | 0.268 | 0.269 | 0.189 | 0.266 | 0.000 | 0.000 | 19 |
| 20 | 0.000 | 0.000 | 0.000 | 0.274 | 0.275 | 0.272 | 0.268 | 0.268 | 0.111 | 0.266 | 0.000 | 0.000 | 20 |
| 21 | 0.000 | 0.000 | 0.000 | 0.274 | 0.275 | 0.272 | 0.267 | 0.268 | 0.266 | 0.266 | 0.000 | 0.000 | 21 |
| 22 | 0.000 | 0.000 | 0.000 | 0.273 | 0.275 | 0.271 | 0.267 | 0.268 | 0.276 | 0.268 | 0.000 | 0.000 | 22 |
| | 0.000 | 0.000 | 0.000 | 0.273 | 0.276 | 0.271 | 0.267 | 0.268 | 0.266 | 0.267 | 0.000 | 0.000 | 23 |
| 24 | 0.000 | 0.000 | 0.000 | 0.273 | 0.276 | 0.271 | 0.266 | 0.268 | 0.267 | 0.267 | 0.000 | 0.000 | 24 |
| 25 | 0.000 | 0.000 | 0.000 | 0.273 | 0.275 | 0.271 | 0.266 | 0.268 | 0.268 | 0.267 | 0.000 | 0.000 | 25 |
| 26 | 0.000 | 0.000 | 0.000 | 0.273 | 0.276 | 0.271 | 0.267 | 0.269 | 0.269 | 0.266 | 0.000 | 0.000 | 26 |
| 27 | 0.000 | 0.000 | 0.000 | 0.273 | 0.276 | 0.271 | 0.267 | 0.269 | 0.139 | 0.266 | 0.000 | 0.000 | 27 |
| 28 | 0.000 | 0.000 | 0.000 | 0.273 | 0.277 | 0.270 | 0.267 | 0.269 | 0.000 | 0.092 | 0.000 | 0.000 | 28 |
| 29 | 0.000 | 0.000 | 0.000 | 0.274 | 0.254M | 0.271 | 0.267 | 0.270 | 0.000 | 0.000 | 0.000 | 0.000 | 29 |
| 30 | 0.000 | | 0.000 | 0.273 | 0.277 | 0.271 | 0.268 | 0.270 | 0.250 | 0.237 | 0.000 | 0.000 | 30 |
| 31 | 0.000 | | 0.016 | | 0.277 | | 0.267 | 0.270 | | 0.034M | | 0.000 | 31 |
| Mean | 0.000 | 0.000 | 0.001 | 0.274 | 0.274 | 0.229 | 0.269 | 0.269 | 0.237 | 0.244 | 0.000 | 0.000 | |
| Maximum | 0.000 | 0.000 | 0.016 | 0.278 | 0.277 | 0.276 | 0.272 | 0.270 | 0.276 | 0.272 | 0.000 | 0.000 | |
| Day of Max. | 1 | 1 | 31 | 1 | 30 | 13 | 6 | 14 | 22 | 1 | 1 | 1 | |
| Min | 0.000 | 0.000 | 0.000 | 0.273 | 0.254 | 0.000 | 0.261 | 0.258 | 0.000 | 0.000 | 0.000 | 0.000 | |
| Day of Min. | 1 | 1 | 1 | 24 | 29 | 8 | 5 | 9 | 28 | 29 | 1 | 1 | |
| Total | 0.000 | 0.000 | 0.016 | 8.216 | 8.504 | 6.869 | 8.329 | 8.327 | 7.112 | 7.556 | 0.000 | 0.000 | |

Above summary is for Daily Totals of Cum. Vol

Data Codes : E - Edited ? - Suspect U - Unchecked M - Missing

E. A. Midlands - Headquarters Hydrometry

Auth. Ref. : 26005
Loc. Desc. : BROMSGROVE
Report Type : Daily Totals For Yr.
Parameter : Cum. Vol
Units : mm

Station Name : BATTLEFIELD BK B/H
Catchment Ref.: US
Grid Ref. : SO948705

Period : 1998

Start of Day : 09:00 GMT

| Day | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Day |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.195 | 0.201 | | | | | | | | | | | 1 |
| 2 | 0.196 | 0.200 | | | | | | | | | | | 2 |
| 3 | 0.196 | 0.200 | | | | | | | | | | | 3 |
| | 0.196 | 0.200 | | | | | | | | | | | 4 |
| 5 | 0.196 | 0.200 | | | | | | | | | | | 5 |
| 6 | 0.196 | 0.187M | | | | | | | | | | | 6 |
| 7 | 0.197 | 0.200 | | | | | | | | | | | 7 |
| 8 | 0.197 | 0.199 | | | | | | | | | | | 8 |
| 9 | 0.075 | 0.199 | | | | | | | | | | | 9 |
| 10 | 0.000 | 0.199 | | | | | | | | | | | 10 |
| 11 | 0.000 | 0.199 | | | | | | | | | | | 11 |
| 12 | 0.000 | 0.200 | | | | | | | | | | | 12 |
| 13 | 0.000 | 0.200 | | | | | | | | | | | 13 |
| 14 | 0.000 | 0.200 | | | | | | | | | | | 14 |
| 15 | 0.000 | 0.199 | | | | | | | | | | | 15 |
| 16 | 0.000 | 0.198 | | | | | | | | | | | 16 |
| 17 | 0.000 | 0.198 | | | | | | | | | | | 17 |
| 18 | 0.000 | 0.199 | | | | | | | | | | | 18 |
| 19 | 0.000 | 0.200 | | | | | | | | | | | 19 |
| 20 | 0.000 | 0.038M | | | | | | | | | | | 20 |
| 21 | 0.000M | | | | | | | | | | | | 21 |
| 22 | 0.000 | | | | | | | | | | | | 22 |
| 23 | 0.000 | | | | | | | | | | | | 23 |
| 24 | 0.000 | | | | | | | | | | | | 24 |
| 25 | 0.000 | | | | | | | | | | | | 25 |
| 26 | 0.000 | | | | | | | | | | | | 26 |
| 27 | 0.000 | | | | | | | | | | | | 27 |
| 28 | 0.000 | | | | | | | | | | | | 28 |
| 29 | 0.139 | | | | | | | | | | | | 29 |
| 30 | 0.202 | | | | | | | | | | | | 30 |
| 31 | 0.201 | | | | | | | | | | | | 31 |
| Mean | 0.071 | 0.191 | | | | | | | | | | | |
| Maximum | 0.202 | 0.201 | | | | | | | | | | | |
| Day of Max. | 30 | 1 | | | | | | | | | | | |
| Min | 0.000 | 0.038 | | | | | | | | | | | |
| Day of Min. | 10 | 20 | | | | | | | | | | | |
| Total | 2.186 | 3.815 | | | | | | | | | | | |

Above summary is for Daily Totals of Cum. Vol

Data Codes : E - Edited ? - Suspect U - Unchecked M - Missing

# Appendix 8

# Blakedown Brook

## Blakedown Brook

| | | |
|---|---|---|
| Wyre Forest District Council | - | 01562 751503 |
| Mal Storey Tackle | - | Brakemill Pool 01562 745 221 |
| Mrs Ling | - | Stakenbridge Pool 0121 678 8257 |
| Mr Haywood | - | Churchill Forge Pool 01562 700 476 |
| Mr Wilcox | - | Hurcott Pool 01562 754 809 |
| Mr Tolly | - | Podmore Pool 01562 515 619 |
| Ramblers Association Local Representative | - | Mr Baston 01562 741 322 |
| Hereford and Worcester Countryside Secretary | - | Mr Coleman 01527 877 471 |
| Meg Payne, Walk Organiser | - | 01562 68971 |
| Mr and Mrs Pilborough, Childrens Walk Organiser | - | 01562 700719 |
| Hagley Library | - | 01562 883441 |
| Environment Agency | - | Rick North 01743 272 828<br>Mike Averill 01562 863 887<br>John Ratcliffe 0121 711 2324<br>Glenn Hoban 0121 711 2324 |

## General

| | | |
|---|---|---|
| Ramblers Association | - | 0171 582 6878 |
| Countryside Commission | - | 0171 831 3510 |
| Office National Statistics | - | 0171 233 9233 |
| Halifax Building Society's Statistical Service | | 01422 333 333 |
| Talking Pages | - | 0800 600 900 |

**Blakedown Brook**

For sometime the Agency has been involved in trying to alleviate low flow problems which had occurred on the Blakedown Brook and its tributaries. This has resulted in two schemes being commissioned to solve the short term requirements on two of the tributaries.

1. A borehole to supplement flows into and maintain levels in the Ladies, Forge and Swans Pools.

2 Similarly a borehole is supplementing flow into and maintaining levels in the Coopers, Harborough and Pavillion Pools.

These boreholes are operated by the Agency and are triggered by pool levels, but will not provide in flow to the mainline Blakedown Brook.

The mainline brook has two SSSI towards the lower reaches of the brook at Podmore and Hurcott Pools. There is a requirement to provide an inflow to those pools to maintain the SSSI. At present no actual flow requirement has been quantified for these SSSIs but it has been decided that a trial flow review will be implemented before the Year 2000 to estimate what improvements can be achieved. This has further complications because the existing waste treatment works operated in Severn Trent Water plc at Hagley and Blakedown may be closed and then effluent will be transferred out of the catchment. After discussion with Severn Trent Water plc it has been agreed that:

A) The Hagley effluent will be exported to Roundhill WTW for treatment and then returned to the Blakedown Brook.

B) The works at Blakedown will be upgraded.

In addition to returning the Hagley effluent (1.5 Ml/d) the return pipeline will have a capacity of 3.0 Ml/d. This capacity will be available to supplement the inflow to Blakedown Brook from Roundhill WTWs.

Therefore the options which are to be considered are:

1 Roundhilll returned and additional effluent of 3.0 Ml/d.

2 The main Public Works abstraction for the mainline Blakedown Brook is via boreholes operated by South Staffs Water. They have agreed to reduce their abstraction from these boreholes, and to provide a compensation release into the Blakedown Brook either from an existing borehole or from a purpose drill new borehole. The trial flow is to be 2.0 Ml/d.

3 The only major pool which has not been reinstated is Windmill Pool situated on a tributary of the Blakedown Brook upstream of Pavilion Pool. The option to be considered for this pool is a new borehole to provide 1.0 Ml/d inflow to the pool. The volume to which this pool will be maintained has not yet been investigated, but for the benefit assessment it must be considered to be similar to its original capacity. This can only be estimated for contours on the OS Map. It is expected that no outflow will

occur from the pool, and that the pump at the new borehole will be in operation for at least 80% of the time.

At present we have no duration/frequency graphs for the mainline of the Blakedown Brook. Spot gauging runs are being undertaken on a monthly timescale, and a site ajacent to the upstream end of Hurcott Pool which is part of the existing current meter schedule is to have a level recorder (Logger) installed before the Summer of 1998. For the purpose of this investigation it should be noted that the Hagley returned effluent will be in operation 365 days per year (Option 1) and that Option 2 will be in operation for 80% of the time. Could you please produce benefits for Option 1, Option 1+2, Option 3 and Option 1+2+3. In respect of lengths to be affected by this additional flow, for Option 1 and 2 there will be no lengths rewatered but 6Km with substanial increase in flow. It must be emphasised that at present the inflow to Hurcott and Podmore Pools can be very close to zero and that the investigated options will very much increase these flows (see enclosed spot gauging listing).

J Ratcliffe
12 March 1998

## BLAKEDOWN BROOK

| SITE | NGR | 29-Sep-97 | 22-Jul-97 | 09-Apr-97 | 09-Sep-96 | 25-Jul-96 | 25-Jun-96 | 13-May-96 | 22-Aug-95 | 25- |
|---|---|---|---|---|---|---|---|---|---|---|
| NORTON STW DISCHARGE | SO90408128 | 0.035 | 0.052 | 0.023 | 0.084 | 0.153 | 0.051 | 0.243 | | 1.5 |
| HAGLEY U/S WRW | SO89837999 | 1.866 | 0.892 | 0.526 | 0.224 | 0.124 | 0.201 | 0.452 | 0.612 | 1.3 |
| HAGLEY D/S WRW | SO8987790 | 2.998 | 1.132 | 3.225 | 1.371 | 0.860 | 0.835 | 1.478 | 1.645 | 2.0 |
| INPUT FROM HAGLEY WRW | | 1.132 | 0.240 | 2.899 | 1.147 | 0.736 | 0.634 | 1.026 | 1.032 | 0.7 |
| CLENT BROOK OUTFLOW | SO89687985 | | 0.052 | 0.135 | 0.015 | 0.009 | 0.072 | 0.443 | 0.298 | 0.0 |
| CHURCHILL | SO88107950 | 2.039 | 1.980 | 0.472 | 0.691 | 0.337 | 0.449 | 1.564 | 1.653 | 0.7 |
| BROOME(100 ACRE FARM | SO89707850 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | | | |
| FORGE POOL U/S | SO88507780 | 0.052 | 0.010/0.160 | | 0.009 | 0.035 | 0.060 | | | |
| COOPERS POOL D/S | SO87907890 | 0.017 | 0.020 | 0.041 | 0.017 | 0.009 | 0.017 | | | |
| BLAKEDOWN D/S HARBOR | SO88407880 | 0.009 | 0.008 | 0.000 | 0.008 | | 0.009 | | 0.060 | 0.0 |
| SWAN POOL D/S | SO87607830 | 0.052 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | |
| BLAKEDOWN U/S WTW | SO87207820 | 2.488 | 1.110 | 1.088 | 0.829 | 0.415 | 0.778 | 1.578 | 1.841 | 0.7 |
| BLAKEDOWN D/S WTW | SO86507810 | 2.100 | 1.190 | 1.101 | 1.028 | 0.406 | 0.994 | 2.100 | 2.111 | 0.7 |
| INPUT FROM BLAKEDOWN WRW | | -0.388 | 0.080 | 0.013 | 0.199 | -0.009 | 0.216 | 0.522 | 0.270 | 0.0 |
| HURCOTT POOL D/S(MAIN) | SO85007792 | 0.829 | 0.470 | 0.000 | 0.000 | 0.000 | 0.207 | 0.000 | 1.205 | 0.0 |
| HURCOTT POOL D/S(SMALL) | SO85007788 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.463 | 0.( |
| SUMMATION HURCOTT POOLS | | 0.829 | 0.470 | 0.000 | 0.000 | 0.000 | 0.207 | 0.000 | 1.668 | 0.( |
| BROADWATERS | SO83907790 | 1.080 | 0.350 | 0.558 | 0.259 | 0.432 | 0.528 | | 2.115 | 0.: |

30/03/98

| 16-Jun-95 | 23-May-95 | 28-Apr-95 | 12-Oct-94 | 09-Aug-94 | 22-Jul-94 | 17-Jun-94 | 20-Apr-94 | 29-Sep-93 | 07-Sep-93 | 26-Aug-93 | 10-Aug-93 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.312 | 0.214 | 0.678 | 0.597 | | | | | | | | |
| 0.709 | 0.557 | 1.537 | | | | | | 0.147 | 0.078 | 0.225 | 0.890 |
| 1.693 | 1.596 | 2.911 | | | | | | 1.192 | 0.301 | 0.985 | 1.633 |
| 0.984 | 1.039 | 1.574 | | | | | | 1.045 | 0.224 | 0.760 | 0.743 |
| 0.332 | 0.289 | 0.555 | | | | | | | | | |
| 1.218 | 1.605 | 2.775 | 1.166 | 0.596 | 0.520 | 0.596 | 2.419 | 0.829 | 0.527 | 0.527 | 1.045 |
| | | | 0.000 | 0.000 | 0.000 | 0.060 | 0.173 | | | | |
| | | | 0.000 | 0.000 | 0.328 | 0.000 | 0.562 | | | | |
| | | | 0.104 | 0.060 | 0.026 | 0.000 | | 0.052 | | 0.035 | 0.000 |
| 0.000 | 0.000 | 0.000 | | | | | | 0.778 | | 0.527 | |
| 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | | | | |
| 1.760 | 1.760 | 2.278 | 1.184 | 0.907 | 0.346 | 1.210 | 2.989 | 0.804 | 0.501 | 0.579 | 0.968 |
| 1.618 | 0.000 | 2.798 | 1.495 | 1.089 | 0.320 | 1.426 | 3.231 | 0.899 | 0.734 | 0.821 | 1.477 |
| -0.142 | -1.760 | 0.520 | 0.311 | 0.182 | -0.026 | 0.216 | 0.242 | 0.093 | 0.233 | 0.242 | 0.509 |
| 0.860 | 1.169 | 0.804 | 0.000 | 0.000 | 0.000 | 0.181 | 1.401 | | | | |
| 0.213 | 0.450 | 0.396 | | | | | | | | | |
| 1.073 | 1.619 | 1.200 | | | | | | | | | |
| 1.462 | 2.052 | 1.908 | 0.337 | 0.276 | 0.294 | 0.665 | 2.212 | 0.294 | 0.259 | 0.294 | 0.285 |

## BLAKEDOWN BROOK

| SITE | NGR | 29-Sep-97 | 22-Jul-97 | 09-Apr-97 | 09-Sep-96 | 23-Jul-96 | 25-Jun-96 | 13-May-96 | 22-Aug-95 | 23-Jul-95 | 16-Jun-95 | 23-May-95 | 28-Apr-95 | 12-Oct-94 | 09-Aug- |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NORTON STW DISCHARGE | SO90408128 | 0.035 | 0.032 | 0.023 | 0.084 | 0.133 | 0.031 | 0.243 | | 1.337 | 0.312 | 0.214 | 0.678 | 0.397 | |
| HAGLEY U/S WRW | SO89837999 | 1.866 | 0.892 | 0.326 | 0.224 | 0.124 | 0.201 | 0.452 | 0.612 | 1.334 | 0.709 | 0.557 | 1.337 | | |
| HAGLEY D/S WRW | SO8987790 | 2.998 | 1.132 | 3.225 | 1.371 | 0.860 | 0.835 | 1.478 | 1.645 | 2.060 | 1.693 | 1.596 | 2.911 | | |
| INPUT FROM HAGLEY WRW | | 1.132 | 0.240 | 2.899 | 1.147 | 0.736 | 0.634 | 1.026 | 1.033 | 0.706 | 0.984 | 1.039 | 1.574 | | |
| CLENT BROOK OUTFLOW | SO89687983 | | 0.032 | 0.133 | 0.015 | 0.009 | 0.072 | 0.443 | 0.298 | 0.032 | 0.332 | 0.289 | 0.535 | | |
| CHURCHILL | SO88107950 | 2.039 | 1.980 | 0.472 | 0.691 | 0.337 | 0.449 | 1.364 | 1.653 | 0.739 | 1.218 | 1.603 | 2.773 | 1.166 | 0.596 |
| BROOME(100 ACRE FARM | SO89707850 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | | | | | | | 0.000 | 0.000 |
| FORGE POOL U/S | SO88507780 | 0.032 | 0.010/0.160 | | 0.009 | 0.033 | 0.060 | | | | | | | 0.000 | 0.000 |
| COOPERS POOL D/S | SO87907890 | 0.017 | 0.020 | 0.041 | 0.017 | 0.009 | 0.017 | | | | | | | 0.104 | 0.060 |
| BLAKEDOWN D/S HARBOR | SO88407880 | 0.009 | 0.008 | 0.000 | 0.008 | | 0.009 | | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | | |
| SWAN POOL D/S | SO87607830 | 0.052 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| BLAKEDOWN U/S WTW | SO87207820 | 2.488 | 1.110 | 1.088 | 0.829 | 0.415 | 0.770 | 1.578 | 1.841 | 0.742 | 1.760 | 1.760 | 2.278 | 1.164 | 0.907 |
| BLAKEDOWN D/S WTW | SO86307810 | 2.100 | 1.190 | 1.101 | 1.028 | 0.406 | 0.994 | 2.100 | 2.111 | 0.781 | 1.618 | 0.000 | 2.798 | 1.495 | 1.089 |
| INPUT FROM BLAKEDOWN WRW | | -0.388 | 0.080 | 0.013 | 0.199 | -0.009 | 0.216 | 0.522 | 0.270 | 0.039 | -0.142 | -1.760 | 0.520 | 0.311 | 0.182 |
| HURCOTT POOL D/S(MAIN) | SO85007792 | 0.829 | 0.470 | 0.000 | 0.000 | 0.000 | 0.207 | 0.000 | 1.205 | 0.000 | 0.860 | 1.189 | 0.804 | 0.000 | 0.000 |
| HURCOTT POOL D/S(SMALL) | SO85007788 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.463 | 0.000 | 0.213 | 0.430 | 0.396 | | |
| SUMMATION HURCOTT POOLS | | 0.829 | 0.470 | 0.000 | 0.000 | 0.000 | 0.207 | 0.000 | 1.668 | 0.000 | 1.073 | 1.619 | 1.200 | | |
| BROADWATERS | SO83907790 | 1.080 | 0.330 | 0.338 | 0.239 | 0.432 | 0.328 | | 2.115 | 0.334 | 1.462 | 2.032 | 1.908 | 0.337 | 0.276 |

# Appendix 9

# Bow Brook

## Bow Brook

| | | |
|---|---|---|
| Hereford and Worcester County Council | - | 01432 272 395 |
| Wyehaven District Council | - | 01386 565 373 |
| Environment Agency | - | John Ratcliffe 0121 711 2324 |
| | - | Glenn Hoban 0121 711 2324 |
| | - | Anne Penny 01684 850 951 |
| | - | Anne Hardcastle |
| Mr Farquar, Norgrove Court | - | 01527 544 850 |
| Mr Derrington, Worcester and District Angling Club | - | 01527 871 291 |
| Upper Wolverton Farm | - | 01905 345 254 |
| Redditch Tourist Information | - | 01527 60806 |
| Ramblers Association Local Representative Mrs J Mackey | - | 0121 749 4760 |
| Mrs P Hammond | - | 0121 704 9399 |

## General

| | | |
|---|---|---|
| **Ramblers Association** | - | **0171 582 6878** |
| **Countryside Commission** | - | **0171 831 3510** |
| **Office National Statistics** | - | **0171 233 9233** |
| **Halifax Building Society's Statistical Service** | | **01422 333 333** |
| **Talking Pages** | - | **0800 600 900** |

## BOW BROOK

During the late eighties, problems with low flow were identified on the upper reaches of the brook (mainly above Priest bridge). This was due to two main reasons:

1 The closure of small sewage treatment works on the Bow Brook Tributaries.

2 Reduction in base flow due to pumping of water for public consumption.

A study was undertaken, with the conclusion that a compensation release was required to make up the deficit from the above of 2 Ml/d. This has been agree with Severn Trent Water plc and is the only option being considered.

However, so that the amount abstracted can be considered, would you please incorporate two options in your benefit assessment.

A A compensation release at Webheath (SP 0080 6693) of 2 Ml/d to be in operation when the Agency gauging station at Besford bridge is at Q 20% (105 Ml/d) or below.

B As above but using Q 50% (33.5 Ml/d) or below as the trigger flow.

Enclosed are copies of:

A Duration/Frequency Graph - Besford Bridge 1976-1997.

B Derived Duration/Frequency Graph for Old Yarr Bridge.

Both of these show actual figures and modified to show the compensation release.

C Mean daily flow 1990 to 1997

D Mean daily flow against time 1990-1997.

The following length of water course will be improved by the following -

rewatered 2.6 Km, significant increase in flow 32 Km.

Note: 1 Water Quality Questions are being looked at by Dawn McGinn, who will be letting me have her comments within the next few days on the affect this extra water will have on GQAs etc.

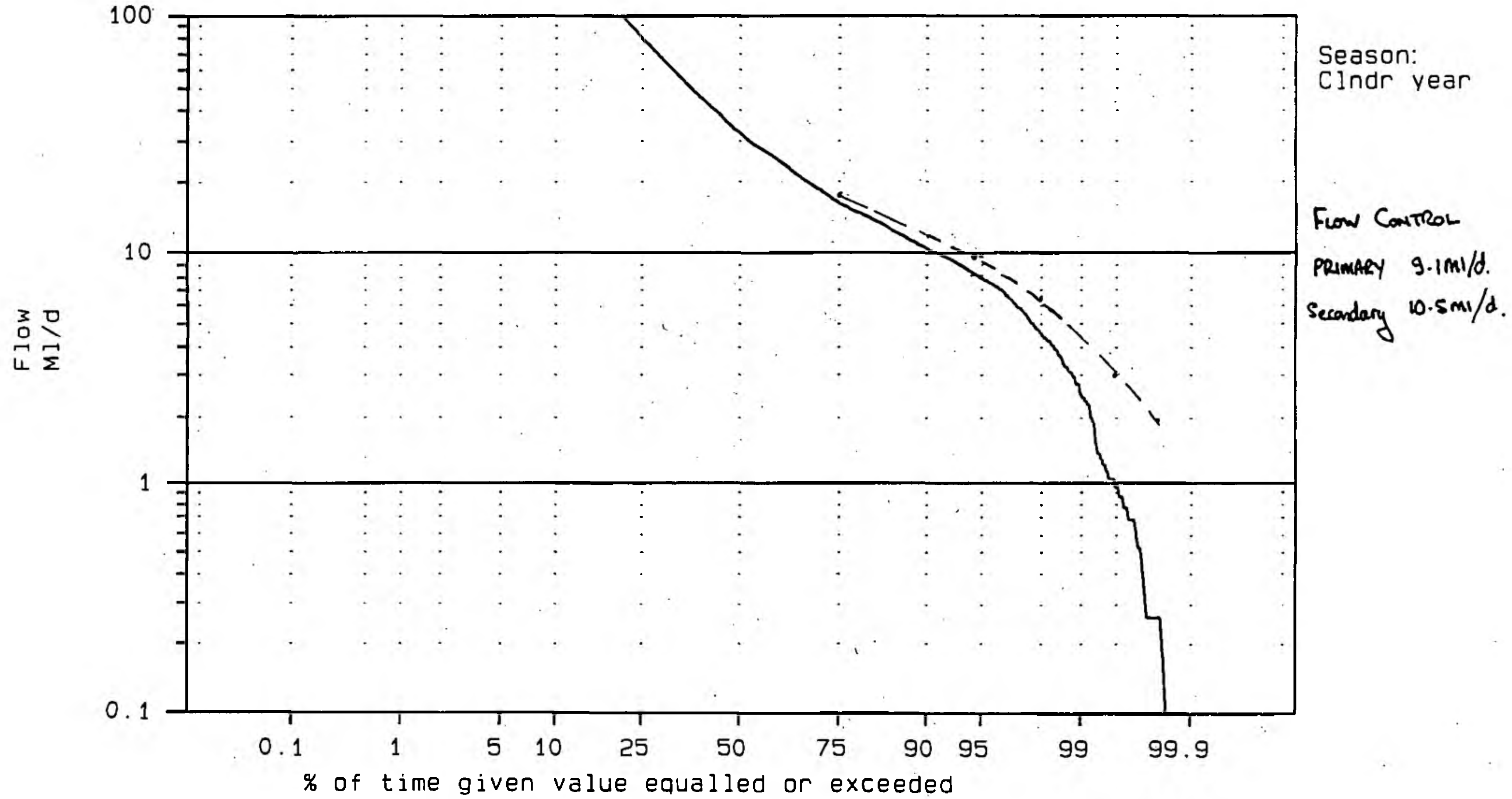
2 We are at present still trying to locate Atkins report on the Bow Brook

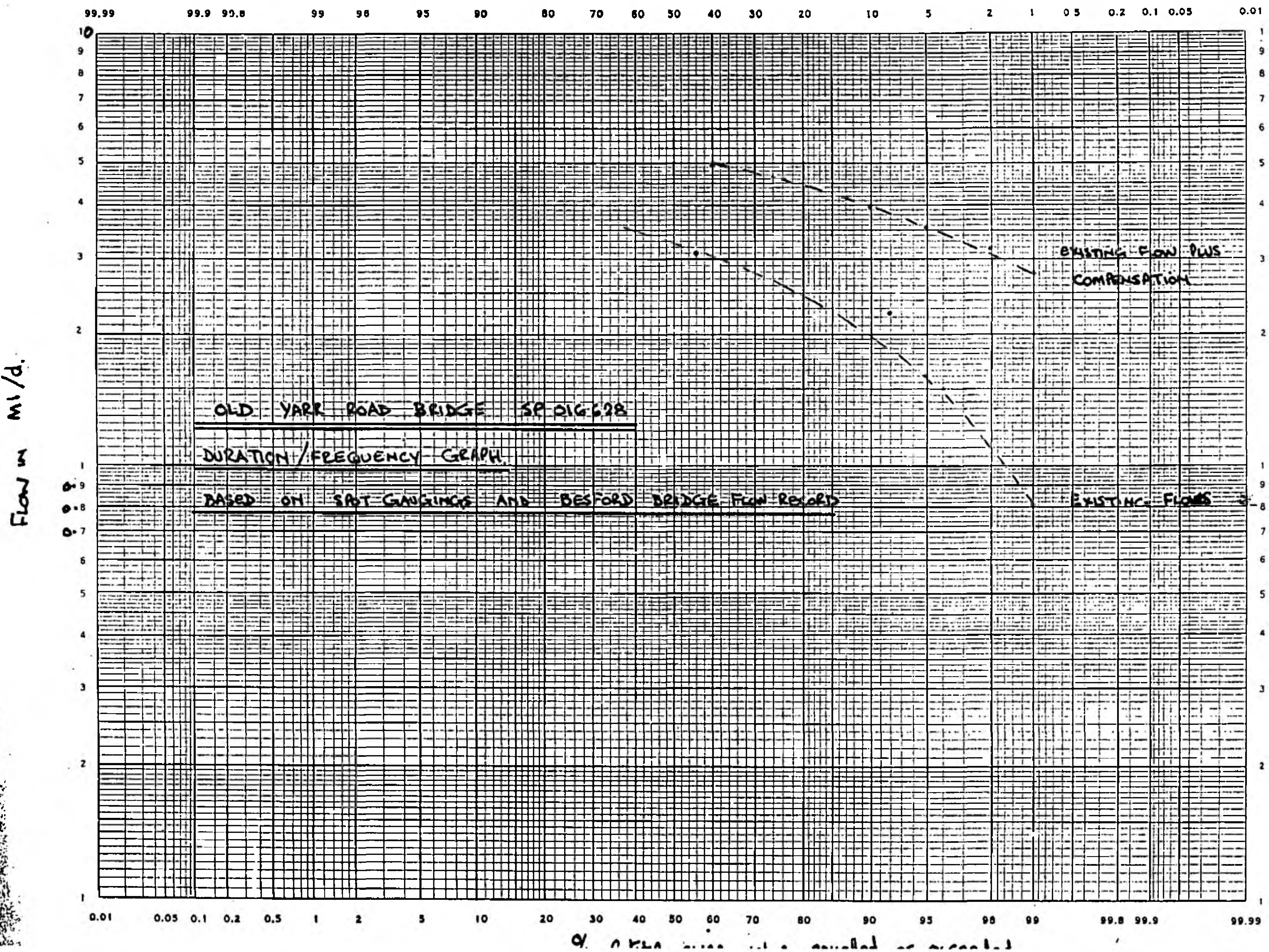
E. A. Midlands - Headquarters Hydrometry

Duration/Frequency Graph

| Auth.: 2015 | Name: BESFORD BRIDGE | Locat.: BOW BR. |
|---|---|---|

Period of Analysis : 1976 to 1997 (20 complete years used)





Flow in Ml/d.
OLD YARR ROAD BRIDGE SP 0IG 628
DURATION/FREQUENCY GRAPH
BASED ON SPOT GAUGINGS AND BESFORD BRIDGE FLOW RECORDS
EXISTING FLOW PLUS COMPENSATION
EXISTING FLOWS
0·9
0·8
0·7

## E. A. Midlands - Headquarters Hydrometry

| | | | | | |
|---|---|---|---|---|---|
| Auth. Ref. | : | 2015 | Station Name | : | BESFORD BRIDGE |
| Loc. Desc. | : | BOW BR. | Catchment Ref. | : | LS |
| Report Type | : | Daily Means For Yr. | Grid Ref. | : | SO 927463 |
| Parameter | : | Flow | Gauge Zero | : | N/A |
| Units | : | Ml/d | Catchment Area | : | 156.000 Sq Km |
| Period | : | 1990 | Start of Day | : | 09:00 GMT |

| Day | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Day |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 88.210 | 787.588 | 177.169 | 33.104 | 23.782 | 13.212 | 10.842 | 4.638 | 6.045 | 9.654 | 18.185 | 13.634 | 1 |
| 2 | 155.936 | 919.295 | 122.464 | 35.433 | 22.637 | 13.038 | 13.220 | 3.664 | 4.482 | 13.760 | 16.274 | 13.233 | 2 |
| 3 | 167.133 | 758.470 | 98.958 | 34.567 | 21.909 | 13.917 | 9.926 | 2.868 | 4.226 | 10.935 | 16.598 | 12.809 | 3 |
| 4 | 125.793 | 385.325 | 87.604 | 32.747 | 22.104 | 12.826 | 9.375 | 2.424 | 4.891 | 9.416 | 15.927 | 13.294 | 4 |
| 5 | 104.081 | 200.283 | 80.779 | 31.210 | 19.750 | 13.164 | 12.028 | 3.439 | 4.620 | 12.822 | 13.975 | 13.096 | 5 |
| 6 | 116.717 | 169.945 | 74.018 | 30.833 | 19.691 | 15.543 | 15.806 | 3.556 | 4.623 | 10.415 | 12.303 | 14.793 | 6 |
| 7 | 150.565 | 876.790 | 67.336 | 30.463 | 18.969 | 16.678 | 13.482 | 2.434 | 4.123 | 10.764 | 12.289 | 15.954 | 7 |
| 8 | 123.993 | 1452.257 | 62.134 | 29.113 | 18.383 | 14.183 | 11.166 | 2.216 | 3.677 | 12.592 | 11.963 | 20.355 | 8 |
| 9 | 106.604 | 332.212 | 55.344 | 28.962 | 18.528 | 18.366 | 10.433 | 2.295 | 3.674 | 10.127 | 11.769 | 31.835 | 9 |
| 10 | 96.614 | 203.346 | 52.012 | 29.318 | 21.336 | 19.104 | 8.391 | 2.608 | 3.102 | 7.467 | 11.801 | 147.420 | 10 |
| 11 | 85.697 | 294.918 | 50.209 | 29.159 | 19.633 | 17.213 | 7.371 | 2.218 | 4.013 | 6.924 | 12.602 | 239.614 | 11 |
| 12 | 93.474 | 360.474 | 47.770 | 28.911 | 18.437 | 14.168 | 6.388 | 1.894 | 5.745 | 6.443 | 14.883 | 160.138 | 12 |
| 13 | 121.306 | 200.755 | 53.441 | 31.621 | 20.007 | 12.455 | 6.617 | 2.327 | 5.115 | 6.213 | 16.588 | 98.195 | 13 |
| 14 | 104.387 | 222.377 | 50.446 | 33.588 | 18.569 | 10.724 | 5.229 | 2.382 | 5.115 | 5.961 | 18.482 | 44.855 | 14 |
| 15 | 91.225 | 217.271 | 43.915 | 31.682 | 22.424 | 11.544 | 5.067 | 2.898 | 5.111 | 5.850 | 18.232 | 32.731 | 15 |
| 16 | 82.474 | 163.774 | 42.401 | 29.807 | 30.714 | 11.897 | 4.722 | 3.875 | 4.410 | 7.949 | 16.545 | 28.089 | 16 |
| 17 | 71.280 | 142.786 | 42.000 | 28.473 | 21.631 | 10.310 | 4.749 | 3.848 | 4.408 | 6.923 | 14.695 | 26.492 | 17 |
| 18 | 61.555 | 134.863 | 41.750 | 29.518 | 17.684 | 12.135 | 4.055 | 4.556 | 4.055 | 10.069 | 13.987 | 25.938 | 18 |
| 19 | 61.334 | 119.544 | 46.280 | 35.776 | 15.943 | 12.629 | 4.413 | 6.172 | 4.413 | 14.350 | 14.441 | 24.560 | 19 |
| 20 | 61.343 | 109.276 | 59.322 | 42.132 | 14.652 | 15.325 | 4.212 | 10.031 | 4.212 | 26.921 | 19.509 | 22.944 | 20 |
| 21 | 57.327 | 100.061 | 47.605 | 43.043 | 16.409 | 18.955 | 3.375 | 12.447 | 3.375 | 14.996 | 43.452 | 26.757 | 21 |
| 22 | 61.940 | 91.066 | 40.565 | 34.426 | 13.854 | 25.290 | 2.787 | 8.211 | 2.787 | 10.867 | 27.478 | 34.608 | 22 |
| 23 | 421.780 | 84.968 | 37.373 | 29.783 | 12.360 | 26.443 | 3.301 | 5.475 | 3.301 | 9.673 | 20.930 | 30.087 | 23 |
| 24 | 299.369 | 83.129 | 37.912 | 28.933 | 12.472 | 17.558 | 3.142 | 4.744 | 3.142 | 9.167 | 18.571 | 27.552 | 24 |
| 25 | 306.424 | 90.405 | 36.030 | 26.943 | 12.787 | 14.426 | 3.267 | 4.038 | 3.267 | 10.184 | 23.452 | 96.984 | 25 |
| 26 | 233.588 | 117.594 | 34.035 | 28.073 | 12.201 | 11.938 | 2.968 | 3.894 | 2.968 | 31.139 | 29.023 | 192.008 | 26 |
| 27 | 320.570 | 131.295 | 33.664 | 27.229 | 12.734 | 9.586 | 3.300 | 4.246 | 3.303 | 94.846 | 20.812 | 113.745 | 27 |
| 28 | 958.427 | 141.733 | 33.694 | 25.755 | 11.172 | 9.778 | 3.811 | 3.883 | 6.590 | 64.448 | 16.809 | 75.682 | 28 |
| 29 | 419.834 | | 33.590 | 24.694 | 11.216 | 9.795 | 4.245 | 3.228 | 7.689 | 79.124 | 14.924 | 125.186 | 29 |
| 30 | 403.533 | | 32.442 | 24.649 | 11.578 | 9.824 | 6.022 | 4.043 | 9.750 | 30.045 | 13.969 | 138.187 | 30 |
| 31 | 1419.660 | | 32.130 | | 12.879 | | 5.545 | 4.326 | | 20.908 | | 89.439 | 31 |
| Mean | 224.909 | 317.564 | 56.593 | 30.998 | 17.627 | 14.401 | 6.750 | 4.157 | 4.541 | 18.740 | 17.682 | 62.910 | |
| Maximum | 1419.660 | 1452.257 | 177.169 | 43.043 | 30.714 | 26.443 | 15.806 | 12.447 | 9.750 | 94.846 | 43.452 | 239.614 | |
| Day of Max. | 31 | 8 | 1 | 21 | 16 | 23 | 6 | 21 | 30 | 27 | 21 | 11 | |
| Min | 57.327 | 83.129 | 32.130 | 24.649 | 11.172 | 9.586 | 2.787 | 1.894 | 2.787 | 5.850 | 11.769 | 12.809 | |
| Day of Min. | 21 | 24 | 31 | 30 | 28 | 27 | 22 | 12 | 22 | 15 | 9 | 3 | |
| Total (TCM) | 6972 | 8892 | 1754 | 930 | 546 | 432 | 209 | 129 | 136 | 581 | 530 | 1950 | |
| Runoff (mm) | 45 | 57 | 11 | 6 | 4 | 3 | 1 | 1 | 1 | 4 | 3 | 13 | |

Above summary is for Daily Means of Flow

E. A. Midlands - Headquarters Hydrometry

| | | | | |
|---|---|---|---|---|
| Auth. Ref. | : 2015 | | Station Name | : BESFORD BRIDGE |
| Loc. Desc. | : BOW BR. | | Catchment Ref. | : LS |
| Report Type | : Daily Means For Yr. | | Grid Ref. | : SO 927463 |
| Parameter | : Flow | | Gauge Zero | : N/A |
| Units | : Ml/d | | Catchment Area | : 156.000 Sq Km |
| Period | : 1991 | | Start of Day | : 09:00 GMT |

| lay | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Day |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 71.578 | 38.641 | 58.713 | 45.388 | 102.615 | 16.848 | 18.430 | 155.662 | 5.653 | 24.376 | 32.884 | 16.536 | 1 |
| 2 | 104.558 | 36.256 | 53.203 | 49.411 | 58.731 | 16.962 | 17.819 | 49.959 | 5.033 | 14.071 | 79.398 | 16.024 | 2 |
| 3 | 97.414 | 34.820 | 49.544 | 54.403 | 44.404 | 17.510 | 19.999 | 21.236 | 4.394 | 10.645 | 58.557 | 15.462 | 3 |
| 4 | 69.737 | 33.485 | 63.618 | 53.554 | 42.068 | 17.791 | 21.867 | 15.854 | 4.207 | 9.624 | 46.101 | 14.923 | 4 |
| 5 | 105.199 | 32.543 | 128.717 | 52.331 | 38.983 | 16.177 | 20.224 | 14.343 | 4.889 | 11.288 | 29.631 | 14.318 | 5 |
| 6 | 170.581 | 30.933 | 158.847 | 45.020 | 33.824 | 16.855 | 17.616 | 13.804 | 4.458 | 13.681 | 22.070 | 14.262 | 6 |
| 7 | 102.620 | 28.479 | 1103.080 | 51.719 | 32.055 | 20.784 | 15.890 | 13.783 | 4.358 | 13.156 | 17.396 | 13.990 | 7 |
| 8 | 150.323 | 34.053 | 886.515 | 52.166 | 31.767 | 19.812 | 17.498 | 16.489 | 3.914 | 12.374 | 15.271 | 13.743 | 8 |
| 9 | 634.759 | 33.042 | 420.012 | 43.547 | 28.298 | 18.589 | 14.224 | 16.169 | 3.622 | 11.080 | 14.997 | 13.991 | 9 |
| 0 | 1219.116 | 31.764 | 341.980 | 41.485 | 27.297 | 17.909 | 14.936 | 14.253 | 3.627 | 12.798 | 15.241 | 13.740 | 10 |
| 1 | 595.050 | 30.620 | 324.110 | 39.313 | 26.290 | 16.430 | 12.212 | 11.369 | 4.346 | 13.422 | 16.222 | 13.498 | 11 |
| 2 | 411.530 | 30.654 | 186.407 | 36.906 | 25.584 | 15.355 | 10.409 | 11.163 | 4.795 | 11.336 | 22.100 | 13.441 | 12 |
| 3 | 185.092 | 31.178 | 147.210 | 34.882 | 24.671 | 15.323 | 10.131 | 9.553 | 5.102 | 10.259 | 22.973 | 13.441 | 13 |
| 4 | 131.780 | 31.614 | 120.194 | 33.243 | 23.348 | 15.661 | 10.774 | 9.243 | 5.486 | 10.352 | 25.119 | 13.531 | 14 |
| 5 | 105.763 | 72.438 | 103.718 | 31.209 | 22.183 | 15.723 | 10.076 | 8.268 | 5.872 | 10.927 | 20.725 | 14.442 | 15 |
| 6 | 86.607 | 178.110 | 102.213 | 30.490 | 23.111 | 26.766 | 15.566 | 7.474 | 6.620 | 10.157 | 18.022 | 16.420 | 16 |
| 7 | 77.993 | 172.097 | 131.050 | 29.944 | 26.865 | 28.301 | 13.052 | 6.652 | 7.279 | 9.690 | 16.803 | 19.842 | 17 |
| 8 | 93.185 | 141.995 | 179.115 | 30.846 | 22.746 | 22.685 | 20.761 | 6.661 | 7.676 | 8.597 | 21.424 | 23.764 | 18 |
| 9 | 197.599 | 132.251 | 194.502 | 33.218 | 22.563 | 18.483 | 20.447 | 6.653 | 6.991 | 8.227 | 95.695 | 26.018 | 19 |
| 0 | 153.499 | 109.219 | 162.883 | 32.516 | 23.217 | 17.609 | 23.635 | 5.488 | 6.736 | 9.743 | 112.838 | 21.930 | 20 |
| 1 | 116.639 | 123.407 | 166.263 | 34.990 | 23.076 | 16.857 | 14.936 | 5.612 | 6.596 | 9.465 | 43.706 | 19.407 | 21 |
| 2 | 91.856 | 143.349 | 128.115 | 31.541 | 23.433 | 15.395 | 10.846 | 6.404 | 6.861 | 9.686 | 30.118 | 18.252 | 22 |
| 3 | 78.541 | 147.307 | 105.218 | 28.854 | 21.699 | 20.163 | 11.895 | 7.336 | 6.460 | 10.735 | 26.494 | 17.207 | 23 |
| 4 | 68.179 | 123.206 | 87.564 | 27.665 | 19.293 | 32.226 | 13.686 | 7.474 | 6.944 | 10.161 | 23.849 | 16.073 | 24 |
| 5 | 61.557 | 104.643 | 73.723 | 28.366 | 19.757 | 39.169 | 16.751 | 7.474 | 7.730 | 9.871 | 21.472 | 15.661 | 25 |
| 6 | 55.063 | 91.674 | 66.658 | 26.531 | 20.183 | 45.611 | 16.000 | 7.474 | 7.750 | 11.722 | 20.470 | 15.022 | 26 |
| 7 | 50.027 | 80.156 | 60.067 | 25.489 | 20.854 | 34.646 | 18.267 | 7.474 | 7.868 | 10.994 | 18.734 | 15.022 | 27 |
| 8 | 47.535 | 69.228 | 53.206 | 26.272 | 18.793 | 40.282 | 12.433 | 7.474 | 10.617 | 12.450 | 17.923 | 14.492 | 28 |
| 9 | 45.174 | | 48.245 | 51.410 | 17.053 | 25.092 | 10.318 | 6.652 | 18.305 | 10.194 | 17.313 | 14.377 | 29 |
| 0 | 42.639 | | 46.713 | 186.750 | 16.640 | 20.464 | 11.102 | 5.746 | 38.106 | 12.427 | 16.856 | 14.090 | 30 |
| 1 | 40.152 | | 46.354 | | 17.380 | | 34.451 | 5.905 | | 26.363 | | 13.974 | 31 |
| lean | 176.172 | 76.684 | 187.024 | 42.982 | 28.993 | 22.049 | 16.008 | 15.778 | 7.410 | 11.931 | 31.347 | 16.029 | |
| laximum | 1219.116 | 178.110 | 1103.080 | 186.750 | 102.615 | 45.611 | 34.451 | 155.662 | 38.106 | 26.363 | 112.838 | 26.018 | |
| ay of Max. | 10 | 16 | 7 | 30 | 1 | 26 | 31 | 1 | 30 | 31 | 20 | 19 | |
| lin | 40.152 | 28.479 | 46.354 | 25.489 | 16.640 | 15.323 | 10.076 | 5.488 | 3.622 | 8.227 | 14.997 | 13.441 | |
| ay of Min. | 31 | 7 | 31 | 27 | 30 | 13 | 15 | 20 | 9 | 19 | 9 | 12 | |
| otal (TCM) | 5461 | 2147 | 5798 | 1289 | 899 | 661 | 496 | 489 | 222 | 370 | 940 | 497 | |
| unoff (mm) | 35 | 14 | 37 | 8 | 6 | 4 | 3 | 3 | 1 | 2 | 6 | 3 | |

Above summary is for Daily Means of Flow

E. A. Midlands - Headquarters Hydrometry

Auth. Ref. : 2015
Loc. Desc. : BOW BR.
Report Type : Daily Means For Yr.
Parameter : Flow
Units : Ml/d

Period : 1992

Station Name : BESFORD BRIDGE
Catchment Ref.: LS
Grid Ref. : SO 927463
Gauge Zero : N/A
Catchment Area: 156.000 Sq Km

Start of Day : 09:00 GMT

| Day | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Day |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 14.218 | 30.472 | 29.353 | 62.774 | 26.991 | 124.415 | 14.399 | 13.528 | 53.298 | 32.100 | 60.596 | 1138.654 | 1 |
| 2 | 14.195 | 29.454 | 33.420 | 111.851 | 25.161 | 189.755 | 35.886 | 12.057 | 32.369 | 32.008 | 60.421 | 1220.118 | 2 |
| 3 | 14.094 | 29.903 | 30.430 | 63.693 | 21.176 | 76.590 | 29.017 | 12.634 | 29.274 | 143.906 | 57.389 | 811.779 | 3 |
| 4 | 16.684 | 29.122 | 28.990 | 43.462 | 19.119 | 40.688 | 57.275 | 12.848 | 28.617 | 320.234 | 47.751 | 269.022 | 4 |
| 5 | 24.720 | 27.939 | 28.155 | 37.401 | 20.094 | 35.230 | 28.135 | 11.569 | 28.413 | 125.113 | 42.177 | 166.034 | 5 |
| 6 | 29.456 | 27.290 | 26.987 | 35.638 | 19.829 | 32.271 | 20.553 | 11.202 | 24.124 | 66.998 | 39.287 | 172.015 | 6 |
| 7 | 23.771 | 27.319 | 27.337 | 39.545 | 18.913 | 44.703 | 16.330 | 11.770 | 22.518 | 45.716 | 38.437 | 229.718 | 7 |
| 8 | 61.501 | 26.477 | 27.811 | 55.513 | 17.418 | 42.367 | 12.670 | 18.914 | 20.440 | 37.433 | 37.495 | 156.908 | 8 |
| 9 | 965.891 | 27.430 | 26.123 | 39.055 | 25.050 | 34.554 | 13.585 | 39.848 | 18.843 | 31.214 | 51.319 | 132.318 | 9 |
| 10 | 742.263 | 27.948 | 24.208 | 32.782 | 31.686 | 35.095 | 14.777 | 39.573 | 16.240 | 28.015 | 147.172 | 124.362 | 10 |
| 11 | 202.233 | 27.666 | 25.396 | 30.783 | 24.013 | 28.574 | 23.361 | 27.161 | 14.662 | 26.618 | 539.975 | 117.378 | 11 |
| 12 | 116.598 | 28.871 | 25.547 | 29.440 | 20.039 | 21.266 | 29.737 | 31.014 | 15.087 | 25.919 | 303.017 | 119.840 | 12 |
| 13 | 83.592 | 29.572 | 24.799 | 25.945 | 16.260 | 19.030 | 35.208 | 90.105 | 26.905 | 24.790 | 127.411 | 109.630 | 13 |
| 14 | 63.217 | 28.530 | 23.962 | 36.945 | 14.917 | 14.584 | 103.525 | 111.470 | 29.632 | 25.024 | 107.647 | 100.491 | 14 |
| 15 | 51.565 | 27.860 | 21.818 | 113.815 | 14.890 | 14.192 | 79.019 | 71.214 | 27.197 | 26.157 | 282.622 | 95.174 | 15 |
| 16 | 43.891 | 26.714 | 23.075 | 78.690 | 13.386 | 12.177 | 33.178 | 61.863 | 20.138 | 28.816 | 431.772 | 126.296 | 16 |
| 17 | 40.237 | 26.500 | 21.889 | 59.120 | 12.237 | 11.380 | 23.552 | 75.435 | 19.454 | 25.642 | 373.807 | 140.821 | 17 |
| 18 | 35.719 | 56.846 | 21.960 | 52.766 | 11.890 | 10.900 | 17.875 | 35.707 | 27.312 | 25.597 | 169.338 | 966.333 | 18 |
| 19 | 33.695 | 110.732 | 22.361 | 40.699 | 11.394 | 10.387 | 14.577 | 23.777 | 33.995 | 24.681 | 138.711 | 587.569 | 19 |
| 20 | 32.055 | 76.356 | 21.700 | 35.297 | 11.247 | 10.305 | 18.241 | 18.294 | 30.223 | 56.434 | 109.304 | 179.028 | 20 |
| 21 | 29.387 | 54.223 | 23.430 | 33.422 | 10.835 | 9.865 | 25.951 | 17.502 | 27.524 | 141.122 | 101.909 | 135.354 | 21 |
| 22 | 27.618 | 45.543 | 25.115 | 32.294 | 10.478 | 9.271 | 34.029 | 16.073 | 207.704 | 79.223 | 138.436 | 109.887 | 22 |
| 23 | 26.549 | 40.703 | 30.859 | 29.601 | 9.627 | 8.531 | 23.795 | 19.463 | 146.534 | 49.591 | 142.548 | 93.452 | 23 |
| 24 | 26.552 | 35.839 | 35.265 | 30.703 | 16.334 | 9.148 | 18.011 | 22.774 | 118.312 | 42.517 | 115.788 | 84.453 | 24 |
| 25 | 30.678 | 33.357 | 29.343 | 29.542 | 16.950 | 8.623 | 16.120 | 28.829 | 85.883 | 247.999 | 564.847 | 76.854 | 25 |
| 26 | 43.152 | 32.296 | 29.757 | 27.510 | 15.482 | 8.158 | 15.897 | 22.087 | 74.046 | 250.770 | 1501.786 | 71.437 | 26 |
| 27 | 36.876 | 29.449 | 30.500 | 25.495 | 10.582 | 8.133 | 20.748 | 29.178 | 64.912 | 133.253 | 450.508 | 73.705 | 27 |
| 28 | 32.668 | 28.766 | 26.630 | 24.136 | 9.422 | 7.968 | 26.435 | 28.995 | 45.524 | 166.388 | 389.674 | 79.200 | 28 |
| 29 | 30.825 | 28.777 | 27.464 | 22.794 | 9.243 | 6.477 | 18.998 | 34.653 | 35.838 | 139.210 | 195.504 | 74.660 | 29 |
| 30 | 30.390 | | 34.400 | 24.256 | 9.243 | 7.889 | 14.918 | 35.666 | 31.625 | 103.483 | 918.507 | 69.134 | 30 |
| 31 | 29.704 | | 70.677 | | 9.243 | | 14.447 | 76.076 | | 73.658 | | 64.060 | 31 |
| Mean | 95.290 | 36.274 | 28.347 | 43.499 | 16.231 | 29.751 | 27.427 | 34.235 | 45.221 | 83.214 | 256.172 | 254.700 | |
| Maximum | 965.891 | 110.732 | 70.677 | 113.815 | 31.686 | 189.755 | 103.525 | 111.470 | 207.704 | 320.234 | 1501.786 | 1220.118 | |
| Day of Max. | 9 | 19 | 31 | 15 | 10 | 2 | 14 | 14 | 22 | 4 | 26 | 2 | |
| Min | 14.094 | 26.477 | 21.700 | 22.794 | 9.243 | 6.477 | 12.670 | 11.202 | 14.662 | 24.681 | 37.495 | 64.060 | |
| Day of Min. | 3 | 8 | 20 | 29 | 29 | 29 | 8 | 6 | 11 | 19 | 8 | 31 | |
| Total (TCM) | 2954 | 1052 | 879 | 1305 | 503 | 893 | 850 | 1061 | 1357 | 2580 | 7685 | 7896 | |
| Runoff (mm) | 19 | 7 | 6 | 8 | 3 | 6 | 5 | 7 | 9 | 17 | 49 | 51 | |

Above summary is for Daily Means of Flow

E. A. Midlands - Headquarters Hydrometry

uth. Ref. : 2015
oc. Desc. : BOW BR.
eport Type : Daily Means For Yr.
arameter : Flow
nits : Ml/d

eriod : 1993

Station Name : BESFORD BRIDGE
Catchment Ref.: LS
Grid Ref. : SO 927463
Gauge Zero : N/A
Catchment Area: 156.000 Sq Km

Start of Day : 09:00 GMT

| ıy | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Day |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 59.401 | 74.654 | 35.948 | 40.583 | 33.027 | 44.586 | 24.986 | 17.196 | 12.094 | 26.562 | 25.763 | 113.863 | 1 |
| | 56.917 | 70.196 | 36.145 | 31.918 | 32.088 | 40.876 | 24.018 | 16.603 | 11.183 | 26.080 | 26.153 | 90.239 | 2 |
| | 56.204 | 64.500 | 33.980 | 36.530 | 30.189 | 36.460 | 23.247 | 16.103 | 10.959 | 26.392 | 27.022 | 75.800 | 3 |
| | 62.418 | 61.967 | 32.680 | 53.858 | 27.835 | 33.283 | 21.687 | 15.990 | 11.240 | 23.356 | 26.933 | 68.514 | 4 |
| | 89.545 | 58.690 | 32.747 | 54.142 | 26.905 | 27.996 | 18.617 | 15.245 | 11.159 | 31.017 | 27.098 | 61.147 | 5 |
| | 158.984 | 56.986 | 33.451 | 50.667 | 31.963 | 28.823 | 19.628 | 15.453 | 11.072 | 79.102 | 27.298 | 56.652 | 6 |
| | 177.805 | 55.686 | 33.165 | 50.542 | 32.982 | 27.165 | 17.668 | 15.349 | 10.986 | 79.060 | 26.967 | 60.437 | 7 |
| | 130.218 | 53.459 | 32.758 | 60.249 | 33.179 | 24.741 | 17.864 | 15.347 | 23.054 | 89.888 | 26.079 | 131.190 | 8 |
| | 116.771 | 53.026 | 32.016 | 506.922 | 34.633 | 27.478 | 31.034 | 17.569 | 44.136 | 102.758 | 27.374 | 234.464 | 9 |
| | 368.250 | 52.656 | 31.680 | 262.551 | 30.258 | 122.685 | 45.304 | 12.440 | 42.985 | 64.386 | 81.815 | 128.698 | 10 |
| | 623.252 | 50.705 | 31.555 | 215.938 | 28.118 | 181.042 | 28.337 | 15.585 | 29.749 | 98.580 | 102.286 | 101.458 | 11 |
| | 228.434 | 48.191 | 31.570 | 348.185 | 26.658 | 343.914 | 23.782 | 14.432 | 24.837 | 298.824 | 62.566 | 514.754 | 12 |
| | 1807.260 | 46.873 | 31.585 | 137.877 | 26.922 | 116.956 | 28.444 | 13.873 | 54.516 | 572.804 | 287.638 | 866.195 | 13 |
| | 1138.778 | 46.145 | 31.380 | 98.628 | 27.597 | 242.836 | 44.499 | 13.398 | 59.761 | 477.223 | 1090.773 | 382.800 | 14 |
| | 447.242 | 45.183 | 30.184 | 78.145 | 26.813 | 268.152 | 38.448 | 13.212 | 33.079 | 155.188 | 344.110 | 790.087 | 15 |
| | 234.355 | 44.441 | 30.041 | 65.463 | 25.954 | 204.338 | 45.097 | 14.698 | 28.482 | 93.852 | 147.707 | 284.426 | 16 |
| | 157.579 | 43.569 | 29.269 | 59.025 | 29.448 | 179.012 | 77.448 | 11.282 | 23.743 | 61.959 | 107.371 | 159.415 | 17 |
| | 130.882 | 42.960 | 30.253 | 54.234 | 31.659 | 109.570 | 33.522 | 11.546 | 20.077 | 48.741 | 87.825 | 154.397 | 18 |
| | 120.048 | 41.462 | 28.405 | 46.504 | 26.903 | 83.273 | 28.443 | 11.701 | 17.381 | 41.843 | 71.082 | 243.642 | 19 |
| | 113.537 | 39.758 | 28.551 | 43.383 | 38.246 | 56.450 | 26.741 | 15.111 | 18.445 | 38.707 | 61.836 | 288.516 | 20 |
| | 110.291 | 39.070 | 31.056 | 40.204 | 120.151 | 45.809 | 27.090 | 10.400 | 24.324 | 35.834 | 57.852 | 428.893 | 21 |
| | 118.207 | 38.064 | 34.517 | 38.566 | 61.138 | 40.391 | 24.596 | 15.289 | 25.637 | 33.030 | 49.346 | 201.641 | 22 |
| | 132.042 | 37.045 | 32.644 | 38.729 | 40.166 | 36.769 | 24.510 | 23.627 | 22.372 | 30.954 | 45.368 | 198.328 | 23 |
| | 130.384 | 36.267 | 28.586 | 41.390 | 32.900 | 35.062 | 34.626 | 22.122 | 21.428 | 29.247 | 43.491 | 247.180 | 24 |
| | 104.494 | 38.493 | 27.122 | 44.354 | 29.974 | 32.723 | 43.557 | 17.491 | 17.689 | 28.397 | 47.737 | 175.564 | 25 |
| | 88.848 | 43.958 | 28.316 | 46.078 | 334.594 | 30.874 | 28.282 | 16.467 | 19.348 | 27.885 | 64.672 | 132.356 | 26 |
| | 102.067 | 38.856 | 28.585 | 46.539 | 271.458 | 29.409 | 22.238 | 15.479 | 18.305 | 27.383 | 77.465 | 111.556 | 27 |
| | 116.486 | 35.388 | 28.164 | 38.443 | 107.150 | 27.599 | 21.423 | 13.517 | 16.980 | 27.306 | 66.844 | 303.270 | 28 |
| | 102.959 | | 27.565 | 35.303 | 74.327 | 26.332 | 21.802 | 12.403 | 18.534 | 27.218 | 65.334 | 333.925 | 29 |
| | 90.794 | | 27.913 | 33.676 | 72.969 | 24.756 | 22.770 | 12.201 | 20.998 | 27.133 | 128.144 | 211.873 | 30 |
| | 81.913 | | 30.804 | | 58.468 | | 21.334 | 11.969 | | 26.265 | | 190.494 | 31 |
| ean | 240.528 | 48.509 | 31.053 | 89.954 | 58.215 | 84.312 | 29.388 | 14.939 | 23.485 | 88.935 | 111.065 | 236.831 | |
| aximum | 1807.260 | 74.654 | 36.145 | 506.922 | 334.594 | 343.914 | 77.448 | 23.627 | 59.761 | 572.804 | 1090.773 | 866.195 | |
| ay of Max. | 13 | 1 | 2 | 9 | 26 | 12 | 17 | 23 | 14 | 13 | 14 | 13 | |
| in | 56.204 | 35.388 | 27.122 | 31.918 | 25.954 | 24.741 | 17.668 | 10.400 | 10.959 | 23.356 | 25.763 | 56.652 | |
| ay of Min. | 3 | 28 | 25 | 2 | 16 | 8 | 7 | 21 | 3 | 4 | 1 | 6 | |
| otal (TCM) | 7456 | 1358 | 963 | 2699 | 1805 | 2529 | 911 | 463 | 705 | 2757 | 3332 | 7342 | |
| unoff (mm) | 48 | 9 | 6 | 17 | 12 | 16 | 6 | 3 | 5 | 18 | 21 | 47 | |

Above summary is for Daily Means of Flow

## E. A. Midlands - Headquarters Hydrometry

| | | | |
|---|---|---|---|
| Auth. Ref. | : 2015 | Station Name | : BESFORD BRIDGE |
| Loc. Desc. | : BOW BR. | Catchment Ref. | : LS |
| Report Type | : Daily Means For Yr. | Grid Ref. | : SO 927463 |
| Parameter | : Flow | Gauge Zero | : N/A |
| Units | : Ml/d | Catchment Area | : 156.000 Sq Km |
| Period | : 1994 | Start of Day | : 09:00 GMT |

| Day | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Day |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 165.687 | 81.929 | 138.022 | 180.102 | 34.223 | 25.681 | 10.484 | 7.261 | 16.983 | 19.685 | 118.440 | 42.739 | 1 |
| 2 | 483.384 | 81.017 | 125.889 | 108.774 | 33.600 | 27.292 | 11.774 | 9.540 | 20.284 | 20.681 | 68.277 | 41.052 | 2 |
| 3 | 632.789 | 199.263 | 109.368 | 83.261 | 33.090 | 27.242 | 13.176 | 10.750 | 24.059 | 22.305 | 57.266 | 46.626 | 3 |
| 4 | 719.609 | 183.281 | 97.759 | 194.204 | 32.657 | 27.921 | 14.543 | 12.774 | 16.033 | 23.755 | 150.209 | 139.403 | 4 |
| 5 | 869.518 | 119.074 | 91.215 | 162.342 | 32.534 | 30.587 | 14.801 | 18.116 | 14.592 | 20.737 | 420.202 | 250.110 | 5 |
| 6 | 430.365 | 123.948 | 80.343 | 153.483 | 32.877 | 26.469 | 17.818 | 19.843 | 13.606 | 18.523 | 220.304 | 312.326 | 6 |
| 7 | 173.445 | 145.138 | 78.219 | 121.434 | 33.785 | 23.838 | 19.093 | 11.277 | 12.474 | 17.417 | 118.471 | 513.154 | 7 |
| 8 | 143.324 | 110.367 | 72.457 | 173.205 | 32.494 | 22.890 | 17.860 | 8.784 | 20.365 | 16.961 | 91.021 | 658.134 | 8 |
| 9 | 193.867 | 95.894 | 86.259 | 251.147 | 29.421 | 21.985 | 14.820 | 7.815 | 25.365 | 17.234 | 298.143 | 305.690 | 9 |
| 10 | 452.892 | 105.106 | 93.919 | 163.950 | 29.005 | 21.581 | 11.637 | 9.819 | 26.685 | 18.717 | 362.545 | 156.514 | 10 |
| 11 | 208.863 | 827.509 | 77.789 | 109.293 | 28.066 | 21.056 | 10.801 | 13.913 | 19.510 | 17.100 | 148.368 | 121.379 | 11 |
| 12 | 286.492 | 356.361 | 73.031 | 90.505 | 28.307 | 19.318 | 10.673 | 13.821 | 21.949 | 16.388 | 289.237 | 100.921 | 12 |
| 13 | 638.914 | 156.189 | 66.993 | 82.160 | 27.970 | 18.986 | 9.121 | 14.898 | 19.010 | 15.788 | 535.633 | 90.777 | 13 |
| 14 | 245.649 | 121.938 | 58.117 | 68.080 | 30.629 | 18.338 | 8.431 | 10.180 | 56.604 | 15.852 | 191.872 | 119.988 | 14 |
| 15 | 181.761 | 104.888 | 59.361 | 60.960 | 49.858 | 17.038 | 9.169 | 8.903 | 289.318 | 16.247 | 137.916 | 99.589 | 15 |
| 16 | 177.574 | 95.366 | 59.451 | 55.504 | 55.516 | 15.905 | 9.153 | 8.612 | 330.714 | 17.176 | 104.611 | 85.912 | 16 |
| 17 | 137.451 | 104.471 | 56.946 | 50.927 | 45.919 | 15.182 | 9.578 | 9.114 | 111.661 | 17.262 | 86.348 | 84.038 | 17 |
| 18 | 120.899 | 129.770 | 59.518 | 48.127 | 33.331 | 15.372 | 8.616 | 9.481 | 47.109 | 15.942 | 89.075 | 378.838 | 18 |
| 19 | 116.722 | 119.935 | 78.410 | 47.898 | 28.995 | 14.752 | 7.860 | 11.785 | 47.110 | 16.001 | 112.198 | 262.060 | 19 |
| 20 | 104.777 | 102.720 | 62.187 | 46.484 | 28.206 | 14.483 | 7.878 | 10.090 | 99.275 | 19.286 | 103.285 | 137.203 | 20 |
| 21 | 98.548 | 88.798 | 54.002 | 45.717 | 29.589 | 15.064 | 8.369 | 8.800 | 72.935 | 19.601 | 110.470 | 104.042 | 21 |
| 22 | 92.580 | 83.251 | 52.185 | 47.399 | 34.442 | 14.907 | 7.830 | 7.671 | 46.306 | 27.916 | 92.929 | 87.096 | 22 |
| 23 | 95.546 | 371.469 | 52.056 | 47.400 | 29.591 | 14.607 | 7.721 | 9.491 | 32.832 | 43.830 | 79.553 | 76.587 | 23 |
| 24 | 99.848 | 450.064 | 49.907 | 44.379 | 29.700 | 14.426 | 6.894 | 8.427 | 27.847 | 37.519 | 69.061 | 73.439 | 24 |
| 25 | 122.059 | 224.188 | 50.288 | 38.788 | 40.935 | 16.797 | 6.334 | 7.149 | 28.661 | 27.424 | 63.107 | 91.556 | 25 |
| 26 | 174.469 | 880.837 | 49.087 | 36.915 | 70.293 | 15.169 | 7.113 | 12.636 | 29.941 | 24.787 | 56.836 | 159.385 | 26 |
| 27 | 129.177 | 504.081 | 45.250 | 35.145 | 57.430 | 13.521 | 8.735 | 10.466 | 25.775 | 24.644 | 53.331 | 854.293 | 27 |
| 28 | 101.275 | 179.108 | 55.186 | 34.535 | 35.675 | 12.320 | 9.381 | 8.375 | 22.691 | 24.978 | 50.152 | 692.663 | 28 |
| 29 | 90.188 | | 47.504 | 34.515 | 30.228 | 11.681 | 11.551 | 7.783 | 21.161 | 98.241 | 45.817 | 363.178 | 29 |
| 30 | 85.981 | | 47.357 | 34.329 | 27.228 | 10.958 | 8.483 | 7.070 | 19.690 | 209.386 | 44.110 | 264.484 | 30 |
| 31 | 79.129 | | 86.933 | | 25.827 | | 7.659 | 8.313 | | 206.532 | | 198.191 | 31 |
| Mean | 246.864 | 219.499 | 71.452 | 88.365 | 35.207 | 18.846 | 10.560 | 10.418 | 52.018 | 35.739 | 145.628 | 222.947 | |
| Maximum | 869.518 | 880.837 | 138.022 | 251.147 | 70.293 | 30.587 | 19.093 | 19.843 | 330.714 | 209.386 | 535.633 | 854.293 | |
| Day of Max. | 5 | 26 | 1 | 9 | 26 | 5 | 7 | 6 | 16 | 30 | 13 | 27 | |
| Min | 79.129 | 81.017 | 45.250 | 34.329 | 25.827 | 10.958 | 6.334 | 7.070 | 12.474 | 15.788 | 44.110 | 41.052 | |
| Day of Min. | 31 | 2 | 27 | 30 | 31 | 30 | 25 | 30 | 7 | 13 | 30 | 2 | |
| Total (TCM) | 7653 | 6146 | 2215 | 2651 | 1091 | 565 | 327 | 323 | 1561 | 1108 | 4369 | 6911 | |
| Runoff (mm) | 49 | 39 | 14 | 17 | 7 | 4 | 2 | 2 | 10 | 7 | 28 | 44 | |

Above summary is for Daily Means of Flow

E. A. Midlands - Headquarters Hydrometry

| | | | |
|---|---|---|---|
| Auth. Ref. | : 2015 | Station Name | : BESFORD BRIDGE |
| Loc. Desc. | : BOW BR. | Catchment Ref. | : LS |
| Report Type | : Daily Means For Yr. | Grid Ref. | : SO 927463 |
| Parameter | : Flow | Gauge Zero | : N/A |
| Units | : Ml/d | Catchment Area | : 156.000 Sq Km |
| Period | : 1995 | Start of Day | : 09:00 GMT |

| Day | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Day |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 146.626 | 198.516 | | | 30.050 | 32.475 | 10.530 | 8.453 | 8.246 | 13.212 | 14.703 | 46.831 | 1 |
| 2 | 134.385 | | | | 28.261 | 26.019 | 9.737 | 8.922 | 8.937 | 12.996 | 13.968 | 37.408 | 2 |
| 3 | 108.714 | | | | 28.253 | 26.976 | 11.690 | 8.367 | 9.819 | 13.037 | 13.757 | 34.323 | 3 |
| 4 | 98.317 | | | | 27.490 | 40.455 | 13.366 | 8.499 | 10.449 | 13.327 | 13.749 | 43.706 | 4 |
| 5 | 192.777 | | | | 26.785 | 28.691 | 13.285 | 7.925 | 12.664 | 13.953 | 13.242 | 49.253 | 5 |
| 6 | 214.788 | | | | 26.486 | 23.287 | 11.078 | 6.501 | 12.826 | 15.364 | 13.029 | 38.490 | 6 |
| 7 | 138.269 | | | | 25.928 | 21.613 | 10.798 | 6.613 | 17.588 | 16.211 | 12.910 | 33.471 | 7 |
| 8 | 123.518 | | | | 24.968 | 20.348 | 10.183 | 6.159 | 20.997 | 17.661 | 13.089 | 29.997 | 8 |
| 9 | 113.055 | | | | 23.780 | 18.142 | 9.162 | 5.461 | 32.182 | 17.392 | 17.494 | 27.315 | 9 |
| 0 | 105.422 | | | | 23.026 | 15.052 | 9.920 | 5.134 | 25.818 | 15.075 | 40.344 | 24.920 | 10 |
| 1 | 120.841 | | | | 23.477 | 18.227 | 14.023 | 4.787 | 32.116 | 15.754 | 84.070 | 22.982 | 11 |
| 2 | 102.949 | | | | 23.740 | 19.264 | 28.792 | 5.887 | 47.686 | 14.083 | 89.055 | 21.975 | 12 |
| 3 | 90.609 | | | | 23.274 | 17.876 | 21.763 | 6.425 | 32.063 | 13.004 | 52.140 | 21.977 | 13 |
| 4 | 86.907 | | | | 22.726 | 17.174 | 16.110 | 5.955 | 40.387 | 13.028 | 40.673 | 22.073 | 14 |
| 5 | 87.797 | | | | 22.091 | 15.980 | 27.075 | 5.482 | 28.108 | 13.138 | 35.162 | 21.677 | 15 |
| 6 | 95.880 | | | | 23.685 | 15.500 | 34.598 | 5.656 | 30.809 | 12.791 | 35.270 | 21.579 | 16 |
| 7 | 772.875 | | | | 65.251 | 15.328 | 18.296 | 5.296 | 34.069 | 12.512 | 31.713 | 21.910 | 17 |
| 8 | 1027.406 | | | | 54.055 | 16.119 | 15.087 | 5.307 | 26.073 | 11.929 | 30.559 | 22.892 | 18 |
| 9 | 405.031 | | | | 32.135 | 15.120 | 15.488 | 6.393 | 22.722 | 12.601 | 24.339 | 50.420 | 19 |
| 0 | 676.016 | | | | 26.891 | 13.958 | 11.121 | 6.020 | 19.944 | 12.754 | 21.326 | 397.872 | 20 |
| 1 | 652.223 | | | | 24.208 | 12.816 | 11.110 | 5.303 | 16.451 | 12.124 | 20.825 | 666.486 | 21 |
| 2 | 566.876 | | | | 23.919 | 11.351 | 10.985 | 5.408 | 15.062 | 12.079 | 20.468 | 1888.174 | 22 |
| 3 | 279.065 | | | | 23.627 | 10.647 | 10.563 | 6.931 | 14.306 | 12.192 | 21.545 | 1691.761 | 23 |
| 4 | 170.125 | | | | 22.983 | 11.226 | 9.688 | 7.090 | 14.271 | 13.124 | 19.826 | 812.460 | 24 |
| 5 | 273.041 | | | 38.782 | 22.783 | 10.701 | 9.114 | 7.045 | 13.961 | 21.357 | 20.834 | 236.179 | 25 |
| 6 | 644.659 | | | 35.064 | 22.938 | 10.989 | 8.555 | 8.713 | 18.136 | 33.955 | 29.329 | 120.756 | 26 |
| 7 | 534.544 | | | 32.325 | 22.569 | 11.125 | 8.277 | 8.674 | 16.743 | 25.281 | 47.207 | 85.860 | 27 |
| 8 | 660.531 | | | 31.344 | 26.361 | 10.101 | 7.883 | 8.208 | 16.369 | 22.969 | 61.830 | 69.634 | 28 |
| 9 | 445.198 | | | 31.676 | 26.972 | 10.038 | 8.052 | 8.116 | 14.956 | 18.703 | 84.732 | 58.059 | 29 |
| 0 | 266.699 | | | 31.933 | 28.230 | 10.485 | 7.492 | 7.616 | 13.712 | 16.515 | 76.208 | 53.639 | 30 |
| 1 | 182.227 | | | | 55.579 | | 7.054 | 7.893 | | 15.792 | | 55.991 | 31 |
| ean | 307.012 | 198.516 | | 33.520 | 28.468 | 17.569 | 13.254 | 6.782 | 20.916 | 15.610 | 33.778 | 217.099 | |
| aximum | 1027.406 | 198.516 | | 38.782 | 65.251 | 40.455 | 34.598 | 8.922 | 47.686 | 33.955 | 89.055 | 1888.174 | |
| ay of Max. | 18 | 1 | | 25 | 17 | 4 | 16 | 2 | 12 | 26 | 12 | 22 | |
| in | 86.907 | 198.516 | | 31.344 | 22.091 | 10.038 | 7.054 | 4.787 | 8.246 | 11.929 | 12.910 | 21.579 | |
| ay of Min. | 14 | 1 | | 28 | 15 | 29 | 31 | 11 | 1 | 18 | 7 | 16 | |
| otal (TCM) | 9517 | 41 | | 193 | 883 | 527 | 411 | 210 | 627 | 484 | 1013 | 6730 | |
| unoff (mm) | 61 | 0 | N/A | 1 | 6 | 3 | 3 | 1 | 4 | 3 | 6 | 43 | |

Above summary is for Daily Means of Flow

## E. A. Midlands - Headquarters Hydrometry

Auth. Ref. : 2015
Loc. Desc. : BOW BR.
Report Type : Daily Means For Yr.
Parameter : Flow
Units : Ml/d

Period : 1996

Station Name : BESFORD BRIDGE
Catchment Ref.: LS
Grid Ref. : SO 927463
Gauge Zero : N/A
Catchment Area: 156.000 Sq Km

Start of Day : 09:00 GMT

| Day | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Day |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 124.072 | 44.983 | 90.976 | 56.178 | 53.103 | 22.608 | 14.968 | 7.215 | 12.500 | 13.556 | 16.125 | 24.772 | 1 |
| 2 | 200.760 | 44.856 | 84.200 | 49.289 | 58.537 | 20.409 | 13.259 | 6.787 | 11.509 | 14.464 | 19.621 | 22.581 | 2 |
| 3 | 166.869 | 43.134 | 79.465 | 46.599 | 45.111 | 21.064 | 12.870 | 6.331 | 11.743 | 12.405 | 16.517 | 27.977 | 3 |
| 4 | 144.828 | 41.310 | 72.849 | 43.270 | 38.215 | 20.460 | 12.596 | 5.986 | 11.416 | 12.480 | 16.480 | 58.535 | 4 |
| 5 | 149.497 | 41.185 | 67.131 | 42.496 | 35.781 | 19.254 | 13.367 | 5.579 | 10.584 | 12.385 | 17.543 | 36.311 | 5 |
| 6 | 253.260 | 44.142 | 63.048 | 43.506 | 35.359 | 18.586 | 14.548 | 5.801 | 9.617 | 12.652 | 21.148 | 26.723 | 6 |
| 7 | 553.999 | 44.185 | 60.329 | 42.022 | 33.820 | 20.782 | 14.388 | 6.218 | 8.849 | 13.938 | 16.750 | 22.447 | 7 |
| 8 | 532.305 | 41.071 | 59.597 | 39.918 | 32.235 | 39.502 | 13.658 | 6.191 | 9.417 | 13.578 | 16.134 | 20.597 | 8 |
| 9 | 952.691 | 107.799 | 69.492 | 38.928 | 30.785 | 26.708 | 12.568 | 6.540 | 9.596 | 14.083 | 17.454 | 19.618 | 9 |
| 10 | 681.189 | 413.468 | 62.582 | 40.824 | 31.630 | 20.238 | 11.382 | 10.210 | 9.094 | 15.803 | 15.393 | 20.046 | 10 |
| 11 | 276.628 | 303.029 | 60.972 | 40.533 | 28.922 | 19.829 | 10.429 | 16.656 | 8.439 | 15.532 | 14.319 | 18.043 | 11 |
| 12 | 380.772 | 482.535 | 103.535 | 129.527 | 28.321 | 21.909 | 9.971 | 27.168 | 8.097 | 12.777 | 14.011 | 17.826 | 12 |
| 13 | 358.523 | 711.622 | 113.781 | 533.127 | 27.051 | 19.828 | 9.565 | 29.140 | 8.022 | 10.864 | 13.074 | 17.575 | 13 |
| 14 | 169.569 | 253.535 | 87.889 | 143.347 | 25.287 | 16.720 | 9.225 | 22.017 | 7.991 | 10.298 | 13.264 | 17.042 | 14 |
| 15 | 118.882 | 145.137 | 78.212 | 98.821 | 25.223 | 14.956 | 8.820 | 15.433 | 8.441 | 11.011 | 13.333 | 16.638 | 15 |
| 16 | 97.525 | 119.124 | 73.446 | 81.311 | 26.296 | 13.873 | 8.286 | 12.525 | 8.437 | 10.316 | 13.678 | 15.969 | 16 |
| 17 | 87.144 | 100.786 | 71.470 | 74.929 | 26.342 | 13.063 | 8.052 | 10.989 | 8.279 | 9.740 | 16.881 | 15.765 | 17 |
| 18 | 80.162 | 99.335 | 66.161 | 63.045 | 29.340 | 12.850 | 7.685 | 9.713 | 7.491 | 10.250 | 28.168 | 23.500 | 18 |
| 19 | 73.746 | 86.117 | 63.150 | 57.636 | 48.135 | 12.675 | 7.143 | 10.262 | 8.018 | 12.651 | 29.780 | 222.652 | 19 |
| 20 | 67.836 | 68.752 | 62.114 | 54.771 | 37.849 | 12.084 | 6.824 | 10.188 | 8.422 | 16.347 | 40.305 | 437.373 | 20 |
| 21 | 62.767 | 62.910 | 86.487 | 51.422 | 35.597 | 11.316 | 6.478 | 10.446 | 8.327 | 13.925 | 45.513 | 99.910 | 21 |
| 22 | 63.115 | 65.671 | 95.530 | 51.407 | 57.868 | 10.942 | 5.653 | 11.192 | 8.354 | 15.567 | 31.273 | 51.811 | 22 |
| 23 | 60.241 | 67.535 | 125.664 | 178.991 | 44.106 | 10.355 | 5.203 | 14.826 | 8.259 | 12.930 | 22.779 | 39.253 | 23 |
| 24 | 72.101 | 100.459 | 118.729 | 115.904 | 45.266 | 10.237 | 5.093 | 23.467 | 7.845 | 12.205 | 22.531 | 31.160 | 24 |
| 25 | 77.745 | 222.963 | 103.309 | 72.623 | 45.482 | 10.371 | 5.092 | 31.643 | 9.144 | 11.341 | 36.224 | 26.826 | 25 |
| 26 | 62.547 | 382.639 | 115.741 | 59.073 | 31.762 | 10.543 | 6.141 | 20.835 | 8.777 | 11.866 | 41.873 | 23.221 | 26 |
| 27 | 56.051 | 197.484 | 90.986 | 52.054 | 31.239 | 10.814 | 6.419 | 19.700 | 9.495 | 17.066 | 28.033 | 21.995 | 27 |
| 28 | 52.914 | 128.509 | 78.515 | 47.456 | 28.498 | 11.798 | 6.108 | 18.781 | 10.313 | 26.522 | 22.614 | 21.097 | 28 |
| 29 | 50.242 | 102.843 | 68.521 | 46.338 | 26.862 | 13.571 | 6.285 | 16.735 | 11.779 | 27.610 | 21.063 | 20.968 | 29 |
| 30 | 47.980 | | 61.401 | 45.587 | 25.804 | 16.711 | 6.431 | 14.108 | 12.360 | 25.332 | 23.671 | 20.166 | 30 |
| 31 | 46.672 | | 58.581 | | 24.002 | | 6.998 | 13.208 | | 18.351 | | 17.776 | 31 |
| Mean | 197.504 | 157.487 | 80.447 | 81.364 | 35.285 | 16.802 | 9.210 | 13.738 | 9.354 | 14.447 | 22.185 | 46.973 | |
| Maximum | 952.691 | 711.622 | 125.664 | 533.127 | 58.537 | 39.502 | 14.968 | 31.643 | 12.500 | 27.610 | 45.513 | 437.373 | |
| Day of Max. | 9 | 13 | 23 | 13 | 2 | 8 | 1 | 25 | 1 | 29 | 21 | 20 | |
| Min | 46.672 | 41.071 | 58.581 | 38.928 | 24.002 | 10.237 | 5.092 | 5.579 | 7.491 | 9.740 | 13.074 | 15.765 | |
| Day of Min. | 31 | 8 | 31 | 9 | 31 | 24 | 25 | 5 | 18 | 17 | 13 | 17 | |
| Total (TCM) | 6123 | 4567 | 2494 | 2441 | 1094 | 504 | 286 | 426 | 281 | 448 | 666 | 1456 | |
| Runoff (mm) | 39 | 29 | 16 | 16 | 7 | 3 | 2 | 3 | 2 | 3 | 4 | 9 | |

Above summary is for Daily Means of Flow

E. A. Midlands - Headquarters Hydrometry

Auth. Ref. : 2015
Loc. Desc. : BOW BR.
Report Type : Daily Means For Yr.
Parameter : Flow
Units : Ml/d

Period : 1997

Station Name : BESFORD BRIDGE
Catchment Ref.: LS
Grid Ref. : SO 927463
Gauge Zero : N/A
Catchment Area: 156.000 Sq Km

Start of Day : 09:00 GMT

| Day | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Day |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 16.895 | 16.836 | 60.797 | 17.307 | 14.432 | 9.696 | 33.398 | | | | | | 1 |
| 2 | 19.294 | 17.200 | 56.125 | 16.749 | 13.189 | 8.726 | | | | | | | 2 |
| 3 | 17.860 | 16.891 | 49.557 | 17.013 | 13.000 | 8.365 | | | | | | | 3 |
| 4 | 17.884 | 16.820 | 43.845 | 16.328 | 14.916 | 8.163 | | | | | | | 4 |
| 5 | 17.667 | 17.204 | 44.695 | 16.112 | 21.816 | 8.958 | | | | | | | 5 |
| 6 | 17.932 | 16.731 | 41.494 | 16.145 | 33.706 | 10.199 | | | | | | | 6 |
| 7 | 17.217 | 16.526 | 38.100 | 16.078 | 24.107 | 9.996 | | | | | | | 7 |
| 8 | 16.539 | 16.466 | 35.591 | 14.633 | 20.118 | 10.106 | | | | | | | 8 |
| 9 | 16.805 | 16.834 | 33.662 | 14.565 | 66.282 | 9.051 | | | | | | | 9 |
| 10 | 16.766 | 17.937 | 32.688 | 14.175 | 50.091 | 9.217 | | | | | | | 10 |
| 11 | 16.585 | 19.396 | 31.132 | 13.969 | 61.874 | 14.289 | | | | | | | 11 |
| 12 | 17.128 | 22.553 | 30.038 | 13.967 | 38.282 | 16.027 | | | | | | | 12 |
| 13 | 17.842 | 34.137 | 27.005 | 14.296 | 32.217 | 24.579 | | | | | | | 13 |
| 14 | 17.567 | 29.998 | 26.222 | 14.712 | 23.576 | 54.070 | | | | | | | 14 |
| 15 | 16.533 | 24.655 | 27.282 | 14.119 | 19.142 | 44.007 | | | | | | | 15 |
| 16 | 16.507 | 23.268 | 24.972 | 12.750 | 17.910 | 32.613 | | | | | | | 16 |
| 17 | 16.594 | 31.010 | 23.781 | 13.141 | 22.397 | 19.909 | | | | | | | 17 |
| 18 | 16.931 | 179.607 | 23.389 | 13.316 | 24.909 | 15.126 | | | | | | | 18 |
| 19 | 17.857 | 131.981 | 22.319 | 13.608 | 26.548 | 13.508 | | | | | | | 19 |
| 20 | 18.828 | 171.067 | 21.723 | 13.568 | 34.682 | 16.974 | | | | | | | 20 |
| 21 | 17.373 | 87.067 | 21.165 | 13.067 | 35.796 | 33.776 | | | | | | | 21 |
| 22 | 18.498 | 61.058 | 20.918 | 12.404 | 25.117 | 38.785 | | | | | | | 22 |
| 23 | 23.350 | 56.797 | 21.646 | 11.555 | 19.174 | 27.206 | | | | | | | 23 |
| 24 | 20.695 | 110.212 | 23.020 | 11.670 | 16.479 | 18.621 | | | | | | | 24 |
| 25 | 20.062 | 308.810 | 21.837 | 29.073 | 14.884 | 20.806 | | | | | | | 25 |
| 26 | 19.076 | 204.252 | 20.104 | 58.959 | 13.288 | 193.545 | | | | | | | 26 |
| 27 | 18.280 | 122.820 | 19.161 | 44.854 | 12.558 | 331.086 | | | | | | | 27 |
| 28 | 17.696 | 77.988 | 18.306 | 28.937 | 11.925 | 77.426 | | | | | | | 28 |
| 29 | 16.788 | | 18.038 | 20.710 | 11.044 | 42.670 | | | | | | | 29 |
| 30 | 17.148 | | 17.387 | 16.541 | 10.276 | 30.923 | | | | | | | 30 |
| 31 | 17.017 | | 17.240 | | 10.043 | | | | | | | | 31 |
| Mean | 17.846 | 66.647 | 29.459 | 18.144 | 24.315 | 38.614 | 33.398 | | | | | | |
| Maximum | 23.350 | 308.810 | 60.797 | 58.959 | 66.282 | 331.086 | 33.398 | | | | | | |
| Day of Max. | 23 | 25 | 1 | 26 | 9 | 27 | 1 | | | | | | |
| Min | 16.507 | 16.466 | 17.240 | 11.555 | 10.043 | 8.163 | 33.398 | | | | | | |
| Day of Min. | 16 | 8 | 31 | 23 | 31 | 4 | 1 | | | | | | |
| Total (TCM) | 553 | 1866 | 913 | 544 | 754 | 1158 | 33 | | | | | | |
| Runoff (mm) | 4 | 12 | 6 | 3 | 5 | 7 | 0 | N/A | N/A | N/A | N/A | N/A | |

Above summary is for Daily Means of Flow.

Output from HYDROLOG Data Management System V2.33(C) 1991-97 Hydro-Logic Ltd
Long Term Statistics Printed on 03/07/1997 at 14:48 hrs

E. A. Midlands - Headquarters Hydrometry

| | | | |
|---|---|---|---|
| Auth. Ref. | : 2015 | Station Name | : BESFORD BRIDGE |
| Loc. Desc. | : BOW BR. | Catchment Ref. | : LS |
| Report Type | : Duration/Frequency | Grid Ref. | : SO 927463 |
| Parameter | : Flow | Gauge Zero | : N/A |
| Units | : Ml/d | Catchment Area | : 156.000 Sq Km |
| Period | : 01/10/1969 to 30/06/1997 | Start of Day | : 09:00 GMT |

Analysis period : Calendar Year

DATA FREQUENCY ANALYSIS

| Daily Mean Value(DMV) | DMV as % of LTA | % values exceeding | Range of values of DMV From | To | No. in Range |
|---|---|---|---|---|---|
| 2505.600 | 2812.855 | 0.000 | >2505.600 | | 0 |
| 1400.000 | 1571.678 | 0.173 | 1400.000 - | 2505.600 | 12 |
| 760.000 | 853.197 | 1.585 | 760.000 - | 1400.000 | 98 |
| 420.000 | 471.503 | 3.991 | 420.000 - | 760.000 | 167 |
| 230.000 | 258.204 | 8.818 | 230.000 - | 420.000 | 335 |
| 130.000 | 145.942 | 16.340 | 130.000 - | 230.000 | 522 |
| 71.000 | 79.707 | 28.646 | 71.000 - | 130.000 | 854 |
| 39.000 | 43.782 | 45.403 | 39.000 - | 71.000 | 1163 |
| 22.000 | 24.698 | 66.427 | 22.000 - | 39.000 | 1459 |
| 12.000 | 13.472 | 87.435 | 12.000 - | 22.000 | 1458 |
| 6.600 | 7.409 | 96.830 | 6.600 - | 12.000 | 652 |
| 3.700 | 4.154 | 98.473 | 3.700 - | 6.600 | 114 |
| 2.000 | 2.245 | 99.135 | 2.000 - | 3.700 | 46 |
| 1.100 | 1.235 | 99.380 | 1.100 - | 2.000 | 17 |
| 0.620 | 0.696 | 99.640 | 0.620 - | 1.100 | 18 |
| 0.340 | 0.382 | 99.712 | 0.340 - | 0.620 | 5 |
| 0.190 | 0.213 | 99.798 | 0.190 - | 0.340 | 6 |
| 0.100 | 0.112 | 99.813 | 0.100 - | 0.190 | 1 |
| 0.057 | 0.064 | 99.827 | 0.057 - | 0.100 | 1 |
| 0.032 | 0.036 | 99.841 | 0.032 - | 0.057 | 1 |
| 0.018 | 0.020 | 99.856 | 0.018 - | 0.032 | 1 |
| 0.010 | 0.011 | 99.870 | 0.010 - | 0.018 | 1 |
| 0.005 | 0.006 | 99.885 | 0.005 - | 0.010 | 1 |
| 0.003 | 0.003 | 99.899 | 0.003 - | 0.005 | 1 |
| 0.002 | 0.002 | 99.914 | 0.002 - | 0.003 | 1 |
| 0.000 | 0.000 | 99.928 | 0.000 - | 0.002 | 1 |
| 0.000 | 0.000 | 99.942 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 99.957 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 99.971 | 0.000 - | 0.000 | 1 |
| 0.000 | 0.000 | 99.986 | 0.000 - | 0.000 | 1 |
| | | | <= | 0.000 | 1 |

SUMMARY STATISTICS FOR ANALYSIS PERIOD

| | | | |
|---|---|---|---|
| Maximum Daily Mean Value | = 2505.600 | Minimum Daily Mean Val. | = 0.000 |
| LTA Daily Mean (Lin Calc) | = 89.077 | Median Daily Mean Value | = 33.523 |
| Actual 95% Daily Mean | = 8.294 | Modal Daily Mean Value | = 12.571 |
| | | (Class Interval 5% of median value) | |

Number of values used = 6940
First year used = 1976
Last year used = 1996
Number of years used = 19 out of 21

)utput from HYDROLOG Data Management System V2.33(C) 1991-97 Hydro-Logic Ltd
.ong Term Statistics Printed on 03/07/1997 at 14:47 hrs

E. A. Midlands - Headquarters Hydrometry

| | | | |
|---|---|---|---|
| \uth. Ref. | : 2015 | Station Name | : BESFORD BRIDGE |
| .oc. Desc. | : BOW BR. | Catchment Ref. | : LS |
| teport Type | : Duration/Frequency | Grid Ref. | : SO 927463 |
| 'arameter | : Flow | Gauge Zero | : N/A |
| Jnits | : Ml/d | Catchment Area | : 156.000 Sq Km |
| 'eriod | : 01/10/1969 to 30/06/1997 | Start of Day | : 09:00 GMT |

\nalysis period : Calendar Year

DAILY MEAN VALUE EXCEEDED STATED AMOUNT FOR GIVEN PERCENTAGE OF TIME

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0% | | 914.89 | 669.25 | 517.45 | 419.99 | 368.24 | 312.34 | 277.78 | 250.04 | 226.37 |
| 10% | 203.73 | 188.44 | 174.53 | 164.33 | 150.85 | 141.09 | 132.11 | 125.37 | 118.54 | 112.23 |
| 20% | 105.24 | 100.48 | 95.472 | 90.547 | 86.832 | 82.512 | 78.797 | 75.859 | 72.835 | 69.898 |
| 30% | 66.960 | 64.195 | 61.690 | 59.616 | 57.283 | 55.296 | 52.963 | 51.149 | 49.162 | 47.434 |
| 40% | 46.051 | 44.842 | 43.459 | 41.990 | 40.694 | 39.485 | 38.275 | 36.547 | 35.683 | 34.560 |
| 50% | 33.523 | 32.746 | 31.795 | 30.845 | 29.981 | 29.203 | 28.598 | 28.080 | 27.475 | 26.870 |
| 60% | 26.266 | 25.661 | 24.797 | 24.192 | 23.587 | 22.896 | 22.291 | 21.600 | 21.082 | 20.390 |
| 70% | 19.872 | 19.440 | 18.922 | 18.490 | 17.885 | 17.366 | 16.848 | 16.416 | 15.984 | 15.552 |
| 80% | 15.120 | 14.774 | 14.429 | 13.997 | 13.651 | 13.219 | 12.701 | 12.182 | 11.664 | 11.232 |
| 90% | 10.800 | 10.368 | 10.022 | 9.590 | 8.986 | 8.294 | 7.690 | 6.394 | 4.493 | 2.419 |

SUMMARY STATISTICS FOR ANALYSIS PERIOD

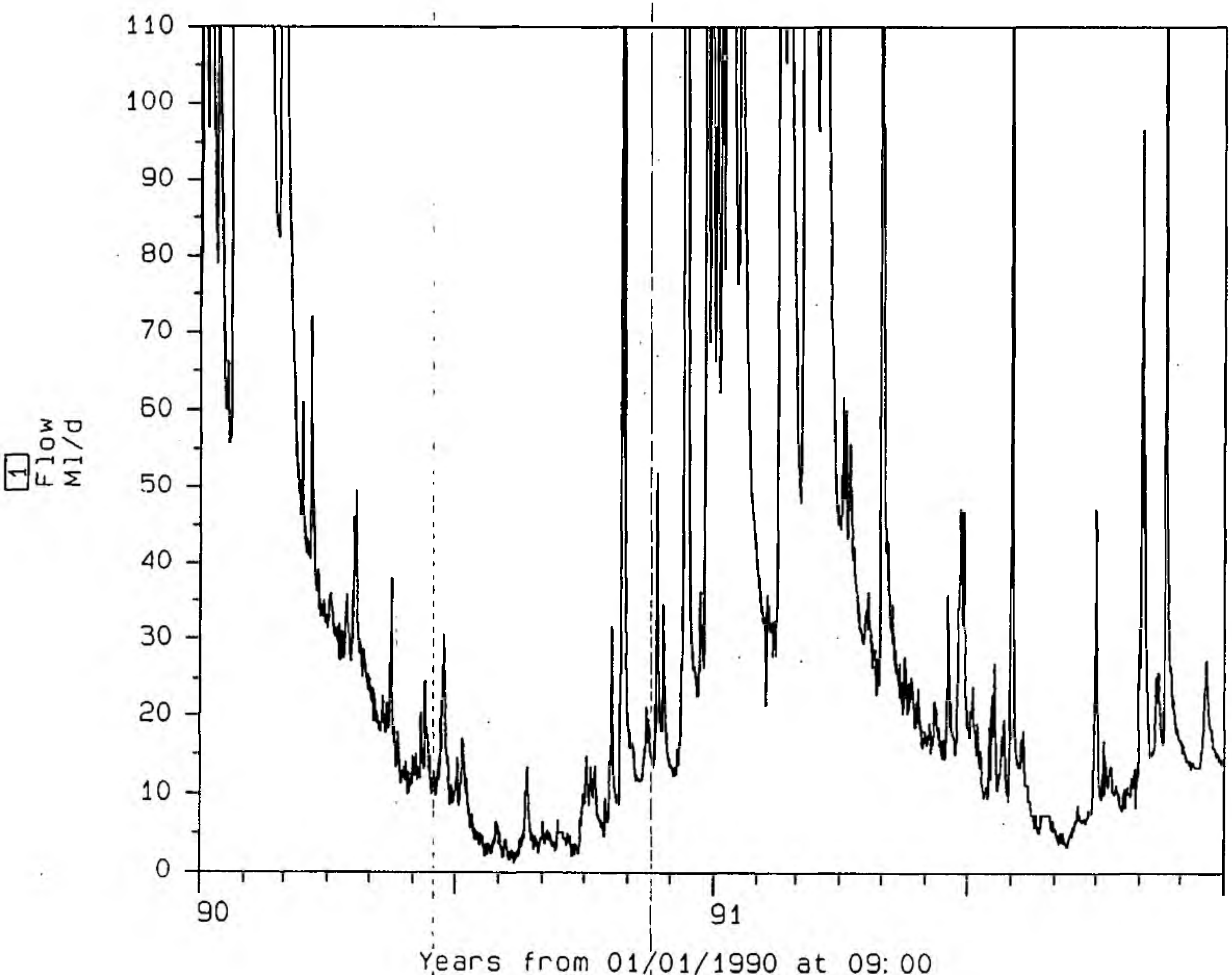
| | | | |
|---|---|---|---|
| Maximum Daily Mean Value | = 2505.600 | Minimum Daily Mean Val. | = 0.000 |
| LTA Daily Mean (Lin Calc) | = 89.077 | Median Daily Mean Value | = 33.523 |
| LTA Daily Mean (Log Calc) | = 40.069 | Log Standard Deviation | = 1.192 |
| Actual 95% Daily Mean | = 8.294 | Calc 95% Daily Mean | = 3.872 |

(Log-Normal distribution assumed)

Number of values used = 6940
First year used = 1976
Last year used = 1996
Number of years used = 19 out of 21

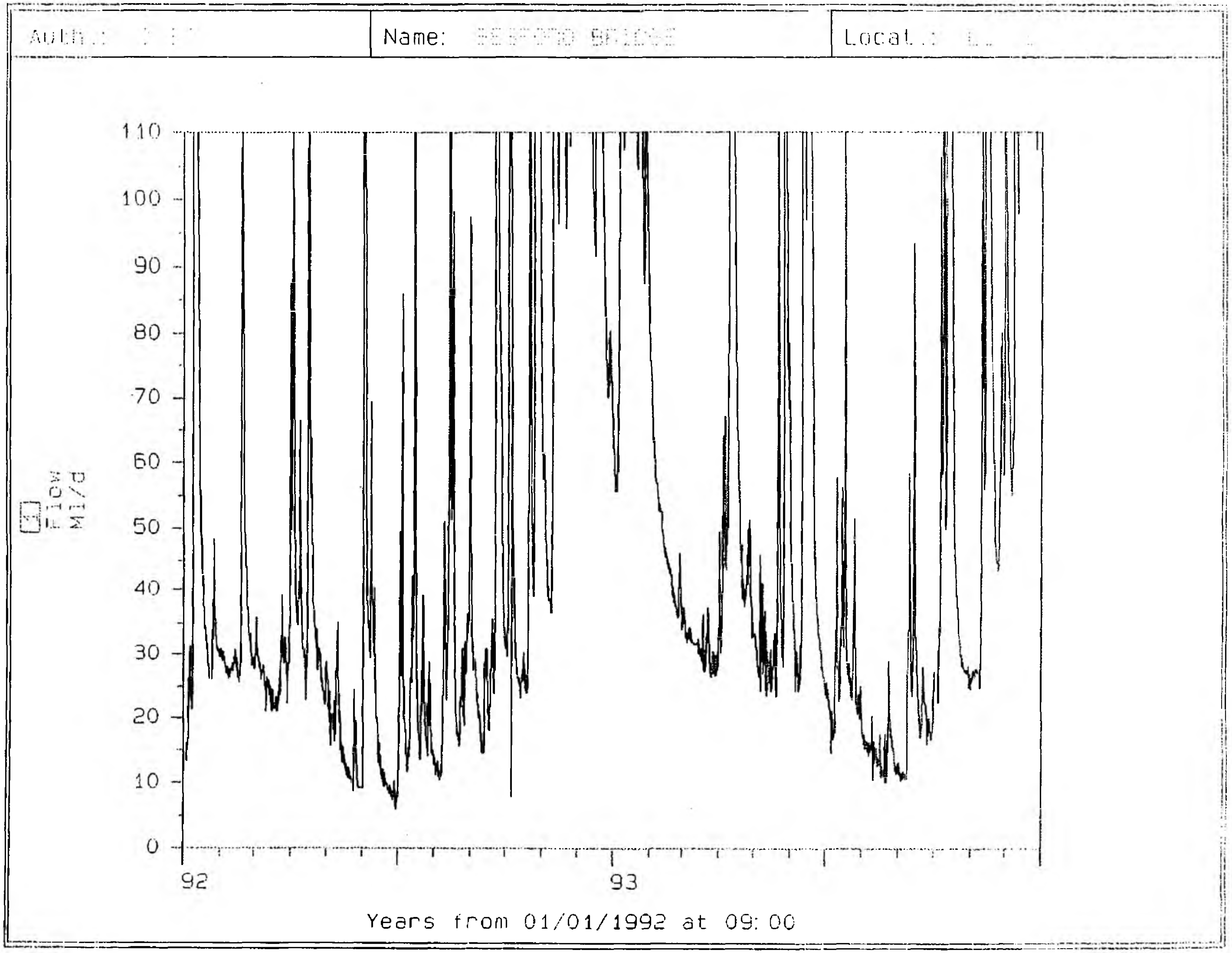
Only complete calendar years of data used

| Auth.: 2015 | Name: BESFORD BRIDGE | Locat.: BOW BR. |
|---|---|---|

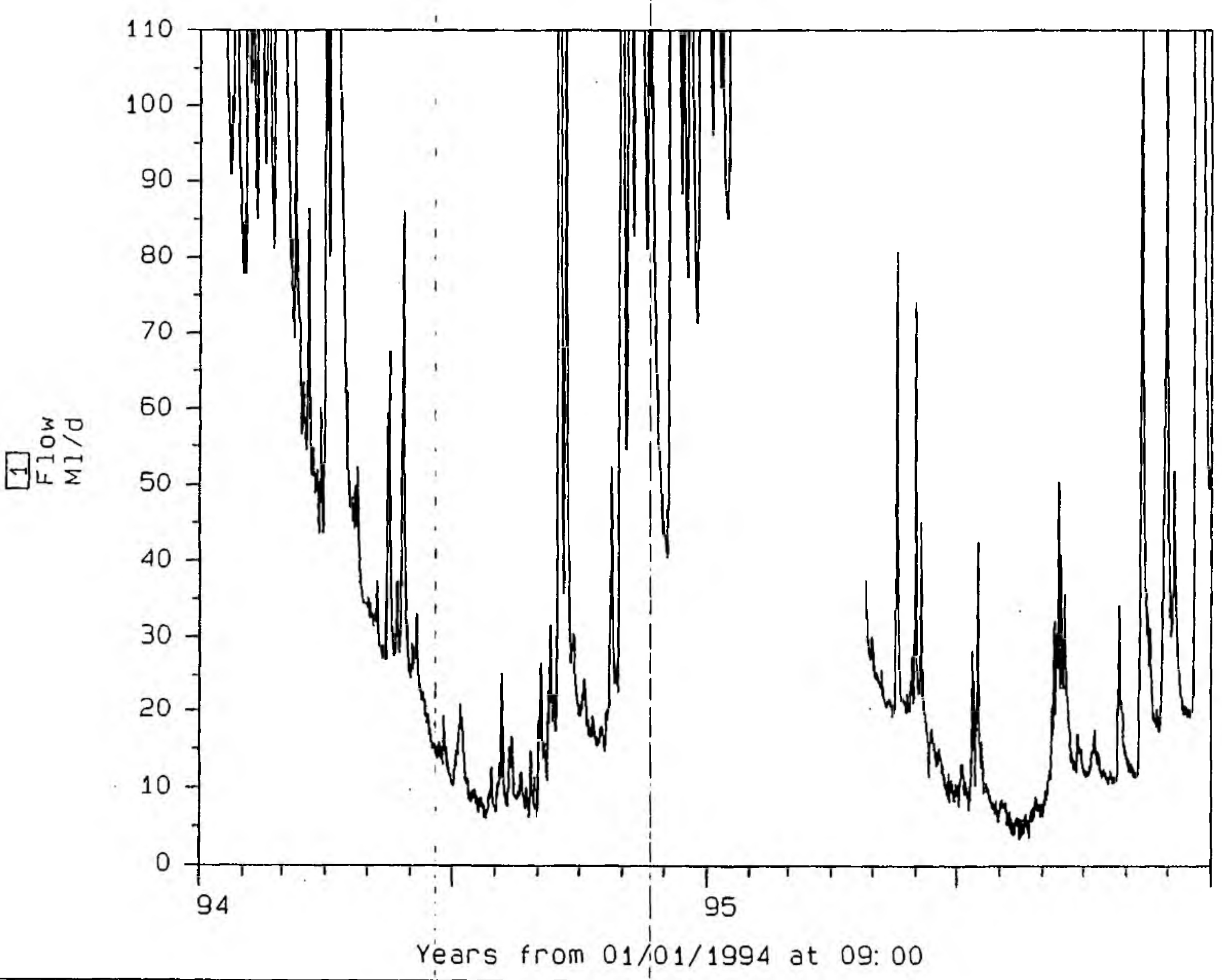


E. A. Midlands - Headquarters Hydrometry

HYDROLOG Archive Report

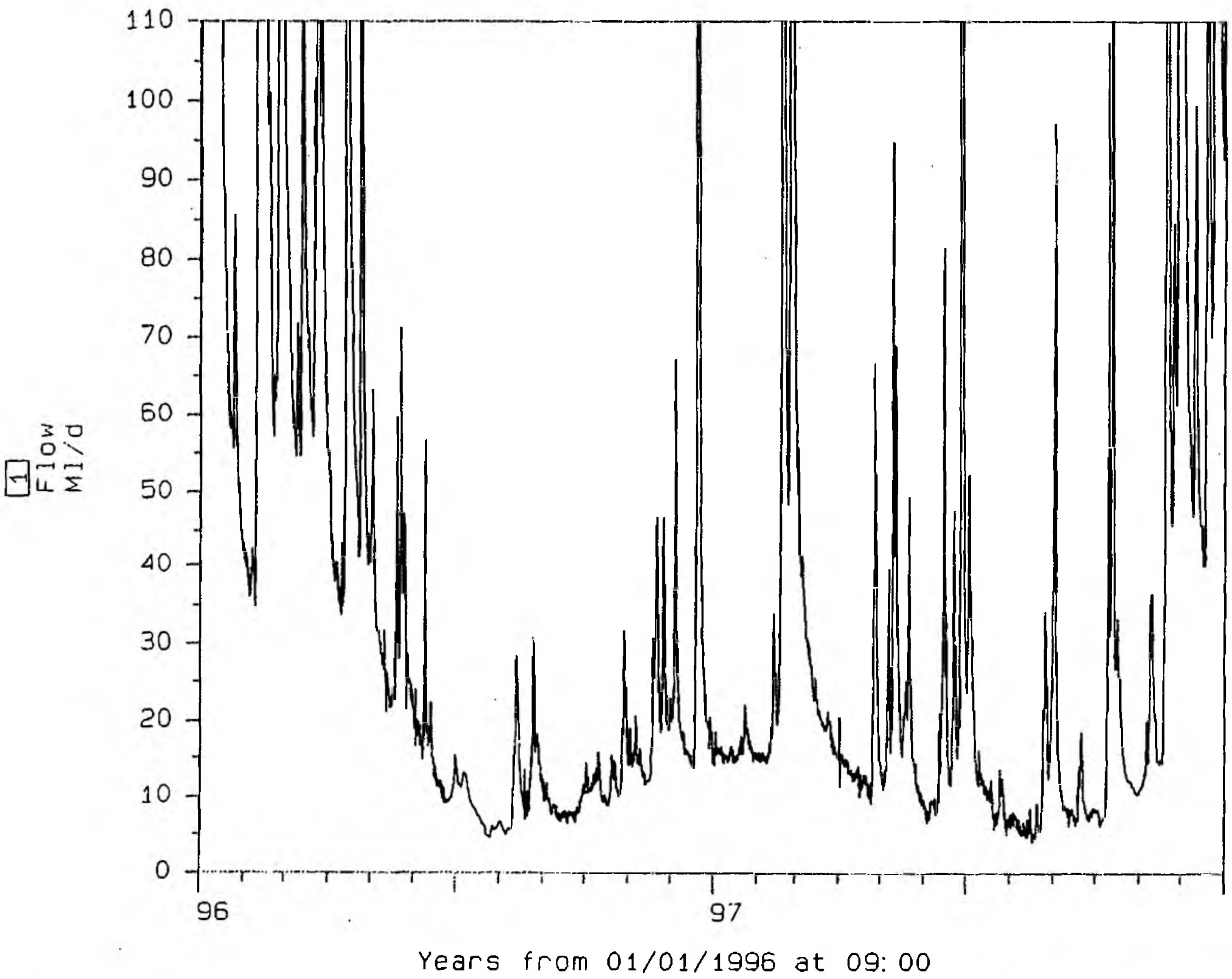


| Auth.: 2015 | Name: BESFORD BRIDGE | Locat.: BOW BR. |
|---|---|---|



E. A. Midlands - Headquarters Hydrometry HYDROLOG Archive Report

| Auth.: 2015 | Name: BESFORD BRIDGE | Locat.: BOW BR. |
|---|---|---|



AMP3 Water Resources Schemes - Bow Brook.

It is proposed to increase the flow at the top of Bow Brook catchment as part of the AMP3 low flow alleviation schemes. We have therefore been asked to determine what benefits this would have in terms of water quality. In response to the email from Dave Martin on 4th February 1998 and the enquiry from John Ratcliffe in Water Resources at Solihull, I have the following comments to make:

I have recalculated the consent for Priest Bridge assuming that a constant addition of 2ml/d is made to the top of the Bow Brook at Webheath when the flow at Besford Bridge reaches a minimum value. This was done by adding 2000m3/d as a constant addition to river flow for both BOD and NH3 and re-running the mass balance calculations.

| | Without 2ml/d | With 2ml/d |
|---|---|---|
| BOD (95%ile) | 8.52mg/l | 9.46mg/l |
| NH3 (95%ile) | 2.23mg/l | 2.56mg/l |

There is so little dilution in relation to the discharge flow that the extra flow upstream makes very little difference. The AMP3 consent conditions proposed to STWL for Priest Bridge STW were 20:10:3. I therefore do not anticipate that the consent conditions would need to be relaxed.

Diane McIlroy, 18th March 1998.

# Appendix 10

# Hewell Grange Lake

# Hewell Grange Lake

| | | |
|---|---|---|
| Environment Agency | - | John Ratcliffe 0121 711 2324<br>Glenn Hoban 0121 711 2324<br>Liz Galloway Fax 01684 293 599<br>Derek Lippett 0468 861 281 |
| David Bamber, Governor Hewell Grange Prisons | - | Fax 01527 550178 |
| English Heritage | - | 0171 973 3000 |
| English Nature, Jonathan Burney, Economist | - | 01733 455 000 |
| Arthur Amos Associates | - | Fax 01905 640 477 |

## General

| | | |
|---|---|---|
| **Ramblers Association** | - | **0171 582 6878** |
| **Countryside Commission** | - | **0171 831 3510** |
| **Office National Statistics** | - | **0171 233 9233** |
| **Halifax Building Society's Statistical Service** | | **01422 333 333** |
| **Talking Pages** | - | **0800 600 900** |

**Hewell Grange - SSSI**

Enclosed is a copy of the "Outline Case for inclusion in AMP3" for Hewell Park Lake. This sets out English Nature's view on the lake's requirements for maintenance of the lake. The Agency has undertaken a review of the last 10 years of Level records for the lake. From these we have compiled Tables 1 and 2 which indicate the number of days per year the lake falls below stipulated levels. In addition the rate of change of level has been calculated, this allows a leakage rate against level to be produced (see Figure 2). Using these tables and Figure 2 it is possible to estimate the volume of water which will be required to maintain stipulated levels.

You have been provided with the details of the outside contact (A Amoss) who has been involved with the SSSI as the Prison Service contact as well as our own expert Liz Galloway (Area Landscape Architect - Tewkesbury) who will be able to assist you in estimating the benefit for the option to be considered.

Could you therefore consider the benefits to both the Garden and the SSSI of keeping the lake at a minimum level of:

- A - 100mm
- B - 200 mm
- C - 300 mm
- D - 400 mm

It is known that the compensation release will be triggered by the lake level, and that this will be an Agency monitoring point. The location of the Severn Trent Water plc borehole which will provide the compensation release is at NGR SP 0020 7020, situated on the southern stream feeding the lake.

SSSIs: OUTLINE CASE FOR INCLUSION IN AMP3
WATER COMPANY ABSTRACTIONS

HEWELL.MID

| | |
|---|---|
| SSSI Name: | HEWELL PARK LAKE |
| Name of water body, if different: | Hewell Lake |

| | |
|---|---|
| SAC Name: | |

| | |
|---|---|
| SPA Name: | |

| | | | | | |
|---|---|---|---|---|---|
| County: | H + W | EA Region: | MIDLANDS | EN LAT: | THREE COUNTIES |

**Wildlife interest:**
Open water is a scarce habitat in Worcestershire. The lake margins have extensive areas of reed, which support one of the largest reed warbler colonies in Worcestershire. Breeding waterfowl include great crested grebe. Good populations of amphibians and reptiles include a high density of grass snakes.

**Problem affecting wildlife interest:**
The lake was formerly in hydrological continuity with the water table, and received surface water from a small catchment. This maintained a high water table all year (and fed a series of water features in the Repton designed landscape). Water abstraction within c1km lowered the water table, so the lake leaks. Concurrently the lake had lost substantial inputs from surface run-off due to changes in catchment drainage.The major part of this will be restored by maintenance work on the culvert under the Worcester and Birmingham Canal. At present the Environment Agency is in discussion with BW so that modifications to feed arrangements can be agreed. These will probably be in the form of a Memorandum of Understanding which will be in operation for 5 years.
The most noticeable effect in wildlife terms is that the main body of the reedbed is dry in summer. Terrestrial vegetation is becoming established, and this main block has largely lost breeding reed warblers. Great crested grebe numbers have also apparently declined. Reed is also spreading along both the eastern and western sides of the lake, in the latter case causing a conflict with landscape objectives.

**Origin of concern:**
Impact of Water Abstraction on Wetland SSSI's (August 1996 report by hydrological consultants to English Nature)
A botanical survey of wetlands planned by the Worcestershire Wildlife Trust for 1998 will quantify actual vegetation changes since an earlier survey in 1978.

| Water Company: | Severn-Trent Water plc | | | |
|---|---|---|---|---|
| **Abstraction location:** | **Licence Nos:** | **SW/GW*[1]** | **Abstraction quantity:** | **Likely action required *[2]:** |
| SP00087022 | 18/54/15/0183 | GW | 2903.8 tcma | Compensation pumping during periods of low levels which will be triggered by the automatic monitored reservoir level logger. Variation in discharge rates will be trialed to confirm restoration of levels in the lake and monitor the effect on SSSI, fishery and gardens. |
| SP00906690 | 18/54/19/0113 | GW | 2646.3 tcma | |

**Risks to nature conservation of not carrying out works:**
There is likely to be a continuing decline in numbers of breeding reed warblers and aquatic waterfowl. However, these losses should be fairly easily reversed if higher water levels are restored. There are also serious implications for the aquatic flora and fauna.

*[1] SW/GW - surface water/ groundwater
*[2] 0 - no reduction required; 1 - reduce licence by 0-25%; 2 - reduce licence by 25-50%; 3 - reduce licence by 50-75%; 4 - move borehole; 5 - revoke abstraction licence; 6 - compensation water (if reductions are seasonal, state which months)

HEWELL ANGE

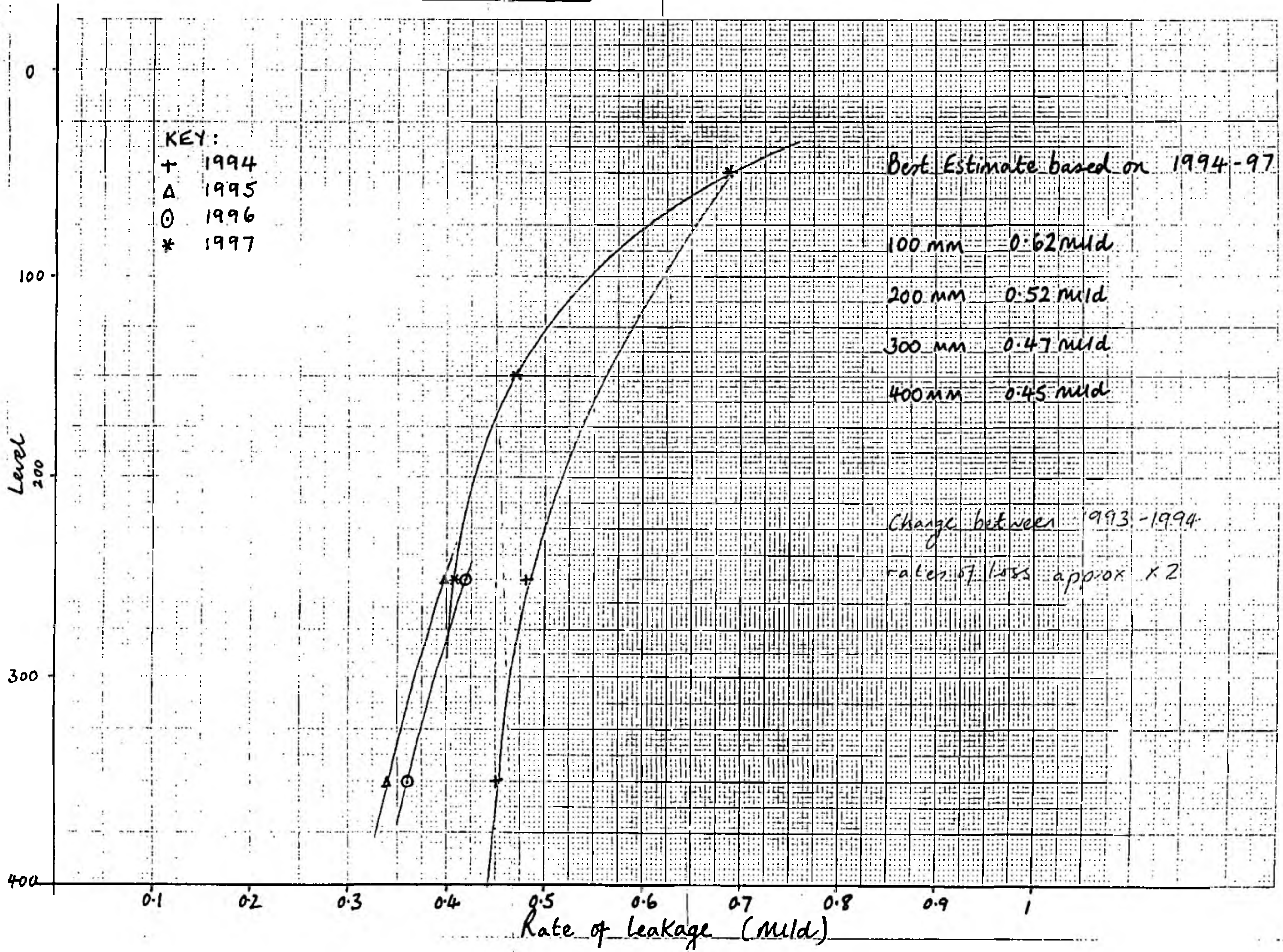

KEY:
+ 1994
Δ 1995
⊙ 1996
* 1997
Best Estimate based on 1994-97
100 mm 0·62 Mld
200 mm 0·52 Mld
300 mm 0·47 Mld
400 mm 0·45 Mld
Change between 1993-1994
rates of loss approx x 2
Level
0
100
200
300
400
0·1
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
1
Rate of Leakage (Mld)

TABLE I

# HEWELL GRANGE RESERVOIR LEVELS

-0 LEVEL

| START DATE | DAY NO. IN YEAR | END DATE | DAY NO. IN YEAR | NO. DAYS BELOW LEVEL |
|---|---|---|---|---|
| 18/12/88 | 49 | 01/12/92 | 336 | 1747 |
| 01/02/93 | 32 | 01/12/93 | 335 | 303 |
| 23/04/94 | 113 | 13/12/94 | 347 | 234 |
| 01/03/95 | 60 | 27/06/97 | 178 | 118 |
| 03/07/97 | 184 | 21/12/97 | 355 | 181 |

-100 LEVEL

| START DATE | DAY NO. IN YEAR | END DATE | DAY NO. IN YEAR | NO. DAYS BELOW LEVEL |
|---|---|---|---|---|
| 07/03/88 | 67 | 18/02/89 | 49 | 347 |
| 25/04/89 | 115 | 20/11/92 | 325 | 1305 |
| 13/06/93 | 164 | 01/12/94 | 330 | 166 |
| 28/04/94 | 118 | 01/12/94 | 335 | 217 |
| 01/04/95 | 91 | 24/02/96 | 55 | 329 |
| 04/03/96 | 64 | 23/06/97 | 174 | 475 |
| 15/07/97 | 196 | 22/11/97 | 326 | 130 |

-200

| START DATE | DAY NO. IN YEAR | END DATE | DAY NO. IN YEAR | NO. DAYS BELOW LEVEL |
|---|---|---|---|---|
| 19/04/88 | 110 | 30/01/89 | 30 | 285 |
| 23/05/89 | 143 | 06/03/90 | 65 | 287 |
| 30/04/90 | 120 | 07/11/92 | 312 | 922 |
| 14/07/93 | 195 | 19/11/93 | 323 | 128 |
| 12/06/94 | 163 | 26/11/94 | 330 | 167 |
| 12/05/95 | 132 | 24/12/95 | 358 | 226 |
| 03/01/96 | 3 | 04/02/96 | 35 | 32 |
| 09/05/96 | 130 | 19/06/97 | 170 | 405 |
| 31/07/97 | 212 | 18/11/97 | 322 | 110 |

-300

| START DATE | DAY NO. IN YEAR | END DATE | DAY NO. IN YEAR | NO. DAYS BELOW LEVEL |
|---|---|---|---|---|
| 22/06/88 | 174 | 14/01/89 | 14 | 205 |
| 12/06/89 | 163 | 16/02/90 | 47 | 249 |
| 07/08/90 | 219 | 03/09/91 | 246 | 392 |
| 07/10/91 | 280 | 13/04/92 | 104 | 189 |
| 24/06/92 | 176 | 19/08/92 | 232 | 56 |
| 01/08/93 | 213 | 11/11/93 | 315 | 102 |
| 26/06/94 | 177 | 19/11/94 | 323 | 146 |
| 30/05/95 | 150 | 29/10/95 | 302 | 152 |
| 01/12/95 | 335 | 07/12/95 | 341 | 6 |
| 14/06/96 | 166 | 03/03/97 | 62 | 261 |
| 26/03/97 | 85 | 08/05/97 | 128 | 43 |
| 27/05/97 | 147 | 15/06/97 | 166 | 19 |
| 19/08/97 | 231 | 28/08/97 | 240 | 9 |
| 11/09/97 | 254 | 04/10/97 | 277 | 23 |

-400 LEVEL

| START DATE | DAY NO. IN YEAR | END DATE | DAY NO. IN YEAR | NO. DAYS BELOW LEVEL |
|---|---|---|---|---|
| 19/07/88 | 201 | 31/12/88 | 365 | 164 |
| 06/07/89 | 187 | 22/01/90 | 22 | 200 |
| 02/10/90 | 275 | 30/10/90 | 303 | 28 |
| 26/11/90 | 330 | 20/12/90 | 354 | 24 |
| 11/07/94 | 192 | 26/09/94 | 269 | 77 |
| 19/10/94 | 292 | 31/10/94 | 304 | 12 |
| 18/06/95 | 169 | 17/07/95 | 198 | 29 |
| 03/07/96 | 185 | 27/02/97 | 58 | 238 |

| NO. DAYS BELOW LEV[illegible] AND VOLUME IN ML/D | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| DEPTH BELOW RES. SURF. | 1993 DAYS | 1993 VOLUME | 1994 DAYS | 1994 VOLUME | 1995 DAYS | 1995 VOLUME | 1996 DAYS | 1996 VOLUME | 1997 DAYS | 1997 VOLUME |
| less than 0 | 303 | | 234 | | 305 | | 365 | | 359 | |
| less than 100 | 166 | 102.92 | 217 | 134.54 | 274 | 169.88 | 356 | 220.72 | 304 | 188.48 |
| less than 200 | 128 | 66.56 | 167 | 86.84 | 226 | 117.52 | 270 | 140.4 | 280 | 145.6 |
| less than 300 | 102 | 47.94 | 146 | 68.62 | 152 | 71.44 | 199 | 93.53 | 156 | 73.32 |
| less than 400 | 0 | 0 | 89 | 40.05 | 29 | 13.05 | 180 | 81 | 58 | 26.1 |

# Appendix 11

## River Sherbourne

<u>**River Sherbourne**</u>

| | | |
|---|---|---|
| **Environment Agency** | - | **John Ratcliffe 0121 711 2324**<br>**Glenn Hoban 0121 711 2324**<br>**John Irish 01684 850 951** |
| **Nuneaton Council** | - | **Fax 01203 376 433** |
| **Coventry City Council** | - | **01203 832 333** |
| **Leisure Services** | - | **01203 832 437** |
| **Parks Department** | - | **01203 832 348** |
| **Coventry Tourist Information Centre** | - | **01203 832 303** |
| **Local Ramblers Association Member** | - | **Mr Meek 01676 541 836** |

## General

| | | |
|---|---|---|
| **Ramblers Association** | - | **0171 582 6878** |
| **Countryside Commission** | - | **0171 831 3510** |
| **Office National Statistics** | - | **0171 233 9233** |
| **Halifax Building Society's Statistical Service** | | **01422 333 333** |
| **Talking Pages** | - | **0800 600 900** |

**River Sherborne**

TheRiver Sherborne and its tributaries the Pickford and the Guphill brooks have all been affected by groundwater abstraction undertaken by the local public water company. This has resulted in the upper reaches of the river having a history of low/zero flow. The spot gaugings which were undertaken in 1991, 1992 and 1995 indicated that during July/Oct 91, May/Aug 93 and July/Aug 95 there was no flow in the River Sherborne at Wall Hill (SP 2950 8340) and Stonehouse (SP 2930 8210). Also at Allesley (SP 3090 8020) during Sept/Nov 95 zero flow was recorded. Similarly on the Prickford brook zero flows were recorded July/Aug 95 at Windmill Hill (SP 2860 8100) Upper Eastern Green (SP 2740 8070) and Allesley Green (SP 2910 8050). As can be seen from the enclosed full spot gauging record limited information is available, but local information suggests that the river and tributaries are dry for considerable periods each year. In February 98 sites at Sandpit Farm (SP 2750 8254) and Hawkes Enf (SP 2936 8289) were observed to have zero flows.

There are a number of options which are to be considered. In some cases this is to try and indicate how sensitive the analysis is to relatively small changes in location and flow. The options to be reviewed at:

1 Pickford Brook (SP 2700 8250) to receive a compensation release from existing STW plc borehole (Meriden) of 1Ml/d.

2 River Shelbourne (SP 3070 8280) to receive a compensation release from existing STW plc borehole (Brown Green) of 1Ml/d.

3a River Sherbourne (SP 2950 8300) to receive a compensation release form existing STW plc pipelines (Chlorinated Water) of 1Ml/d.

3b River Sherborne (SP 2850 8390) to receive a compensation release from proposed new borehole of 1Ml/d.

4 A combination of Options 1 + 2.

5 A combination of Options 1 + 2 + 3a

6 A combination of Options 1 + 2 + 3b

In all cases the downstream point for consideration will be the confluence of the River Sherbourne with the River Avon (SP 3450 7550). Enclosed are the population figures for each option or combination of options relating to 0.8, 3 and 17 Km radius of the rivers and brooks.

With so little information it is difficult to estimate what should be the trigger flow which set the compensation release in operation. We have produced two Duration/Frequency Graphs for the sites at Kingsbury Road (SP 3090 8020) and Bagington A45 bridge (SP ~~3090 8020~~).(3440 7560 From these and from the spot gaugings data base could you consider a trigger of Q50 at Kingsbury (2.0 Ml/d) as the starting flow for all options. It is hoped to refine these relationships during the next 12 months.

| | | | |
|---|---|---|---|
| **Option 1** | **rewatered** | 4.2 | **Km** |
| | Substantial increase in flow | 7.6 | Km |
| **Option 2** | **rewatered** | 2.8 | **Km** |
| | Substantial increase in flow | 7.6 | Km |
| **Option 3a** | **rewatered** | 3.2 | **Km** |
| | Substantial increase in flow | 7.6 | Km |
| **Option 3b** | **rewatered** | 5.2 | **Km** |
| | Substantial increase in flow | 7.6 | Km |
| **Option 1 + 2** | **rewatered** | 7.6 | **Km** |
| | Substantial increase in flow | 7.6 | Km |
| **Option 1 + 2 + 3a** | **rewatered** | 10.0 | **Km** |
| | Substantial increase in flow | 7.6 | Km |
| **Option 1 + 2 + 3b** | **rewatered** | 12.0 | **Km** |
| | Substantial increase in flow | 7.6 | Km |

SHERBOURNE CURRENT METER GAUGINGS UPDATE 18-Jun-97

| River name | NGR | Location | Date of gauging | Discharge cumecs | Discharge Mld | Comments |
|---|---|---|---|---|---|---|
| SHERBOURNE | SP29508340 | WALL HILL | 22-May-91 | 0.000 | 0.026 | PICKFORD GREENSURVEY |
| SHERBOURNE | SP29508340 | WALL HILL | 26-Jun-91 | 0.001 | 0.060 | PICKFORD GREEN BORE-HOLE SURVEYAFTER WET SPELL |
| SHERBOURNE | SP29508340 | WALL HILL | 10-Jul-91 | 0.000 | 0.000 | PICKFORD GREENBOREHOLE SURVEY |
| SHERBOURNE | SP29508340 | WALL HILL | 24-Jul-91 | 0.000 | 0.000 | PICKFORD BOREHOLESURVEY |
| SHERBOURNE | SP29508340 | WALL HILL | 07-Aug-91 | 0.000 | 0.035 | PICKFORD GREENBOREHOLE SURVEY |
| SHERBOURNE | SP29508340 | WALL HILL | 02-Oct-91 | 0.001 | 0.052 | PICKFORD GREENBOREHOLE SURVEY |
| SHERBOURNE | SP29508340 | WALL HILL | 16-Oct-91 | 0.000 | 0.000 | PICKFORD GREENBOREHOLE SURVEY |
| SHERBOURNE | SP29508340 | WALL HILL | 30-Oct-91 | 0.003 | 0.294 | PICKFORD GREENBOREHOLE SURVEY |
| SHERBOURNE | SP29508340 | WALL HILL | 27-Nov-91 | 0.002 | 0.147 | PICKFORD GREEN STUDY |
| SHERBOURNE | SP29508340 | WALL HILL | 20-Dec-91 | 0.003 | 0.268 | PICKFORD GREENBOREHOLE SURVEY |
| SHERBOURNE | SP29508340 | WALL HILL | 26-Dec-91 | 0.003 | 0.268 | PICKFORD GREEN BOREHOLE SURVEY |
| SHERBOURNE | SP29508340 | WALL HILL | 22-Jan-92 | 0.002 | 0.216 | PICKFORD GREENBOREHOLE SURVEY |
| SHERBOURNE | SP29508340 | WALL HILL | 18-Mar-92 | 0.002 | 0.199 | PICKFORD GREENBOREHOLE SURVEY |
| SHERBOURNE | SP29508340 | WALL HILL | 29-Apr-92 | 0.001 | 0.069 | PICKFORD GREENSURVEY |
| SHERBOURNE | SP29508340 | WALL HILL | 13-May-92 | 0.000 | 0.026 | PICKFORD GREENSURVEY |
| SHERBOURNE | SP29508340 | WALL HILL | 13-May-92 | 0.000 | 0.026 | PICKFORD GREENSURVEY |
| SHERBOURNE | SP29508340 | WALL HILL | 28-May-92 | 0.000 | 0.000 | DUMMY GAUGINGVERY SMALL FLOWPICKFORD GREEN SURVEY |
| SHERBOURNE | SP29508340 | WALL HILL | 10-Jun-92 | 0.000 | 0.009 | PICKFORD GREENSURVEY |
| SHERBOURNE | SP29508340 | WALL HILL | 24-Jun-92 | 0.000 | 0.000 | DUMMY GAUGINGNO FLOWPICKFORD GREEN SURVEY |
| SHERBOURNE | SP29508340 | WALL HILL | 08-Jul-92 | 0.000 | 0.000 | PICKFORD GREEN SURVEY |
| SHERBOURNE | SP29508340 | WALL HILL | 22-Jul-92 | 0.001 | 0.043 | PICKFORD GREENSURVEY |
| SHERBOURNE | SP29508340 | WALL HILL | 05-Aug-92 | 0.000 | 0.000 | DUMMY GAUGING 0 FLOWPICKFORD GREEN SURVEY |
| SHERBOURNE | SP29508340 | WALL HILL | 19-Aug-92 | 0.000 | 0.000 | DUMMY GAUGING.VERYSMALL TRICKLE WITH WATERLYING IN STREAM BEDPICKFORD GREEN SURVEY |
| SHERBOURNE | SP29508340 | WALL HILL | 02-Sep-92 | 0.001 | 0.095 | PICKFORD GREEN SURVEY |
| SHERBOURNE | SP29508340 | WALL HILL | 16-Sep-92 | 0.000 | 0.026 | PICKFORD GREENSURVEY |
| SHERBOURNE | SP29508340 | WALL HILL | 30-Sep-92 | 0.002 | 0.147 | PICKFORD GREENSURVEY |
| SHERBOURNE | SP29508340 | WALL HILL | 22-Apr-93 | 0.002 | 0.216 | PICKFORD GREENSURVEY |
| SHERBOURNE | SP29508340 | WALL HILL | 12-May-93 | 0.002 | 0.138 | PICKFORD GREENSURVEY |
| SHERBOURNE | SP29508340 | WALL HILL | 09-Jun-93 | 0.002 | 0.173 | PICKFORD GREENSURVEY |
| SHERBOURNE | SP29508340 | WALL HILL | 07-Jul-93 | 0.000 | 0.035 | PICKFORD GREENSURVEY |
| SHERBOURNE | SP29508340 | WALL HILL | 03-Sep-93 | 0.001 | 0.052 | PICKFORD GREENSURVEY |
| SHERBOURNE | SP29508340 | WALL HILL | 24-Jul-95 | 0.000 | 0.000 | BONE DRY |
| SHERBOURNE | SP29508340 | WALL HILL | 25-Aug-95 | 0.000 | 0.000 | BONE DRY |
| SHERBOURNE | SP29368284 | HAWKES END | 18-Feb-98 | | 0.000 | |
| SHERBOURNE | SP29308210 | STONE HOUSE | 22-May-91 | 0.000 | 0.026 | PICKFORD GREENSURVEY |
| SHERBOURNE | SP29308210 | STONE HOUSE | 26-Jun-91 | 0.001 | 0.052 | PICKFORD GREEN BORE-HOLE SURVEYAFTER WET SPELL |
| SHERBOURNE | SP29308210 | STONE HOUSE | 10-Jul-91 | 0.000 | 0.009 | PICKFORD GREENBOREHOLE SURVEY |
| SHERBOURNE | SP29308210 | STONE HOUSE | 24-Jul-91 | 0.000 | 0.017 | PICKFORD BOREHOLESURVEY |
| SHERBOURNE | SP29308210 | STONE HOUSE | 07-Aug-91 | 0.000 | 0.009 | PICKFORD GREENBOREHOLE SURVEY |
| SHERBOURNE | SP29308210 | STONE HOUSE | 21-Aug-91 | 0.000 | 0.017 | GAUGED AS PICKFORDGREEN AREA STUDY |
| SHERBOURNE | SP29308210 | STONE HOUSE | 02-Oct-91 | 0.000 | 0.009 | PICKFORD GREENBOREHOLE SURVEY |
| SHERBOURNE | SP29308210 | STONE HOUSE | 16-Oct-91 | 0.000 | 0.017 | PICKFORD GREENBOREHOLE SURVEY |
| SHERBOURNE | SP29308210 | STONE HOUSE | 30-Oct-91 | 0.001 | 0.052 | PICKFORD GREENBOREHOLE SURVEY |
| SHERBOURNE | SP29308210 | STONE HOUSE | 27-Nov-91 | 0.000 | 0.017 | PICKFORD GREEN STUDY |
| SHERBOURNE | SP29308210 | STONE HOUSE | 20-Dec-91 | 0.001 | 0.121 | PICKFORD GREENBOREHOLE SURVEY |
| SHERBOURNE | SP29308210 | STONE HOUSE | 26-Dec-91 | 0.001 | 0.121 | PICKFORD GREENBOREHOLE SURVEY |
| SHERBOURNE | SP29308210 | STONE HOUSE | 22-Jan-92 | 0.002 | 0.216 | PICKFORD GREENBOREHOLE SURVEY |
| SHERBOURNE | SP29308210 | STONE HOUSE | 18-Mar-92 | 0.001 | 0.121 | PICKFORD GREENBOREHOLE SURVEY |
| SHERBOURNE | SP29308210 | STONE HOUSE | 29-Apr-92 | 0.001 | 0.060 | PICKFORD GREENSURVEY |
| SHERBOURNE | SP29308210 | STONE HOUSE | 13-May-92 | 0.001 | 0.052 | PICKFORD GREENSURVEY |
| SHERBOURNE | SP29308210 | STONE HOUSE | 13-May-92 | 0.001 | 0.052 | PICKFORD GREENSURVEY |
| SHERBOURNE | SP29308210 | STONE HOUSE | 28-May-92 | 0.000 | 0.017 | PICKFORD GREENSURVEY |
| SHERBOURNE | SP29308210 | STONE HOUSE | 10-Jun-92 | 0.000 | 0.035 | PICKFORD GREENSURVEY |
| SHERBOURNE | SP29308210 | STONE HOUSE | 24-Jun-92 | 0.000 | 0.000 | PICKFORD GREENSURVEY |
| SHERBOURNE | SP29308210 | STONE HOUSE | 08-Jul-92 | 0.000 | 0.000 | PICKFORD GREEN SURVEY |
| SHERBOURNE | SP29308210 | STONE HOUSE | 22-Jul-92 | 0.000 | 0.000 | PICKFORD GREENSURVEY |
| SHERBOURNE | SP29308210 | STONE HOUSE | 05-Aug-92 | 0.000 | 0.000 | DUMMY GAUGINGLESS THAN 0.005 MLDPICKFORD GREEN SURVEY |
| SHERBOURNE | SP29308210 | STONE HOUSE | 19-Aug-92 | 0.000 | 0.000 | DUMMY GAUGING.REASONABLE TRICKLE BUT UNMEASURABLE.WATER LYING IN STREAM BEDPICKFORD GREEN SURVEY |
| SHERBOURNE | SP29308210 | STONE HOUSE | 02-Sep-92 | 0.001 | 0.043 | PICKFORD GREEN SURVEY |
| SHERBOURNE | SP29308210 | STONE HOUSE | 16-Sep-92 | 0.000 | 0.000 | PICKFORD GREENSURVEY |
| SHERBOURNE | SP29308210 | STONE HOUSE | 30-Sep-92 | 0.001 | 0.069 | PICKFORD GREENSURVEY |
| SHERBOURNE | SP29308210 | STONE HOUSE | 22-Apr-93 | 0.002 | 0.138 | PICKFORD GREENSURVEY |
| SHERBOURNE | SP29308210 | STONE HOUSE | 12-May-93 | 0.001 | 0.043 | PICKFORD GREENSURVEY |
| SHERBOURNE | SP29308210 | STONE HOUSE | 09-Jun-93 | 0.001 | 0.052 | PICKFORD GREENSURVEY |
| SHERBOURNE | SP29308210 | STONE HOUSE | 07-Jul-93 | 0.000 | 0.017 | PICKFORD GREENSURVEY |

SHERBOURNE CURRENT METER GAUGINGS UPDATE 18-Jun-97

| River name | | NGR | Location | Date of gauging | Discharge cumecs | Discharge Mld | Comments |
|---|---|---|---|---|---|---|---|
| SHERBOURNE | | SP29308210 | STONE HOUSE | 06-Aug-93 | 0.000 | 0.009 | PICKFORD GREENSURVEY |
| SHERBOURNE | | SP29308210 | STONE HOUSE | 03-Sep-93 | 0.000 | 0.009 | PICKFORD GREENSURVEY |
| SHERBOURNE | | SP29308210 | STONE HOUSE | 24-Jul-95 | 0.000 | 0.000 | UNMEASURABLE BUT ATRICKLE OF WATER INTOSMALL POOLS. |
| SHERBOURNE | | SP29308210 | STONE HOUSE | 26-Aug-95 | 0.000 | 0.000 | NO MEASUREABLE FLOWTRICKLE JUST VISIBLE BYSTIRRING UP SILT POOLSIN BED MUCH LOWER THANPREVIOUS VISIT |
| SHERBOURNE (TRIB) | NORTH BR | SP30728160 | COUNDON | 28-Feb-85 | 0.004 | 0.346 | |
| SHERBOURNE (TRIB) | NORTH BR | SP30728160 | COUNDON | 25-Oct-85 | 0.000 | 0.000 | |
| SHERBOURNE (TRIB) | PICKFORD BR | SP27508254 | SANDPIT FARM | 18-Feb-98 | | 0.000 | |
| SHERBOURNE (TRIB) | PICKFORD BR | SP28608100 | WINDMILL HILL | 24-Jul-95 | | 0.00 | |
| SHERBOURNE (TRIB) | PICKFORD BR | SP28608100 | WINDMILL HILL | 25-Aug-95 | | 0.03 | |
| SHERBOURNE (TRIB) | PICKFORD BR | SP27408070 | UPPER EASTERN GREEN | 24-Jul-95 | | 0.00 | |
| SHERBOURNE (TRIB) | PICKFORD BR | SP27408070 | UPPER EASTERN GREEN | 25-Aug-95 | | 0.00 | |
| SHERBOURNE (TRIB) | PICKFORD BR | SP29108050 | ALLESLEY | 24-Jul-95 | | 0.00 | |
| SHERBOURNE (TRIB) | PICKFORD BR | SP29108050 | ALLESLEY | 25-Aug-95 | | 0.00 | |
| SHERBOURNE | | SP30808025 | ALLESLEY | 05-Aug-81 | 0.016 | 1.365 | |
| SHERBOURNE | | SP30808025 | ALLESLEY | 25-Oct-85 | 0.006 | 0.518 | |
| SHERBOURNE | | SP30808025 | ALLESLEY | 28-Feb-86 | 0.024 | 2.074 | |
| SHERBOURNE | | SP30108110 | ALLESLEY | 26-Jun-91 | 0.002 | 0.138 | PICKFORD GREEN BORE-HOLE SURVEYAFTER WET SPELL |
| SHERBOURNE | | SP30708050 | ALLESLEY WEDGE PARK | 24-Jul-95 | 0.001 | 0.104 | U.S FOOTBR. |
| SHERBOURNE | | SP30708050 | ALLESLEY WEDGE PARK | 25-Aug-95 | 0.004 | 0.311 | U/S OF PICKFORDBROOK CONFLUENCE |
| SHERBOURNE | | SP30908020 | KINGSBURY RD. | 08-Dec-94 | 0.237 | 20.451 | GAUGED BY EWAN UNDERCONTRACT. GAUGED AFTERDARK BY CAR HEADLIGHTS. |
| SHERBOURNE | | SP30908020 | KINGSBURY RD. | 12-Jan-95 | 0.098 | 8.502 | GAUGED BY EWAN UNDERCONTRACT. |
| SHERBOURNE | | SP30908020 | KINGSBURY RD. | 25-Jan-95 | 0.335 | 28.961 | GAUGED BY EWAN UNDERCONTRACT. |
| SHERBOURNE | | SP30908020 | KINGSBURY RD. | 09-Feb-95 | 0.113 | 9.789 | |
| SHERBOURNE | | SP30909802 | KINGSBURY RD. | 22-Feb-95 | 0.108 | 9.288 | |
| SHERBOURNE | | SP30908020 | KINGSBURY RD. | 09-Mar-95 | 0.161 | 13.919 | |
| SHERBOURNE | | SP30908020 | KINGSBURY RD. | 22-Mar-95 | 0.046 | 3.957 | |
| SHERBOURNE | | SP30908020 | KINGSBURY RD. | 06-Apr-95 | 0.023 | 2.030 | |
| SHERBOURNE | | SP30908020 | KINGSBURY RD. | 25-Apr-95 | 0.029 | 2.540 | AVON EUTROPHICATIONSURVEY |
| SHERBOURNE | | SP30908020 | KINGSBURY RD. | 25-Apr-95 | 0.081 | 7.007 | RECALC DATA |
| SHERBOURNE | | SP30908020 | KINGSBURY RD. | 11-May-95 | 0.013 | 1.149 | AVON EUTROPHICATION PROJECT |
| SHERBOURNE | | SP30908020 | KINGSBURY RD. | 11-May-95 | 0.056 | 4.821 | RECALC DATA |
| SHERBOURNE | | SP30908020 | KINGSBURY RD. | 24-May-95 | 0.011 | 0.985 | AVON EUTROPHICATIONPROJECT |
| SHERBOURNE | | SP30908020 | KINGSBURY RD. | 24-May-95 | 0.047 | 4.087 | RECALC DATA |
| SHERBOURNE | | SP30908020 | KINGSBURY RD. | 09-Jun-95 | 0.008 | 0.717 | AVON EUTROPHICATIONPROJECT |
| SHERBOURNE | | SP30908020 | KINGSBURY RD. | 09-Jun-95 | 0.040 | 3.465 | RECALC DATA |
| SHERBOURNE | | SP30908020 | KINGSBURY RD. | 22-Jun-95 | 0.003 | 0.268 | AVON EUTROPHICATIONPROJECT |
| SHERBOURNE | | SP30908020 | KINGSBURY RD. | 05-Jul-95 | 0.003 | 0.242 | AVON EUTROPHICATIONPROJECT |
| SHERBOURNE | | SP30908020 | KINGSBURY RD. | 18-Jul-95 | 0.004 | 0.311 | |
| SHERBOURNE | | SP30908020 | KINGSBURY RD. | 31-Aug-95 | 0.006 | 0.527 | |
| SHERBOURNE | | SP30908020 | KINGSBURY RD. | 13-Sep-95 | 0.000 | 0.000 | |
| SHERBOURNE | | SP30908020 | KINGSBURY RD. | 28-Sep-95 | 0.000 | 0.000 | NO MEASUREABLE FLOW |
| SHERBOURNE | | SP30908020 | KINGSBURY RD. | 11-Oct-95 | 0.000 | 0.000 | NO FLOW - GAUGINGSMADE UP TO PRODUCEZERO MLD |
| SHERBOURNE | | SP30908020 | KINGSBURY RD. | 26-Oct-95 | 0.000 | 0.000 | NO MEASURABLE FLOW |
| SHERBOURNE | | SP30908020 | KINGSBURY RD. | 08-Nov-95 | 0.000 | 0.000 | NO FLOW FOUND |
| SHERBOURNE | | SP30908020 | KINGSBURY RD. | 23-Nov-95 | 0.004 | 0.354 | |
| SHERBOURNE | | SP30908020 | KINGSBURY RD. | 06-Dec-95 | 0.007 | 0.596 | |
| SHERBOURNE | | SP30908020 | KINGSBURY RD. | 15-Dec-95 | 0.007 | 0.562 | |
| SHERBOURNE | | SP30908020 | KINGSBURY RD. | 17-Jan-96 | 0.065 | 5.590 | |
| SHERBOURNE | | SP30908020 | KINGSBURY RD. | 01-Feb-96 | 0.017 | 1.443 | F104' |
| SHERBOURNE | | SP30908020 | KINGSBURY RD. | 16-Feb-96 | 0.079 | 6.800 | F104' |
| SHERBOURNE | | SP30908020 | KINGSBURY RD. | 29-Feb-96 | 0.066 | 5.668 | F104 |
| SHERBOURNE | | SP30908020 | KINGSBURY RD. | 13-Mar-96 | 0.055 | 4.717 | F104 |
| SHERBOURNE | | SP30908020 | KINGSBURY RD. | 28-Mar-96 | 0.014 | 1.184 | F104 |
| SHERBOURNE | | SP30908020 | KINGSBURY RD. | 16-Apr-96 | 0.020 | 1.754 | F104 |
| SHERBOURNE | | SP30908020 | KINBSBURY RD. | 26-Apr-96 | 0.014 | 1.166 | F104 ABOUT 2CM BELOW G.B. |
| SHERBOURNE | | SP30908020 | KINGSBURY RD. | 15-May-96 | 0.012 | 1.071 | F104 |
| SHERBOURNE | | SP30908020 | KINGSBURY RD. | 31-May-96 | 0.006 | 0.553 | F104 |
| SHERBOURNE | | SP30908020 | KINGSBURY RD. | 13-Jun-96 | 0.003 | 0.285 | F104 |
| SHERBOURNE | | SP30908020 | KINGSBURY RD. | 24-Jun-96 | 0.003 | 0.225 | F104 |
| SHERBOURNE | | SP30908020 | KINGSBURY RD. | 08-Jul-96 | 0.030 | 2.575 | F104 |
| SHERBOURNE | | SP30908020 | KINGSBURY RD. | 24-Jul-96 | 0.002 | 0.138 | F104 |
| SHERBOURNE | | SP30908020 | KINGSBURY RD. | 09-Aug-96 | 0.001 | 0.095 | F104 |
| SHERBOURNE | | SP20908020 | KINGSBURY RD. | 19-Aug-96 | 0.000 | 0.017 | F104 |
| SHERBOURNE | | SP30908020 | KINGSBURY RD. | 04-Sep-96 | 0.003 | 0.276 | F104 |
| SHERBOURNE | | SP30908020 | KINGSBURY RD. | 20-Sep-96 | 0.002 | 0.138 | F104 |

SHERBOURNE CURRENT METER GAUGINGS UPDATE 18-Jun-97

| River name | | NGR | Location | Date of gauging | Discharge cumecs | Discharge Ml/d | Comments |
|---|---|---|---|---|---|---|---|
| SHERBOURNE | | SP30908010 | SHERBOURNE FIELDS | 29-Apr-92 | 0.008 | 0.708 | PICKFORD GREENSURVEY |
| SHERBOURNE | | SP30908010 | SHERBOURNE FIELDS | 13-May-92 | 0.031 | 2.687 | PICKFORD GREENSURVEY |
| SHERBOURNE | | SP30908010 | SHERBOURNE FIELDS | 13-May-92 | 0.031 | 2.687 | PICKFORD GREENSURVEY |
| SHERBOURNE | | SP30908010 | SHERBOURNE FIELDS | 28-May-92 | 0.002 | 0.207 | PICKFORD GREENSURVEY |
| SHERBOURNE | | SP30908010 | SHERBOURNE FIELDS | 10-Jun-92 | 0.004 | 0.389 | PICKFORD GREENSURVEY |
| SHERBOURNE | | SP30908010 | SHERBOURNE FIELDS | 24-Jun-92 | 0.002 | 0.156 | PICKFORD GREENSURVEY |
| SHERBOURNE | | SP30908010 | SHERBOURNE FIELDS | 08-Jul-92 | 0.004 | 0.389 | PICKFORD GREEN SURVEY |
| SHERBOURNE | | SP30908010 | SHERBOURNE FIELDS | 22-Jul-92 | 0.021 | 1.849 | PICKFORD GREENSURVEY |
| SHERBOURNE | | SP30908010 | SHERBOURNE FIELDS | 05-Aug-92 | 0.002 | 0.199 | PICKFORD GREENSURVEY |
| SHERBOURNE | | SP30908010 | SHERBOURNE FIELDS | 02-Sep-92 | 0.047 | 4.018 | PICKFORD GREENSURVEY |
| SHERBOURNE | | SP30908010 | SHERBOURNE FIELDS | 16-Sep-92 | 0.003 | 0.242 | PICKFORD GREENSURVEY |
| SHERBOURNE | | SP30908010 | SHERBOURNE FIELDS | 30-Sep-92 | 0.014 | 1.218 | PICKFORD GREENSURVEY |
| SHERBOURNE | | SP30908010 | SHERBOURNE FIELDS | 22-Apr-93 | 0.023 | 1.987 | PICKFORD GREENSURVEYREPLACES BADLY INPUTTEDGAUGING FOR SAME PLACEAND TIME |
| SHERBOURNE | | SP30908010 | SHERBOURNE FIELDS | 09-Jun-93 | 0.018 | 1.529 | PICKFORD GREENSURVEY |
| SHERBOURNE | | SP30908010 | SHERBOURNE FIELDS | 07-Jul-93 | 0.014 | 1.244 | PICKFORD GREENSURVEY |
| SHERBOURNE | | SP30908010 | SHERBOURNE FIELDS | 03-Sep-93 | 0.002 | 0.199 | PICKFORD GREENSURVEY |
| SHERBOURNE | | SP30908010 | SHERBOURNE FIELDS | 24-Jul-95 | 0.003 | 0.251 | D.S. RD. BR. |
| SHERBOURNE | | SP31008000 | SHERBOURNE FIELDS | 25-Aug-95 | 0.012 | 1.045 | D/S RD BR ON GRAY-WOOD AVE INCL. DISCHARGEUNDER BRIDGE |
| SHERBOURNE | | SP31757930 | FOUR POUNDS AVENUE | 30-Oct-85 | 0.010 | 0.864 | |
| SHERBOURNE (TRIB) | GUPHILL BR | SP27408080 | EASTERN GREEN | 25-Oct-85 | 0.000 | 0.000 | |
| SHERBOURNE (TRIB) | GUPHILL BR | SP28807960 | LOWER EASTERN GREEN | 24-Jul-95 | | 0.14 | |
| SHERBOURNE (TRIB) | GUPHILL BR | SP28807960 | LOWER EASTERN GREEN | 25-Aug-95 | | 0.04 | |
| SHERBOURNE (TRIB) | GUPHILL BR | SP28807960 | WHORBERLEY | 24-Jul-95 | | 0.37 | |
| SHERBOURNE (TRIB) | GUPHILL BR | SP30327943 | WHORBERLEY | 25-Aug-95 | | 0.16 | |
| SHERBOURNE | | SP32507920 | UPPER SPON BK. | 30-Oct-85 | 0.016 | 1.382 | |
| SHERBOURNE | | SP32507920 | UPPER SPON BK. | 28-Feb-86 | 0.044 | 3.802 | |
| SHERBOURNE | | SP34407830 | THE CHARTERHOUSE | 30-Oct-85 | 0.073 | 6.307 | |
| SHERBOURNE | | SP34707750 | SHORTLEY RD. | 12-Jan-95 | 0.295 | 25.505 | GAUGED BY EWAN UNDERCONTRACT. ALTERNATIVESITE TO BAGINGTON A45. |
| SHERBOURNE | | SP34707750 | SHORTLEY RD. | 25-Jan-95 | 0.312 | 26.974 | GAUGED BY EWAN UNDERCONTRACT. |
| SHERBOURNE | | SP34707750 | SHORTLEY RD. | 09-Feb-95 | 0.284 | 24.538 | GAUGING INTERRUPTED- CONNECTOR FAILURE.RE-STARTED WHEN CABLE REPLACED. |
| SHERBOURNE | | SP34707750 | SHORTLEY RD. | 24-Jul-95 | 0.090 | 7.759 | LOW FLOW SURVEYFOR GP DAVIES - NO STARTOR END TIME ENTERED ONRAWDATA SHEET SO 1000AND 1020 ARE ESTIMATES |
| SHERBOURNE | | SP34707750 | SHORTLEY RD. | 25-Aug-95 | 0.052 | 4.501 | GP DAVIES REQUEST |

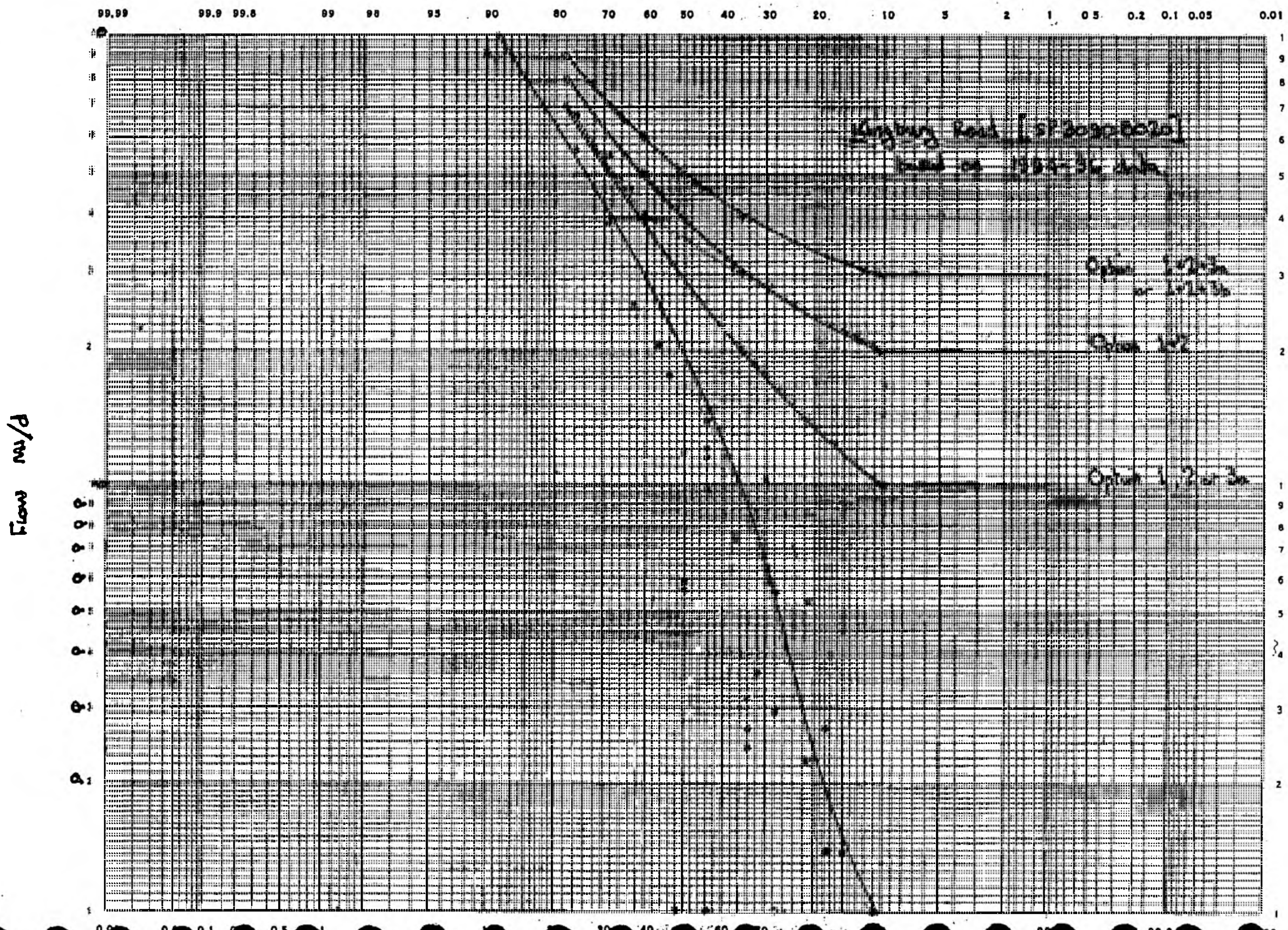
SHERBOURNE CURRENT METER GAUGINGS UPDATE 18-Jun-97

| River name | NGR | Location | Date of gauging | Discharge cumecs | Discharge Mld | Comments |
|---|---|---|---|---|---|---|
| SHERBOURNE | SP34337571 | BAGINGTON A45 BDGE | 25-Aug-77 | 0.335 | 28.944 | |
| SHERBOURNE | SP34337571 | BAGINGTON A45 BDGE | 27-Jun-78 | 0.078 | 6.739 | |
| SHERBOURNE | SP34337571 | BAGINGTON A45 BDGE | 26-Sep-78 | 0.096 | 8.294 | |
| SHERBOURNE | SP34337571 | BAGINGTON A45 BDGE | 24-Jul-79 | 0.136 | 11.750 | |
| SHERBOURNE | SP34337571 | BAGINGTON A45 BDGE | 29-Aug-80 | 0.575 | 49.680 | |
| SHERBOURNE | SP34337571 | BAGINGTON A45 BDGE | 05-Aug-81 | 0.122 | 10.541 | |
| SHERBOURNE | SP34337571 | BAGINGTON A45 BDGE | 15-Aug-83 | 0.116 | 10.040 | |
| SHERBOURNE | SP34307580 | BAGINGTON A45 BDGE | 25-Jul-89 | 0.160 | 13.824 | GAUGED 5M USTREAMRD BRIDGE |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 24-Aug-89 | 0.147 | 12.684 | GAUGED UNDER RD BRBAGINGTON COVENTRY |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 23-Jul-90 | 0.068 | 5.892 | |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 07-Aug-90 | 0.074 | 6.394 | |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 17-Sep-90 | 0.142 | 12.286 | AVON LOW FLOW SURVEY |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 03-Sep-91 | 0.074 | 6.385 | LOW FLOW SURVEY |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 23-Jun-92 | 0.065 | 5.616 | ____LOFLO |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 19-Jul-94 | 0.092 | 7.966 | GAUGED FOR LOW FLOWSURVEY |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 08-Dec-94 | 1.293 | 111.732 | GAUGED BY EWAN UNDERCONTRACT. SKEW ANGLEMEASURED BY JFC AS 34ALTHOUGH EWAN SAY 42. 34USED IN CALCULATIONS. |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 22-Feb-95 | 0.331 | 28.564 | |
| SHERBOURNE | SP34307560 | BAGINGTON A45 BDGE | 09-Mar-95 | 0.406 | 35.078 | |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 22-Mar-95 | 0.221 | 19.094 | |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 06-Apr-95 | 0.219 | 18.904 | |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 24-Apr-95 | 0.211 | 18.265 | RECALC DATA |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 25-Apr-95 | 0.109 | 9.461 | AVON EUTROPHICATIONSURVEY |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 11-May-95 | 0.168 | 14.550 | RECALC DATA |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 11-May-95 | 0.068 | 5.892 | AVON EUTROPHICATIONPROJECT |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 24-May-95 | 0.064 | 5.486 | AVON EUTROPHICATIONPROJECT |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 24-May-95 | 0.156 | 13.478 | RECALC DATA |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 09-Jun-95 | 0.095 | 8.182 | C31 METER USEDBECAUSE OF CABLE FAILUREON C2 |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 22-Jun-95 | 0.009 | 0.821 | AVON EUTROPHICATIONPROJECT |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 05-Jul-95 | 0.009 | 0.743 | AVON EUTROPHICATIONPROJECT |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 18-Jul-95 | 0.011 | 0.968 | |
| SHERBOURNE | SP34307560 | BAGINGTON A45 BDGE | 24-Jul-95 | 0.076 | 6.558 | LOW FLOW SURVEY FORGP DAVIES |
| SHERBOURNE | SP34307560 | BAGINGTON A45 BDGE | 24-Jul-95 | | 6.560 | MUHIB RAKEEB |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 25-Jul-95 | 0.212 | 18.317 | LOW FLOWS SURVEY |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 09-Aug-95 | 0.087 | 7.500 | LOW FLOW SURVEY |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 22-Aug-95 | 0.048 | 4.164 | LOW FLOW SURVEY |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 22-Aug-95 | 0.048 | 4.164 | LOW FLOW SURVEY |
| SHERBOURNE | SP34307560 | BAGINGTON A45 BDGE | 23-Aug-95 | 0.067 | 5.754 | GP DAVIES REQUEST |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 31-Aug-95 | 0.097 | 8.355 | |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 13-Sep-95 | 0.164 | 14.152 | |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 28-Sep-95 | 0.123 | 10.610 | |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 28-Sep-95 | 0.093 | 8.035 | AS COMPARISON WITHCONTRACTOR GAUGING ONSAME DAY |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 11-Oct-95 | 0.092 | 7.923 | |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 26-Oct-95 | 0.097 | 8.364 | |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 08-Nov-95 | 0.089 | 7.716 | |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 23-Nov-95 | 0.075 | 6.489 | |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 06-Dec-95 | 0.070 | 6.057 | |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 15-Dec-95 | 0.121 | 10.489 | |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 17-Jan-96 | 0.223 | 19.259 | AVON EUTRO CHECK GAUGING SITE F103/JFC' |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 17-Jan-96 | 0.205 | 17.677 | |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 01-Feb-96 | 0.110 | 9.478 | F103' |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 16-Feb-96 | 0.235 | 20.313 | F103' |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 16-Feb-96 | 0.225 | 19.423 | AVON EUTRO SHECK GAUGING SITE F103' |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 29-Feb-96 | 0.228 | 19.725 | F103 |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 13-Mar-96 | 0.191 | 16.502 | F103 |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 28-Mar-96 | 0.111 | 9.556 | F103 |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 16-Apr-96 | 0.133 | 11.457 | CHECK GAUGE FOR AVON EUTRO SITE F103 |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 16-Apr-96 | 0.107 | 9.262 | F103 |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 26-Apr-96 | 0.094 | 8.096 | F103 |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 15-May-96 | 0.082 | 7.076 | F103 |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 31-May-96 | 0.072 | 6.221 | F103 |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 13-Jun-96 | 0.049 | 4.277 | F103 |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 24-Jun-96 | 0.068 | 5.918 | F103 |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 08-Jul-96 | 0.080 | 6.921 | F103 |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 24-Jul-96 | 0.066 | 5.728 | F103 |
| SHERBOURNE | SP3440 756 | BAGINGTON A45 BDGE | 24-Jul-96 | 0.059 | 5.124 | PART OF LOW FLOW SURVEY GAUGES 5M U/S BRIDGE A45. |

SHERBOURNE CURRENT METER GAUGINGS UPDATE 18-Jun-97

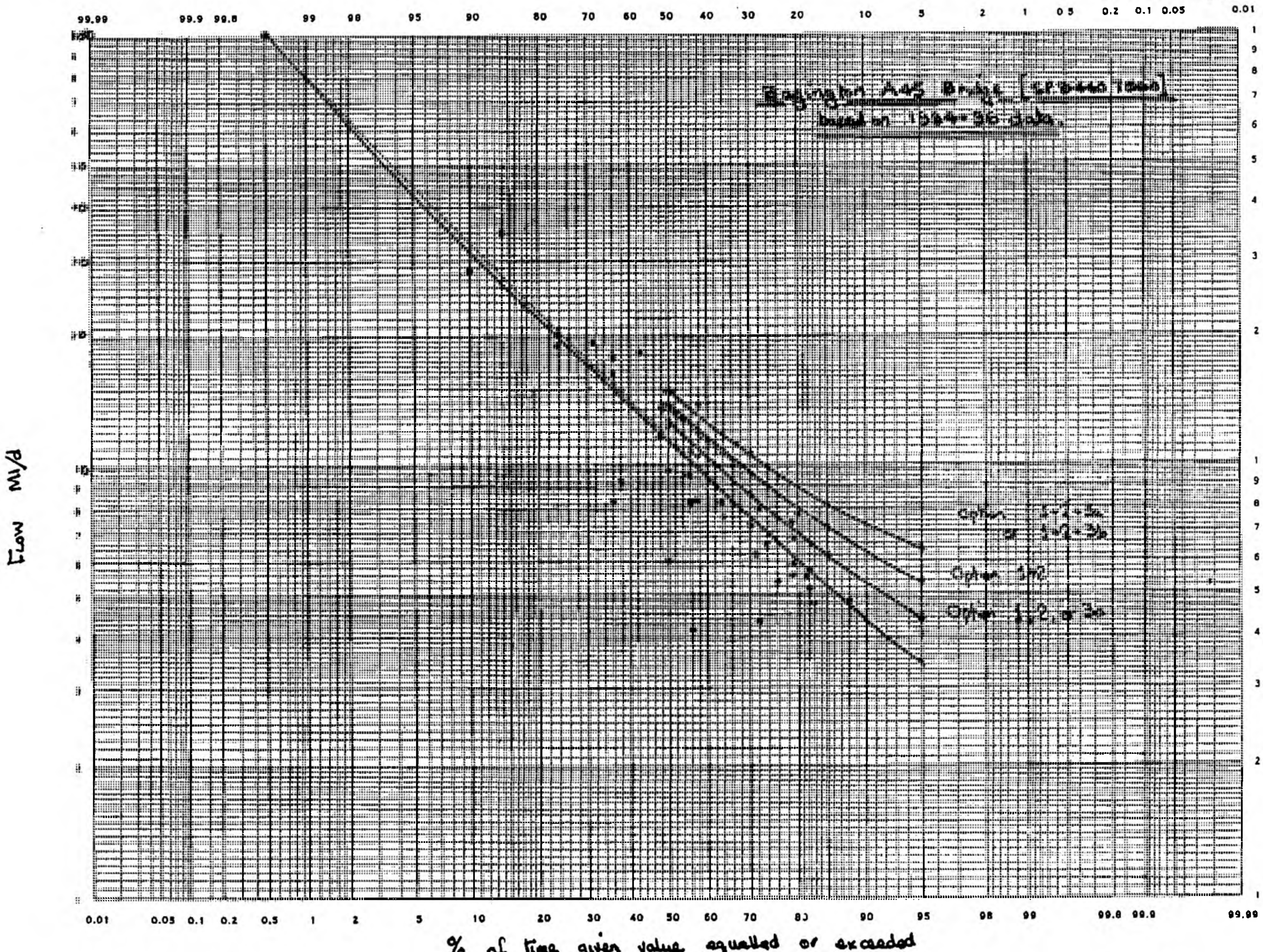
| River name | NGR | Location | Date of gauging | Discharge cumecs | Discharge Mld | Comments |
|---|---|---|---|---|---|---|
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 09-Aug-96 | 0.062 | 5.314 | F103 |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 19-Aug-96 | 0.056 | 4.873 | F103 |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 04-Sep-96 | 0.067 | 5.780 | F104 |
| SHERBOURNE | SP34407560 | BAGINGTON A45 BDGE | 20-Sep-96 | 0.053 | 4.588 | F103 |

SP 3090 8020



Flow Ml/d
Kingsbury Road [SP 3090 8020]
based on 1984-96 data
Option 1+2+3a
or 1+2+3b
Option 1+2
Option 1, 2 or 3a

SP 34407560 data



# Appendix 12

# River Worfe

## River Worfe

| | | |
|---|---|---|
| Messrs R & J Tudor, Hallon House | - | 01746 716 229 |
| Mr W Stuttaford, Manor Farm | - | 01952 463 082 |
| H Shepherd and Son, Rookery Farm | - | 01952 460 529 |
| Messrs H & E Chilton, Atchley Manor | - | 01952 750 274 |
| Messrs S & R Slaney, Hatton Grange Farm | - | 01952 460 215 |
| Bridgenorth District Council | - | Mr Gwilt Fax 01746 764 414 |
| Local Ramblers Association Member | - | Mrs M.V. Law 01952 299 9297<br>Mr R. Powell 01743 359 797 |
| Cosford Woodland Walk | - | Mr R. Green 01902 373 062 |
| Environment Agency | - | John Ratcliffe 0121 711 2324<br>Glenn Hoban 0121 711 2324<br>Rick North 01189 491 054<br>John Woodland Fax 01743 272 138<br>Anne Penney 01684 850 951<br>Jean Payne 01743 272 828 |
| Salopian Flyfishers Ltd | - | Mr R Clark 01746 716 656 |

Mr Talbot, Moorlands Farm, Kidderminster

## General

| | | |
|---|---|---|
| **Ramblers Association** | - | **0171 582 6878** |
| **Countryside Commission** | - | **0171 831 3510** |
| **Office National Statistics** | - | **0171 233 9233** |
| **Halifax Building Society's Statistical Service** | | **01422 333 333** |
| **Talking Pages** | - | **0800 600 900** |

**RIVER WORFE**

The river Worfe is one of the original top 20 low flow alleviation sites listed before AMP2. The length between the Albrighton and the Wesley brook which is listed as intermittent flow was addressed in 1996/97. This problem length has now been reclassified as low flow due to a modification provision of an alternative water supply to one riparian owner who used the river for spray irrigation. The lengths which are being targeted are the Ruckley and Cramp Pool brooks. This will enable the Western Arms of the system to be rewatered. The Neachley and Albrighton Brooks will be considered once the West Midlands Groundwater Model has been utilised to indicate which groundwater abstractions are responsible for the reduction is flows.

The Options being considered at present are:-

1. Pipeline from Sheriffhales Borehole (NGR SJ 766111) which could supply a compensation release of up to 5Ml/d to the Ruckley Brook.

2. Output from Lizard Mill Borehold (NGR SJ 787096) which can supply a compensation release of up to 2Ml/d. to the Ruckley Brook.

3. Output from Hell Bank Borehole (NGR SJ 783068) which can supply a compensation release of up to 1Ml/d to the Neachley Brook.

4. Output from Cramp Pool Borehole (NGR SJ 969087) which can supply a compensation release of up to 1Ml/d to the Cramp Pool Brook.

All the above would be triggered by the flow conditions at Cosford Gauging Station. For the present analysis the trigger flow will be Q20 (21.6Ml/d). The benefit will be for all single options but will also include the sum of options (1+2+3) and (1+2+4). Enclosed is the following information:

1. Duration/Frequency Graphs for Cosford and Burcote.

2. Duration/Frequency tables for Cosford and Burcote.

3. Howard Humphrey's plan of River Worfe low flow areas.

Lengths which will benefit from the addition in flows:

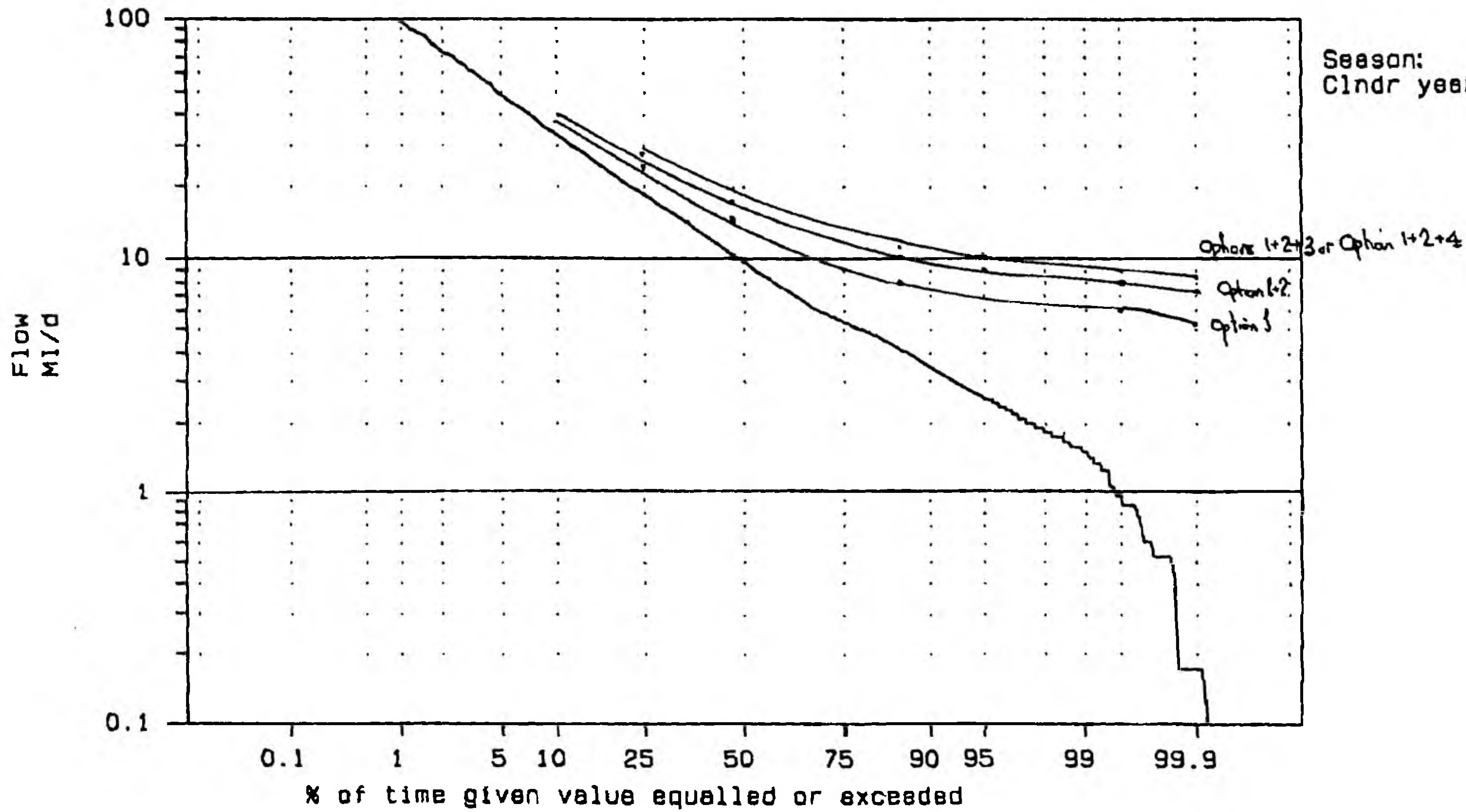
| | | | | |
|---|---|---|---|---|
| 1. | Option 1 | rewatered<br>increased flow | | 11 Km<br>20 Km |
| 2. | Option 2 | rewatered<br>increased flow | | 5 Km<br>20 Km |
| 3. | Option 3 | rewatered<br>increased flow | )<br>) | additional 3Km increased flow will always be linked with Option 1 |
| 4. | Option 4 | rewatered<br>increased flow | )<br>) | additional 2Km increased flow, will always be linked with Option 1. |

E. A. Midlands - Headquarters Hydrometry

Duration/Frequency Graph

| Auth.: 2046 | Name: COSFORD | Locat.: WORFE |
|---|---|---|

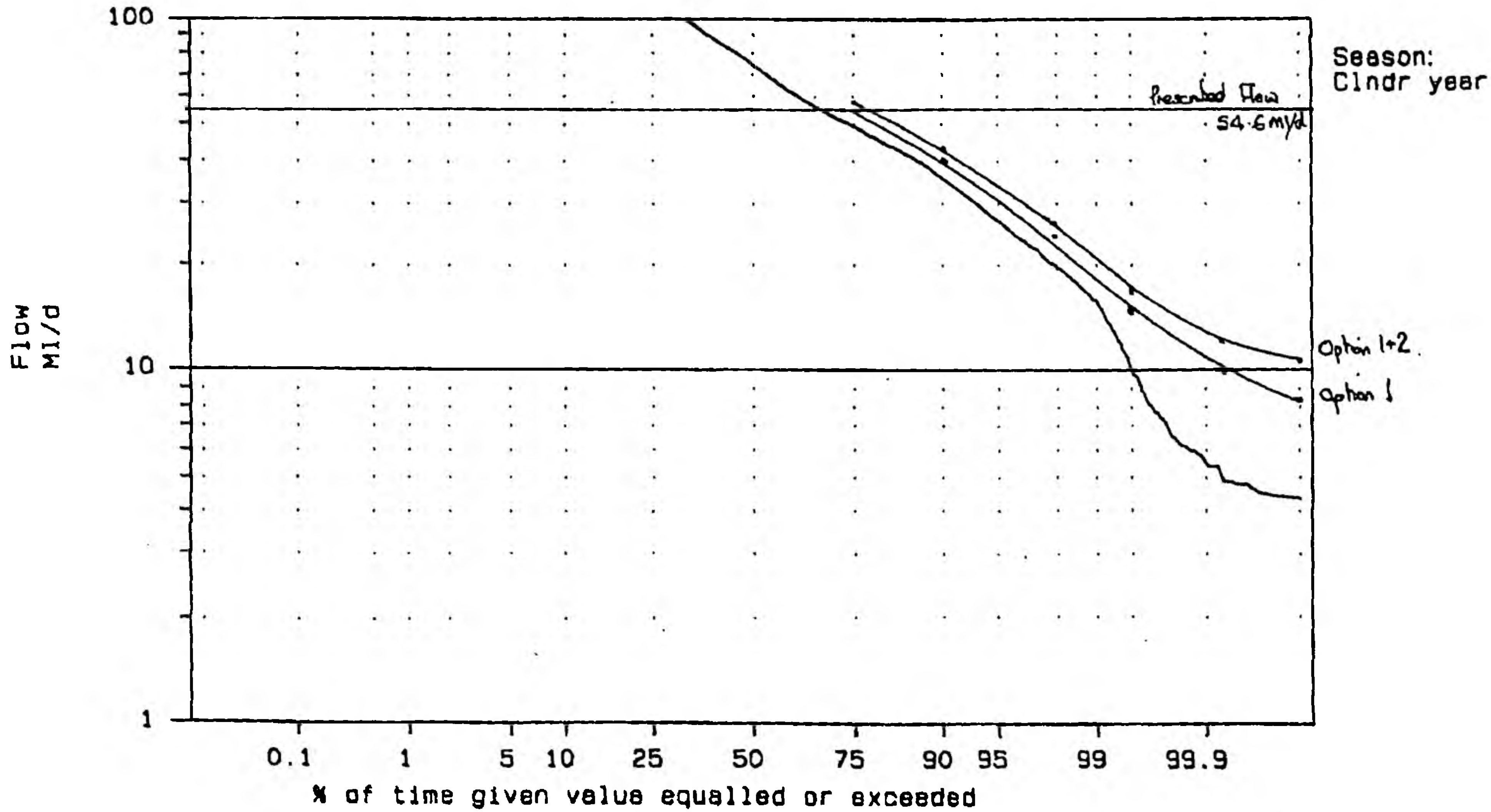
Period of Analysis : 1976 to 1997 ( 18 complete years used)



E. A. Midlands - Headquarters Hydrometry Duration/Frequency Graph

| Auth.: 2024 | Name: BURCOTE | Locat.: WORFE |
|---|---|---|

Period of Analysis : 1970 to 1997 ( 28 complete years used)



Output from HYDROLOG Data Management System V2.50(C) 1991-97 Hydro-Logic Ltd
Long Term Statistics Printed on 04/03/1998 at 10:28 hrs

E. A. Midlands – Headquarters Hydrometry

Auth. Ref. : 2046
Loc. Desc. : WORFE
Report Type : Duration/Frequency
Parameter : Flow
Units : Ml/d

Station Name : COSFORD
Catchment Ref.: US
Grid Ref. : SJ 781046
Gauge Zero : 59.500 MAOD
Catchment Area: 54.900 Sq Km

Period : 01/02/1975 to 28/02/1998 Start of Day : 09:00 GMT

Analysis period : Calendar Year

DAILY MEAN VALUE EXCEEDED STATED AMOUNT FOR GIVEN PERCENTAGE OF TIME

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0% | | 97.200 | 72.576 | 62.035 | 54.346 | 48.470 | 44.323 | 41.126 | 37.843 | 35.251 |
| 10% | 33.350 | 31.622 | 29.981 | 28.771 | 27.475 | 26.266 | 25.056 | 24.365 | 23.155 | 22.464 |
| 20% | 21.600 | 20.909 | 20.304 | 19.786 | 19.267 | 18.749 | 18.230 | 17.712 | 17.107 | 16.762 |
| 30% | 16.416 | 15.898 | 15.466 | 15.120 | 14.774 | 14.429 | 13.910 | 13.478 | 13.219 | 12.874 |
| 40% | 12.442 | 12.182 | 11.837 | 11.578 | 11.318 | 10.973 | 10.714 | 10.454 | 10.195 | 10.022 |
| 50% | 9.763 | 9.504 | 9.331 | 8.986 | 8.813 | 8.640 | 8.467 | 8.208 | 8.035 | 7.862 |
| 60% | 7.690 | 7.517 | 7.344 | 7.171 | 6.912 | 6.826 | 6.566 | 6.480 | 6.307 | 6.134 |
| 70% | 6.048 | 5.875 | 5.789 | 5.702 | 5.530 | 5.443 | 5.357 | 5.184 | 5.098 | 5.011 |
| 80% | 4.925 | 4.838 | 4.666 | 4.579 | 4.406 | 4.234 | 4.147 | 3.974 | 3.802 | 3.629 |
| 90% | 3.456 | 3.283 | 3.110 | 2.938 | 2.765 | 2.592 | 2.419 | 2.160 | 1.901 | 1.469 |

SUMMARY STATISTICS FOR ANALYSIS PERIOD

Maximum Daily Mean Value = 603.158
LTA Daily Mean (Lin Calc) = 15.811
LTA Daily Mean (Log Calc) = 10.274
Actual 95% Daily Mean = 2.592

Minimum Daily Mean Val. = 0.000
Median Daily Mean Value = 9.763
Log Standard Deviation = 0.904
Calc 95% Daily Mean = 2.324
(Log-Normal distribution assumed)

Number of values used = 6575
First year used = 1976
Last year used = 1997
Number of years used = 18 out of 22

Only complete calendar years of data used

Output from HYDROLOG Data Management System V2.50(C) 1991-97 Hydro-Logic Ltd
Long Term Statistics Printed on 04/03/1998 at 10:28 hrs

E. A. Midlands - Headquarters Hydrometry

Auth. Ref. : 2046
Loc. Desc. : WORFE
Report Type : Duration/Frequency
Parameter : Flow
Units : Ml/d

Station Name : COSFORD
Catchment Ref.: US
Grid Ref. : SJ 781046
Gauge Zero : 59.500 MAOD
Catchment Area: 54.900 Sq Km

Period : 01/02/1975 to 28/02/1998 Start of Day : 09:00 GMT

Analysis period : Calendar Year

DATA FREQUENCY ANALYSIS

| Daily Mean Value(DMV) | DMV as % of LTA | % values exceeding | Range of values of DMV From | To | No. in Range |
|---|---|---|---|---|---|
| 603.158 | 3814.854 | 0.000 | > 603.158 | | 0 |
| 350.000 | 2213.679 | 0.015 | 350.000 - | 603.158 | 1 |
| 210.000 | 1328.207 | 0.091 | 210.000 - | 350.000 | 5 |
| 120.000 | 758.976 | 0.380 | 120.000 - | 210.000 | 19 |
| 71.000 | 449.061 | 2.251 | 71.000 - | 120.000 | 123 |
| 41.000 | 259.317 | 7.027 | 41.000 - | 71.000 | 314 |
| 24.000 | 151.795 | 17.278 | 24.000 - | 41.000 | 674 |
| 14.000 | 88.547 | 35.787 | 14.000 - | 24.000 | 1217 |
| 8.200 | 51.863 | 57.414 | 8.200 - | 14.000 | 1422 |
| 4.800 | 30.359 | 81.262 | 4.800 - | 8.200 | 1568 |
| 2.800 | 17.709 | 93.749 | 2.800 - | 4.800 | 821 |
| 1.600 | 10.120 | 98.722 | 1.600 - | 2.800 | 327 |
| 0.960 | 6.072 | 99.437 | 0.960 - | 1.600 | 47 |
| 0.560 | 3.542 | 99.741 | 0.560 - | 0.960 | 20 |
| 0.330 | 2.087 | 99.848 | 0.330 - | 0.560 | 7 |
| 0.190 | 1.202 | 99.863 | 0.190 - | 0.330 | 1 |
| 0.110 | 0.696 | 99.924 | 0.110 - | 0.190 | 4 |
| 0.066 | 0.417 | 99.939 | 0.066 - | 0.110 | 1 |
| 0.039 | 0.247 | 99.954 | 0.039 - | 0.066 | 1 |
| 0.023 | 0.145 | 99.970 | 0.023 - | 0.039 | 1 |
| 0.013 | 0.082 | 99.985 | 0.013 - | 0.023 | 1 |
| | | | <= | 0.000 | 1 |

SUMMARY STATISTICS FOR ANALYSIS PERIOD

Maximum Daily Mean Value = 603.158
LTA Daily Mean (Lin Calc) = 15.811
Actual 95% Daily Mean = 2.592

Minimum Daily Mean Val. = 0.000
Median Daily Mean Value = 9.763
Modal Daily Mean Value = 4.638
(Class Interval 5% of median value)

Number of values used = 6575
First year used = 1976
Last year used = 1997
Number of years used = 18 out of 22

Output from HYDROLOG Data Management System V2.50(C) 1991-97 Hydro-Logic Ltd
Long Term Statistics                    Printed on 04/03/1998 at 10:30 hrs

E. A. Midlands - Headquarters Hydrometry

Auth. Ref. : 2024
Loc. Desc. : WORFE
Report Type : Duration/Frequency
Parameter : Flow
Units : Ml/d

Station Name : BURCOTE
Catchment Ref.: US
Grid Ref. : SP 747953
Gauge Zero : 33.220 MAOD
Catchment Area: 258.000 Sq Km

Period : 01/04/1969 to 01/03/1998 Start of Day : 09:00 GMT

Analysis period : Calendar Year

DAILY MEAN VALUE EXCEEDED STATED AMOUNT FOR GIVEN PERCENTAGE OF TIME

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0% | | 427.85 | 346.81 | 299.81 | 268.27 | 245.29 | 223.26 | 210.38 | 197.68 | 186.97 |
| 10% | 179.37 | 170.90 | 164.33 | 158.89 | 153.62 | 149.21 | 144.72 | 140.92 | 137.12 | 133.23 |
| 20% | 130.12 | 126.92 | 124.16 | 121.22 | 118.63 | 116.21 | 113.44 | 111.28 | 108.95 | 106.88 |
| 30% | 104.72 | 102.64 | 100.14 | 98.582 | 97.027 | 95.040 | 93.571 | 91.757 | 90.374 | 88.992 |
| 40% | 87.437 | 85.968 | 84.672 | 83.462 | 82.253 | 81.130 | 79.834 | 78.451 | 77.069 | 75.686 |
| 50% | 74.304 | 73.267 | 71.798 | 70.502 | 69.120 | 67.910 | 66.614 | 65.491 | 64.541 | 63.331 |
| 60% | 62.467 | 61.517 | 60.566 | 59.616 | 58.493 | 57.802 | 57.024 | 56.160 | 55.469 | 54.605 |
| 70% | 53.654 | 52.963 | 52.099 | 51.494 | 50.803 | 49.939 | 49.075 | 48.384 | 47.347 | 46.570 |
| 80% | 45.619 | 44.755 | 43.978 | 43.114 | 42.336 | 41.299 | 40.435 | 39.398 | 38.275 | 36.893 |
| 90% | 35.424 | 33.955 | 32.573 | 30.586 | 28.944 | 26.870 | 24.883 | 22.637 | 19.958 | 15.898 |

SUMMARY STATISTICS FOR ANALYSIS PERIOD

Maximum Daily Mean Value = 1125.792
LTA Daily Mean (Lin Calc) = 96.539
LTA Daily Mean (Log Calc) = 76.530
Actual 95% Daily Mean = 26.870

Minimum Daily Mean Val. = 4.320
Median Daily Mean Value = 74.304
Log Standard Deviation = 0.670
Calc 95% Daily Mean = 25.436
(Log-Normal distribution assumed)

Number of values used = 10227
First year used = 1970
Last year used = 1997
Number of years used = 28 out of 28

Only complete calendar years of data used

Output from HYDROLOG Data Management System V2.50(C) 1991-97 Hydro-Logic Ltd
Long Term Statistics Printed on 04/03/1998 at 10:30 hrs

E. A. Midlands - Headquarters Hydrometry

| | | | |
|---|---|---|---|
| Auth. Ref. | : 2024 | Station Name | : BURCOTE |
| Loc. Desc. | : WORFE | Catchment Ref. | : US |
| Report Type | : Duration/Frequency | Grid Ref. | : SP 747953 |
| Parameter | : Flow | Gauge Zero | : 33.220 MAOD |
| Units | : Ml/d | Catchment Area | : 258.000 Sq Km |
| Period | : 01/04/1969 to 01/03/1998 | Start of Day | : 09:00 GMT |

Analysis period : Calendar Year

DATA FREQUENCY ANALYSIS

| Daily Mean Value(DMV) | DMV as % of LTA | % values exceeding | Range of values of DMV From | To | No. in Range |
|---|---|---|---|---|---|
| 1125.792 | 1166.155 | 0.000 | >1125.792 | | 0 |
| 900.000 | 932.267 | 0.020 | 900.000 - | 1125.792 | 2 |
| 720.000 | 745.814 | 0.029 | 720.000 - | 900.000 | 1 |
| 580.000 | 600.794 | 0.156 | 580.000 - | 720.000 | 13 |
| 460.000 | 476.492 | 0.714 | 460.000 - | 580.000 | 57 |
| 370.000 | 383.265 | 1.613 | 370.000 - | 460.000 | 92 |
| 300.000 | 310.756 | 2.982 | 300.000 - | 370.000 | 140 |
| 240.000 | 248.605 | 5.173 | 240.000 - | 300.000 | 224 |
| 190.000 | 196.812 | 8.693 | 190.000 - | 240.000 | 360 |
| 150.000 | 155.378 | 14.775 | 150.000 - | 190.000 | 622 |
| 120.000 | 124.302 | 23.379 | 120.000 - | 150.000 | 880 |
| 97.000 | 100.478 | 33.998 | 97.000 - | 120.000 | 1086 |
| 78.000 | 80.797 | 47.296 | 78.000 - | 97.000 | 1360 |
| 62.000 | 64.223 | 60.526 | 62.000 - | 78.000 | 1353 |
| 50.000 | 51.793 | 74.988 | 50.000 - | 62.000 | 1479 |
| 40.000 | 41.434 | 86.448 | 40.000 - | 50.000 | 1172 |
| 32.000 | 33.147 | 92.266 | 32.000 - | 40.000 | 595 |
| 26.000 | 26.932 | 95.473 | 26.000 - | 32.000 | 328 |
| 21.000 | 21.753 | 97.565 | 21.000 - | 26.000 | 214 |
| 16.000 | 16.574 | 98.944 | 16.000 - | 21.000 | 141 |
| 13.000 | 13.466 | 99.286 | 13.000 - | 16.000 | 35 |
| 11.000 | 11.394 | 99.452 | 11.000 - | 13.000 | 17 |
| 8.400 | 8.701 | 99.619 | 8.400 - | 11.000 | 17 |
| 6.700 | 6.940 | 99.775 | 6.700 - | 8.400 | 16 |
| 5.400 | 5.594 | 99.902 | 5.400 - | 6.700 | 13 |
| 4.320 | 4.475 | 99.990 | 4.320 - | 5.400 | 9 |
| | | | <= | 4.320 | 1 |

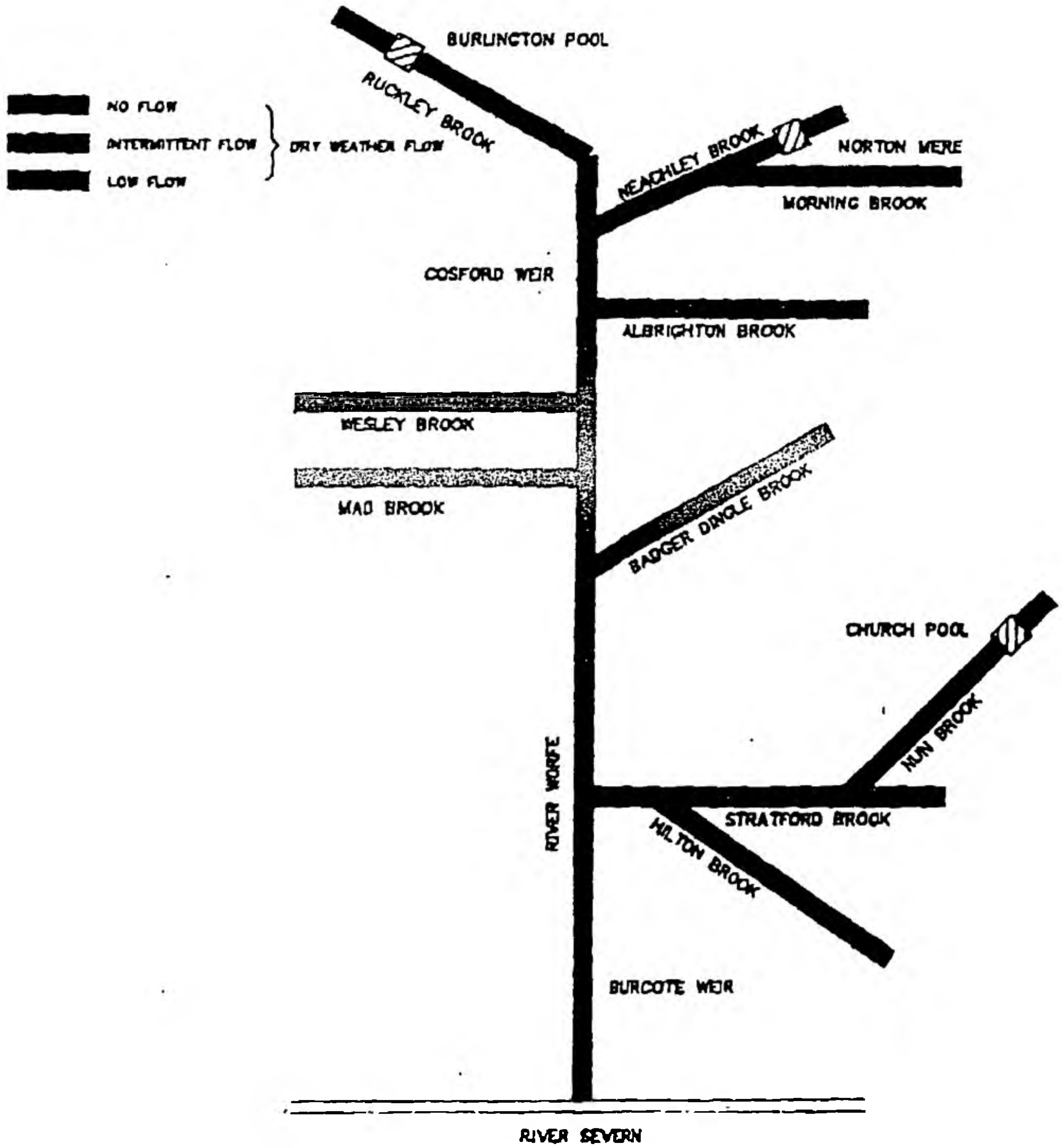
SUMMARY STATISTICS FOR ANALYSIS PERIOD

| | | | |
|---|---|---|---|
| Maximum Daily Mean Value | = 1125.792 | Minimum Daily Mean Val. | = 4.320 |
| LTA Daily Mean (Lin Calc) | = 96.539 | Median Daily Mean Value | = 74.304 |
| Actual 95% Daily Mean | = 26.870 | Modal Daily Mean Value | = 46.440 |

(Class Interval 5% of median value)

Number of values used = 10227
First year used = 1970
Last year used = 1997
Number of years used = 28 out of 28

# RIVER WORFE: LOW FLOW CONDITIONS



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