South West Water Services Ltd
and
National Rivers Authority
South West Region

ROADFORD OPERATIONAL AND ENVIRONMENTAL STUDY

Draft Final Report

Volume 5 - Annex G Monitoring
Annex H Reservoir Operating Agreement

November 1991

HALCROW

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Annex G

MONITORING

HALCROW

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FINAL REPORT

ANNEX G - MONITORING

CONTENTS LIST

ANNEX G - MONITORING

G1 INTRODUCTION AND SUMMARY

G1.1 Introduction

The Terms of Reference for Phase 2 of the Roadford Study require the study team to recommend outline proposals for future environmental monitoring associated with the scheme.

Since the full scheme will not come into operation for some years the proposed monitoring will not only provide post-development impact data but also pre-development baseline data which will be invaluable in the quantification of any future impacts. Such pre-development monitoring will also provide data for use in the consideration of the licence applications associated with the scheme.

The Terms of Reference do not, however, provide for the production of a detailed Roadford monitoring programme but rather, for the general recommendation of locations, timing and type of monitoring required. Any Roadford monitoring will only be part of the overall Regional Monitoring Programme and an assessment of how the proposals should be incorporated into the Regional programme for the South West is not considered.

The reasons for monitoring are discussed in Section 2 and recommendations for three major areas of environmental monitoring have been made in Sections G3, G4 and G5; fisheries, water quality and ecological monitoring respectively. The type of monitoring required, site selection, determinands to be measured and timing considerations are discussed. In addition, requirements for flow measurement in support of the environmental monitoring and the Riparian Owners comments and concerns regarding flow measurement and abstraction control are considered in Section G6.

G1.2 Summary

Proposals have been put forward for the monitoring of migratory fisheries, water quality and ecology in relation to the Roadford scheme and the requirements for flow measurement in support of such monitoring have also been considered.

In relation to fisheries, the main requirement is for direct monitoring of fish movement. To date, most assessments of the likely impacts of the Roadford Scheme have been based upon angling catch statistics due to the lack, except in the case of the Tamar, of adequate, direct observation data. Whilst this approach is considered to be broadly valid, there are limitations and so a fisheries monitoring programme has been recommended to provide such direct observations of fish movement upon which to assess the potential impacts of the Scheme. Recommendations for the monitoring of the performance of spawning and juvenile populations have also been proposed.

Monitoring of water quality is necessary in order to confirm the conclusion that the scheme is unlikely to have a significant impact on water quality and also to provide supporting data for the interpretation of fisheries and ecology data. The need to monitor the major effluent discharges to the rivers affected by the scheme is also addressed.

The need for adequate baseline data is particularly important for assessing the ecological impacts of the scheme and this is reflected in the proposed ecological monitoring programme described in Section G5.

The importance of adequate flow data to support the fisheries, water quality and ecological monitoring programmes is discussed in Section G6. Generally, the existing NRA guaging stations are considered adequate to fulfil this requirement although gauging of flows downstream of the major abstractions would be desirable. This would also go a long way towards satsifying the concerns of the various Riparian Owners Group likely to be affected by the scheme, regarding the compliance with prescribed flow and percentage maximum take abstraction conditions.

The value of harmonisation of the various monitoring programmes has also been expressed although it is recognised that it would be logistically difficult to implement. However, movement in this direction, as far as is practicable, would be highly desirable and would increase the value of the data collected through each of the proposed fisheries, water quality and ecological monitoring programmes.

G2 REASONS FOR MONITORING

G2.1 Fisheries

In the case of all six rivers involved in the Roadford Scheme, there is a need for investigation of the patterns of movement of migratory salmonids in the most critical areas affected by flow changes ie around the abstraction points on the Tamar, Tavy, Dart, Taw and Torridge and below Roadford Reservoir on the Lyd subcatchment and Burrator on the Meavy.

With the exception of the Tamar; the fisheries of which have been the subject of considerable investigation in connection with the Roadford Scheme, there is currently very little adequate data upon which to assess the potential impacts of the Scheme. The assessments which have been made so far have been based almost exclusively on angling catch statistics. Whilst this approach is considered broadly valid there are limitations as described in Section G3.1.1 and direct observations of fish movement are required so that more definitive assessments of the potential impacts of the Scheme can be made.

G2.2 Water Quality

The bringing into operation of Roadford Reservoir is expected to have certain impacts (not necessarily of a detrimental nature) upon water quality. These impacts may be characterised by monitoring before, during and after the bringing into operation of the reservoir. The impression of water quality which is given by a sampling exercise of limited duration is not necessarily representative of year-round scenario. Naturally occurring diurnal and seasonal variations require that any analysis of trend in water quality should be based upon records over an integral number of years. These requirements provide a basis from which to plan the monitoring of water quality in connection with the operation of Roadford.

The monitoring described in Section G4 is intended to yield data from which it will be possible to confirm the impacts of the Roadford Scheme. It is intended that the monitoring should continue for only as long as is necessary in order to assess these impacts. It contains guidelines which may form the basis of a more detailed monitoring programme and analytical requirement specification.

G2.3 Ecology

To develop a successful monitoring strategy demands the establishment of clearly defined objectives because monitoring is a process, or means to an end, and must not be seen as an end in itself. In the case of a monitoring programme established in conjunction with the initial operation of Roadford the objectives must be to:

(a) determine if changes in biota and habitats occur in stretches of river, estuary or reservoir which are influenced by the operation of the scheme;

(b) establish if the impact is detrimental, and if so, its extent/degree;

(c) assess if the impacts are reversible;

(d) define the 'significance' of the biotic change - ie the extent, intensity and justification for concern (eg wholesale change, loss of locally or regional rarities, loss of 'typical' assemblages/habitats).

Roadford will operate under different scenarios during the 1990s and the early years of the next century before operating at its full demand in the 2010s. In most cases this gives an ample opportunity in the next decade to assess what the ecological impacts of the scheme are likely to be. However, no assessment of impact or monitoring can occur without adequate base-line data. The rationale for the ecological monitoring programme is to provide empirical or other objective data which can influence the final operating rules of the scheme to ensure that minimum ecological damage results (or maximum benefit accrues) from it.

The rationale demands that there is an adequate data-base on which to make predictions or judge changes. Where there is an inadequate base the priority is to create one which will allow assessments of impact to be made during the next decade. If there is no potential impact from the Scheme there is no justification for undertaking monitoring just to produce data which will not have a targeted value.

G2.4 Flow

The public water supply abstractions involved in the Roadford Scheme are governed by prescribed flow and percentage maximum take conditions. Monitoring of river flow is, therefore, an important operational requirement of the scheme. Other such requirements include monitoring of compensation flow and river regulation releases.

Flow data however, is also required for other reasons. This report contains recommendations for the monitoring required to assess the environmental impacts of the Scheme. Since any impacts will result primarily from changes in the flow regimes of the affected rivers, flow data is required in support of such environmental monitoring. Therefore, harmonisation, as far as is practicable, of fisheries, water quality and ecological monitoring with flow measurements is required. This not only includes measurement of river flows, but also effluent discharges which are of particular relevance to the assessment of changes in water quality as a result of the Scheme.

Another reason to monitor flow is for abstraction control purposes. The NRA have a duty to ensure that any conditions they impose upon an abstraction licence are being complied with. Such abstraction policing also has a role with regard to public relations (see Section G6.2).

Flow monitoring for operational purposes and abstraction policing do not come within the brief for the Roadford Study. However, provision of recommendations for monitoring the environmental impacts of the Scheme

is required and, as such, further details of the flow measurements required in support of the environmental monitoring described in Sections G3, G4 and G5 of this report are provided in Section G6.1. In addition, the comments and concerns of the Riparian Owners in relation to flow monitoring and abstraction policing are discussed in Section G6.2.

G3 FISHERIES

G3.1 Methods

G3.1.1 Movement of Adult Migratory Salmonids

Apart from the Tamar, the only measure of fish movement so far used in the analysis of likely scheme impact is angling success. This approach is considered broadly valid because:

(a) studies elsewhere have shown that fish are most vulnerable to capture while resting during migration and for a short period (several days) after migration has ceased. Thus detailed angling records, with date and place of capture recorded, can provide a semi-quantitative indication of movement; and

(b) angling success is in itself an important parameter of prime concern to fishermen.

However, for a number of reasons there are limits to this approach. These include

(a) the detailed history of movements of the fish are not known eg exact time (and thus conditions obtaining) during passage past/through the critical area;

(b) fish actually actively migrating are believed to be relatively immune from angling capture;

(c) under some conditions which are believed to be conducive to fish movement, angling may be poor eg turbid water, stormy conditions, at night.

The requirement for more valid observations is for a method of direct monitoring of fish movement. The three presently available methodologies are:

(a) visual observation

(b) electronic counters

(c) telemetry tracking.

Visual observation is only feasible in relatively clear water conditions where the fish are constrained to swim through a small channel, ideally of shallow depth with a pale (eg white painted) bed. Time-lapse video recording using infra-red illumination allows night-time observation. This can be a practical approach to observing movements under low flow conditions in some situations. Retaining fish temporarily in traps and counting them on release, represents an extension to this approach. Trapping may also have a role to play in an integrated programme with counters or telemetry tracking in

providing a breakdown of runs by species or as a source of fish for tracking etc.

Electronic counters represent a potentially powerful approach, theoretically allowing recording (with photographic and video validation) of all fish movements past a fixed point. Major practical problems exist however, including:

(a) cost of suitable structure. Can be of the order of £0.5 million for a full-channel counter in a large river;

(b) of doubtful reliability at elevated water levels;

(c) problem of separating records of large sea trout and small salmon - no information on fish movement except past a fixed point;

(d) timescale for and uncertainty of achieving effective installation. Many attempted installations have failed.

Despite these problems counters are considered to have an important role to play in the Roadford monitoring programme, in particular for observing fish movement at low and medium flows (those most critically affected) in restricted channels (eg exit from a fish pass).

Telemetry tracking allows the continuous or targeted monitoring of the movements of individually tagged fish. The major disadvantages are that only a limited number of fish are monitored (though a properly planned and executed programme ensures that an adequate sample is used) and the relatively intensive manpower requirement (though the cost of this is offset by the low capital expenditure requirement). There is also the critical requirement for obtaining fish in adequate numbers and in good condition at the right place and time. Productive commercial fisheries using seine nets may be a good source for summer fish. In other situations, dedicated netting sessions have to be arranged.

The main advantages of the tracking approach are:

(a) detailed observations of fish movement and behaviour are possible throughout the zone of critical influence eg out of the estuary, over weirs, and past the abstraction point;

(b) flexibility to target detailed observations at locations (eg weirs) and times (eg spates, very low flows) of particular interest;

(c) short lead-time for commissioning of an effective programme eg a few months;

(d) proven approach in Southern UK rivers;

(e) the method lends itself to being contracted-out.

For all approaches to monitoring of adult fish movement there is of course a requirement for detailed monitoring of critical environmental conditions, particularly freshwater discharge. Generally this requirement is already covered by NRA gauging stations (see Section G6.1.1). Other relevant parameters include rainfall, water temperature and turbidity.

As stated earlier, the information derived from analysis of the detailed catch statistics has provided a good start to identifying critical flows and times. This analysis should continue in parallel with the more direct observations proposed above, both by incorporating each years figures as they become available and by further analysis of historic data sets. In this respect, detailed long-term records from individual fisheries may prove particularly useful. It is considered that the analysis of catch records will permit extrapolation from the direct observations of fish movement, as well as providing a direct indicator of one of the most important fisheries parameters, angling success.

G3.1.2 Performance of Spawning and Juvenile Populations

The most effective and accepted approach is by electric fishing surveys of selected reaches. This is a proven methodology in widespread use by SW Region NRA. Records of past surveys in the steams of interest and concurrent surveys in other streams, provide an invaluable database for comparative assessment of performance. Redd counts, while of debatable quantitative value, are nevertheless very effective at indicating the extent of penetration of a river or stream catchment by spawning fish.

G3.2 Proposals for Individual Rivers

G3.2.1 River Tamar

The requirements here are for observations on:

(a) Movements of adult salmon from the upper estuary, over Gunnislake Weir and past the abstraction point. In particular, observations are needed on the movements within a flow range and a time window which are likely to be affected by scheme operation. In addition, the influence of the tidal cycle and water quality require study.

(b) Movement of adult salmon throughout the main stem River Tamar and in the Lyd subcatchment under regulated flow conditions. The distribution of the available stock in relation to the rod fisheries and behaviour of salmon at the confluence of the main tributaries in response to flow and water quality needs investigating.

(c) The production of juvenile salmonid stocks, both wild and hatchery reared, in the Rivers Wolf, Thrushel and Lyd directly affected by the Scheme.

The approach proposed is based on the refinement and continuation of the existing fisheries programme:

(a) Radio tracking should be undertaken in the upper tidal reaches and the lower non-tidal reaches of the River Tamar. Every effort should be made to release a maximum annual total of 100 radio tagged salmon, June to September, from the commercial netting stations located downstream of Cotehole Quay. During 1991 the logistics of integrating the Tamar and Tavy tracking programme should be considered and a limited field exercise undertaken. Gunnislake trap could be used to supplement the numbers of salmon released into the River Tamar, if required.

(b) Monitoring of salmon and sea trout movements past Gunnislake Weir is highly desirable to complement the revised tracking programme. The trap could supply both a qualitative and semi-quantitative assessment of the salmon stocks.

During 1991 an open-channel electronic fish counter will be installed at the exit of the fish pass on the Cornish bank. Once validated, using remote camera techniques, this will provide reliable and continuous counts of all salmon migrating upstream through the pass. Concurrent radio tracking could indicate the proportion of migrants using this route under specific flow and tidal conditions.

(c) Radio tracking of salmon in freshwater should be continued throughout the year in order to monitor changes in behaviour under a regulated flow regime.

Radio tracking in the Lyd subcatchment during the autumn/winter should be limited to a maximum of 20 salmon. These salmon should initially be trapped at either Cookworthy (River Wolf) or Milford (River Thrushel) and then displaced to the main stem River Tamar. Some research is recommended to gain a greater understanding of the response of salmon to artificial freshets and enhanced flow regimes in the River Wolf at spawning time. In addition, to study the behaviour of the main confluences on the Lyd subcatchment.

(d) Existing traps at Cookworthy and Milford should be operated at times. Milford trap should be operated at selected times of the year to enable comparison with upstream salmonid movement at Cookworthy.

Cookworthy trap should be used to monitor both upstream and downstream migration of salmonids (juveniles and adults) throughout the year. An understanding of the population dynamics of the salmon and trout stocks of the River Wolf, including both wild and reared stock, is important if an effective mitigation programme is to continue. Operation of an efficient trap at Cookworthy is considered as an integral package to monitor juvenile and adult stocks, together with redd counts and electro-fishing surveys.

The detailed redd count and distribution survey undertaken on the Lyd subcatchment should be repeated. Similarly the expanded electro-fishing survey involving 20 sites should be continued.

(e) Full analysis of the private rod fishing data and the statutory returns for rod and net catches have been completed and reported. Both data sets should be updated on an annual basis during the study. Of course, access to private hotel/syndicate records is dependent on the authorisation and support of the owners. The commercially sensitive nature of the data sets is recognised and as such they must remain confidential.

G3.2.2 River Tavy

The requirement on the Tavy is for observations on the movement of fish from the estuary, up the fish pass into Lopwell dam, and into the river.

To some extent the details of the approach are dependent upon future management of the net fishery and the upstream hydro-electric abstractions but a basic requirement remains.

The approach proposed is:

(a) feasibility study for installation of an open channel or tube counter at the top of the Lopwell Dam fish pass. This would allow monitoring of movements at low to medium flows.

(b) as an alternative to (a), operation of the existing trap at the same site and/or time-lapse video recording of passage out of the pass (see Section G3.1.1). Even if a fish pass were installed, occasional trap operation would be desirable to aid separation of salmon and sea trout movement records.

(c) a programme of limited radio tagging , ideally integrated with any programme on the Tamar (fish are known to move freely between the two estuaries). Radio tracking is proposed here for the following reasons:

- to obtain a measure of estuary residence time;
- to identify conditions required to move long resident fish from the estuary;
- to investigate the tendency for fish to remain in the impoundment upstream of Lopwell Dam.

Numbers of fish to be tagged would depend upon the approach and the ratio of Tamar and Tavy fish of each species in the sampled catch. In the first instance, a programme that allowed the observation of the behaviour of say 30 salmon and 20 sea trout approaching/entering the Tavy would appear adequate. Strictly the

objectives of the programme could be achieved by tracking the tagged fish from June to the end of September, but in view of the significant resources involved in tagging fish and deploying the tracking equipment consideration should be given to the possibility of extending tracking to spawning time, to gather further information of relevance to general fisheries management.

G3.2.3 River Dart

The requirement here is for observations on the movement of fish out of salt water, though the freshwater tidal zone (and past the area affected by Totnes STW outfall), up to Totnes Weir, ascending the fish passes at Totnes, past the Littlehempston intake and out of the impounded area. A programme of radio tracking is proposed here rather than installation of a counter for the following reasons:

(a) the sites of critical interest are spread over several km of the river;

(b) the pattern of behaviour of salmon and sea trout must be assessed separately;

(c) the proposed timescale for licence application (1994?) requires an immediate start if adequate relevant results are to be used in considering details;

(d) the logistics of installation and operation of an effective counter at Totnes Weir or close upstream appear very complex, even for low flow observations.

A programme should aim to tag about fifty fish of each species per year for a minimum of three years, to ensure that a range of flow conditions is monitored. In view of concern expressed by the Dart riparian owners concerning the situation in May, the "season" for tagging should cover the months May to August. As suggested for the Tavy in Section G3.2.2, serious consideration should be given to extending the time and area of tracking observations beyond those strictly required by the water resource management implications.

There is no doubt however, that an effective fish counter at or near Totnes Weir would provide a tremendous volume of useful data which could allow reduction or even discontinuation of the tracking programme. It is therefore recommended that a feasibility study for the installation of a fish counter, with associated trapping facility, is undertaken in parallel with the tracking programme.

An improvement in spawning success and juvenile salmon production is likely downstream of the intakes for the Devonport Leat on the Cowsic, Blackbrook and West Dart. It is suggested that the NRA should survey these areas by electric fishing on an annual basis for several years to monitor any developments.

G3.2.4 River Plym

The salmon stocks and to a lesser extent the sea trout stock of the Plym are critically dependent upon the productive nursery areas in the Meavy. As with all streams year by year variations in population size and density occur, but it appears that the timing and extent of spill from Burrator Reservoir late in the year are critical for the optimal dispersion of spawning activity. The extremely low compensation flow from Burrator (about 29% of the theoretical Q95 at that point, compared to the Roadford compensation flow of over 300% of theoretical Q95) may also impact on juvenile populations at times.

The requirement for the Plym is therefore a thorough examination of the factors that influence the potentially excellent production potential of the Meavy, to ensure that the situation is optimised whenever possible. In practice, the aspects of the Scheme which are amenable to adjustment are the compensation flow and the timing of spill/large-scale releases from Burrator. The young-fish surveys carried out at intervals of several years by the NRA have given a most useful but incomplete picture of the performance of the Meavy. Annual surveys for at least five years are recommended, in conjunction with thorough redd surveys to establish the timing and extent of penetration of the system by spawning fish. About ten sites on the Meavy and its tributaries and on the Plym downstream of the confluence are recommended. August is the ideal time; attempts should be made to standardise the annual timing for valid comparisons.

The angling catch of salmon is also heavily dependent upon river flows in October-December, though the heavy dependence of good catches upon Burrator spill claimed by anglers may be a coincidence of very wet weather and Burrator spill being related. Careful consideration of catch statistics, with a positive effort to obtain total returns from the club fisheries involved, should provide the information required.

G3.2.5 River Torridge

The requirements for information on fish movements on the River Torridge are inter linked with those for wider management of this river including doubtful estuary and river water quality, generally depressed stocks of migratory fish, and the very low natural dry-weather flows. For this reason an integrated programme is suggested, covering a slightly wider scope than that dictated by Roadford considerations alone. Further, as fish tagged in the estuary are likely to migrate to both the Taw and the Torridge, a joint programme on both rivers is suggested.

The primary requirement is to investigate the influence of low and medium flows on the passage of fish out of salt water, through the tidal river, past Beam Weir, through the reach downstream of Torrington, and past the abstraction point and outfalls from the STW and creamery. As these points of critical interest are well spread out, a programme of radio tracking is suggested as the most effective option. However, as obtaining adequate numbers of Torridge fish for tracking is likely to be problematical, it is

suggested that the programme should be integrated with deployment of a low/medium flow counter installed at Beam Weir, at the exit from the fish pass.

Details of the programme would need development as the project proceeded; the ratio of Torridge/Taw salmon and sea trout at various points in the estuaries are unknown. On average, it is likely that Taw fish outnumber Torridge fish several-fold, but it may be possible to achieve a more effective balance by seeking sites in the upper Torridge estuary. In the first instance, tagging 50 salmon and 50 sea trout each year for 3 years is suggested, with the hope that perhaps 20 of each would ascend the Torridge.

On both rivers it is possible that a problem occurs in brackish water regarding water quality. if the first season of radio tracking indicated this (eg by long delays in tagged fish exiting brackish water) consideration should be given to an integrated programme of estuarine/freshwater tracking using combined acoustic/radio tags (CARTs).

The NRA are currently funding a widespread examination of water quality and other fishery problems in the Torridge. Effective integration of this with the requirements of the Roadford study would be to the mutual benefit of both investigations.

G3.2.6 River Taw

There is a requirement for an investigation of the pattern of migration of both salmon and sea trout into the Taw, particularly at low flows. In view of the minor predicted impact of the proposals on the Taw, a full scale programme of tracking might be difficult to justify. However, most(?) fish tagged in the joint Taw/Torridge estuary would be Taw fish, and a joint programme is proposed (see Section G3.2.5).

G4 WATER QUALITY

G4.1 Introduction

The purpose of water quality monitoring in relation to the Roadford Scheme is:

(a) To monitor the impacts at a limited number of sites where these impacts (of whatever nature) are expected to be most apparent.

(b) To confirm minimal or no impact at a limited number of sites where such is predicted.

The Halcrow Operating Case will give rise to flow changes whose magnitude and significance will vary from season to season. While it is recognised that river flow is not the only factor which governs river quality, nevertheless any quality changes which are brought about by the changes in flow will also exhibit a degree of seasonal variation. Accordingly a limited programme of regularly timed manual sampling is preferred in order to gain a balanced picture of quality throughout the year, and of compliance with quality objectives in particular.

G4.2 Sites to be Sampled

G4.2.1 The Tamar Catchment

The following sites should be sampled:

(a) The River Lyd immediately above its confluence with the River Tamar.

(b) The River Tamar at a suitable site downstream of Gunnislake abstraction, but upstream of Gunnislake weir.

(c) The Tamar estuary in the vicinity of Cotehele Quay, at a location which is clear of the mixing zone of the adjacent creek.

(d) Roadford reservoir in the vicinity of the draw-off.

(e) Roadford reservoir in the centre of the water body, in the vicinity of Lower Grinacombe.

G4.2.2 The Tavy Catchment

It is not considered necessary to monitor the Tavy catchment for water quality purposes alone. However it is suggested that monitoring above Lopwell Dam would serve to complement the fisheries information relating to the catchment.

G4.2.3 The Dart Catchment

The following sites should be sampled:

(a) The River Dart above the abstraction at Littlehempston.

(b) The River Dart below the abstraction at Littlehempston, but above Totnes weir.

(c) The Dart estuary below Totnes weir.

It is further recommended that a limited number of special surveys should be undertaken in order to determine typical diurnal and weekly patterns of variation in the flow and concentrations of dissolved oxygen and ammonia in the final effluent from Totnes STW.

G4.2.4 The Plym Catchment

No monitoring is proposed.

G4.2.5 The Torridge Catchment

The following sites should be sampled:

(a) The River Torridge at Town Mills, above the Great Torrington abstraction.

(b) The River Torridge at Rothern Bridge.

(c) The River Torridge at Beam footbridge.

(d) The Torridge estuary in the vicinity of Annery Kiln.

It is further recommended that the final effluents from Great Torrington STW and the Torridge Vale Creamery should be characterised in the manner suggested for Totnes STW (see G4.2.3 above).

G4.2.6 The Taw Catchment

The River Taw should be sampled below the abstraction at Newbridge, but immediately above its tidal limit.

G4.3 Sampling Frequencies

Table G4.1 shows the proposed sampling frequencies.

G4.4 Suites of Analysis

All samples of river, reservoir and estuary water should be analysed for those determinands which are necessary in order to assess compliance with

locally applicable environmental quality objectives, however these may be defined.

Chlorophyll *a*, phosphate, nitrate, dissolved oxygen, pH and temperature are required as indicators of trophic status, and as such should be monitored at those of the sites listed above which are liable to exhibit characteristics of a related nature.

Effluent samples should be analysed for those determinands for which limits are defined in the applicable consent to discharge, and any other determinands which may be deemed appropriate in order to thrown light upon related issues.

G4.5 Estuarine Stratification

Estuaries should be sampled just below the water surface and at 1 metre depth intervals thereafter; however, analyses for metals and pesticides (where required) need be carried out only on samples taken from the surface. If such depth profiling indicates than there is no significance stratification, then it may be discontinued, and subsequent samples take from just below the surface only.

Table G4.1
WATER QUALITY SAMPLING FREQUENCIES

Site	Sampling frequency
Lyd above Tamar	monthly
Tamar above Gunnislake weir	weekly
Tamar estuary at Cotehele Quay	samples at high and low water on spring and neap tides
Roadford reservoir at draw-off	monthly
Roadford reservoir at Lower Grinacombe	monthly
Tavy above Lopwell Dam	monthly
Dart above Littlehempston	weekly
Dart above Totnes weir	weekly
Dart estuary below Totnes weir	samples at high and low water on spring and neap tides
Torridge at Town Mills	weekly
Torridge at Rothern Bridge	weekly
Torridge at Beam footbridge	weekly
Torridge estuary at Annery Kiln	samples at high and low water on spring and neap tides
Taw at New Bridge	monthly

G5 ECOLOGY

G5.1 Introduction

The location of monitoring sites, and what should be monitored, must always be based upon organisms and locations which can address the objectives of the monitoring programme. The selection of the organisms and locations is dependent on many factors:

(a) Previous surveys. If **good** and **relevant** data have been collected before, site locations and target organisms are best based on these.

(b) Presence of (a) allows a 'before' and 'after' appraisal; - In the absence of this, selection of comparable sites above and below potential impacts are advisable but less frequently possible in practice.

(c) All 'key' taxa should be included. Thus any plants or animals of regional or national importance should be monitored providing sufficient is known about their seasonal/annual/long term behaviour to ensure spurious conclusions are not drawn.

(d) Commonplace or 'typical' taxa are often the best species to monitor since more is usually known about them and their behaviour in neighbouring catchments can indicate if changes in the monitored sites are 'causal' or 'incidental'.

(e) If prioritisation is required for political or financial reasons monitoring should be concentrated on areas potentially impacted the most - this will enable early 'alarm bells' to be rung if impacts are shown to be great. High priority areas are also those which support key communities and where adverse impacts might be readily redressed.

Table G5.1 summarises the areas of potential impact listed with reference to sections in the Ecology Annex (D) of this Report. It indicates:

(a) the depth of ecological information to gather for an area;

(b) the known interests of significance;

(c) the probable influence of Roadford;

(d) habitats or species of significance which are at risk;

(e) a summary of the Baseline survey and Monitoring needs.

More details are given on a catchment by catchment basis in the following sections. The proposals assume that bird counts will continue on the relevant estuaries and reservoirs and assessment made of the data furnished from them.

G5.2 Monitoring Sites

G5.2.1 Tamar Catchment

Reference to Table G5.1 shows that four separate sections require different degrees of monitoring. These are D6 - the Lyd sub-catchment, D7 - Tamar from Lyd Foot to Gunnislake, D8 - the freshwater section of the Tamar below Gunnislake and D9 - Tamar estuary.

D6 - Lyd sub-catchment. Good baseline information is available for macro-invertebrates, non-salmonid fish and macrophytes; there are also data on the physical characteristics of the substrates. Macro-invertebrate surveys continued through 1989, 1990 and 1991 and included an extension of previous surveys to establish the fauna associated with different micro-habitats of the Wolf. This has provided the baseline information required to enable the impact of the scheme on species of conservation significance to be assessed. The data are also capable of separating impacts from the construction, filling and operational phases. The data for this catchment are unusual since they contain both good quality data for pre-scheme conditions and 'controls'. Data on non-salmonid fish are also available, these being quantitative from 1984-1987 and semi-quantitative since then. Selected macrophyte surveys over several years provide a good picture of the plant communities of the Wolf before the Scheme. In 1990 a detailed mapping exercise began to indicate the species and standing crop supported by different habitats (ie submerged gravels, stable boulders, bare shingle, islands, banks, tree roots etc).

Massive physical changes are probable in the Wolf and monitoring of the baseline situation should continue for a period of a minimum of five years. The established invertebrate, fish and plant survey sites are adequate; more consideration may be needed to ascertain the most appropriate locations for establishing sedimentation changes. Invertebrate surveys need to be executed in Spring and Autumn if impacts of an operational nature are to be separated from those such as HEP generation etc. Fish and plant surveys are required annually.

Some background information is available on pre-impoundment conditions and the filling phase for birds of the river and otters. A pre-operational baseline survey is required and future monitoring should enable the impacts of summer releases to be assessed.

D7 - Tamar from Lyd Foot to Gunnislake. Minimal or no impact is expected here. However, the adequacy of the data for future comparison are very limited. Invertebrate data are virtually all to Family level only and no non-salmonid fish data of a quantitative nature have been collected since 1978. Macrophyte data are limited to qualitative estimates of abundance in selected 0.5km lengths.

It is recommended that three baseline survey sites should be set up which incorporate riffle/run/slack habitats. Spring and Autumn invertebrate surveys are required for two years; these should be to species level and

incorporate marginal vegetation, tree root and other in-stream habitat variations. The same sites should have macrophytes qualitatively estimated over a 0.5km length and representative 5m transects mapped for detailed future reference. Non-salmonid fish data should be collected in the standard manner at the three sites (quantitative) too. All should be executed for two years running and then repeated every five years. Following a drought year an Autumn and Spring (the following year) invertebrate survey should be undertaken to ascertain impact. Unlike in the other catchments, this will be to ascertain the impact of elevated summer flows for an extended period.

The whole baseline survey and monitoring programme is of a lower priority than on the Wolf since impact is likely to be negligible, or possibly quantifiably beneficial. However changes may occur and establishing the nature and extent of these could be valuable.

D8 - Freshwater Tamar below Gunnislake. A section or river where little impact is perceived but no data are available now which would enable this to be confirmed in the future. A survey strategy similar to that outlined for D7 is recommended but this would be a single site. Priority is very low.

D9 - Tamar Estuary. As with all estuaries, the potential impacts from the operation of Roadford are difficult to assess. The Tamar should be affected minimally. However it has an history of problems associated with low flow periods and an ornithological interest which justifies proposed SSSI status.

A baseline survey and monitoring strategy common to all five affected estuaries (Tamar, Tavy, Dart, Torridge and Taw) is advocated. Precise details require to be discussed with external organisations with specialist expertise in estuarine ecology (ie Plymouth Marine Laboratory, Oil Pollution Research Unit, Devon Wildlife Trust and English Nature).

A number of stations (c5) should be established along the salinity gradient from the point of abstraction (or obstruction to tidal influence) to a point downstream in the estuary (to be determined on an individual basis) where freshwater flows are not critical to biota. At each station a number of 'typical' invertebrate should be recorded from a variety of habitats such as muds, central channels with gravels, algal communities etc. The precise number of species should be defined through consultation but all must be quantitatively recorded. It is suggested that the number be between 10-20, ensuring that the number selected enables the objectives of the programme to be met. In this respect the length and width of estuary included must be large enough to enable any critical changes to be detected yet not too large to make the exercise excessively expensive and/or irrelevant.

The survey of invertebrates should be undertaken for three consecutive years to obtain an adequate baseline. After this is should be executed every third year to refine the understanding of yearly differences and how the gradient of freshwater influence changes (or is stable). In a drought year when flows naturally drop well below the prescribed flows a one-off survey will be required to ascertain its influence.

Although birds are regarded as the most important wildlife interest in most estuaries, no additional survey is required since the element of interest is centred on winter usage. Surveys are also routinely carried out; a monitoring programme may simply wish to analyse these data in the future (using controls of unaffected estuaries) to ascertain if the operation of Roadford can be implicated in any changes which might occur.

The priority for ecological monitoring in the Tamar is very low when considering the impacts possible in isolation. However the proposals are relatively cheap and would provide useful data to assist in any future water resource developments which might wish to consider a reduction in prescribed flows.

G5.2.2 Tavy Catchment (D4)

Abstraction from the Tavy is from above an head-of-tide obstruction at Lopwell. Inadequate data are available for the upper estuary to enable potential impacts to be determined. A base-line survey akin to that proposed for the Tamar estuary is required. The priority is very low when considering the impacts on the Tavy in isolation since benefits are perceived.

G5.2.3 Dart Catchment (D2)

A short stretch of freshwater Dart is potentially impacted above Totnes weir; however the major area potentially impacted is the upper estuary. Little data exists for these areas making judgements on potential risks to ecological interests impossible. As for the Tavy, priority is low because impacts are predicted to be beneficial.

A baseline survey and monitoring programme similar to that described for D8 and D9 on the Tamar is recommended to provide data to assist in any potential future water resource developments.

G5.2.4 Plym Catchment

Areas of potential impact on the Plym can be conveniently divided into three sections. These are Burrator itself, the Meavy below Burrator, and (for convenience) Devonport Leat. These are shown separately on Table 1.

D3 - Meavy below Burrator. This section of river has been identified as supporting a rich and luxuriant macrophyte community. Too little is known about its invertebrate populations and only a single quantitative non-salmonid fish survey has been executed on it. The Meavy will be potentially impacted through delayed spilling and a reduction in Burrator over-topping during other periods in the year.

The level of information available for the Meavy is similar to that on the Tamar between Lyd Foot and Gunnislake. A baseline survey similar to that proposed for that length of the Tamar is required. Repeating the survey for monitoring purposes will depend upon the regime of Burrator's filling and

spilling (and if the compensation flow is changed for fishery purposes). As there are uncertainties about Burrator's spilling regime, this is of high priority.

D15 - Burrator itself. The reservoir has considerable ecological interest due to both its age and past operating regime. It is noteworthy for supporting Quillwort. Birds are surveyed regularly in winter already and additional surveys will not be required. A single botanical survey is required when the reservoir is drawn down low for the first time. Zonation and relative abundances of the various aquatic plants needs to be determined. The survey should be repeated approximately every five years.

This element of baseline data gathering and monitoring is of the highest priority.

D5 - Devonport Leat. Flows in this historic system have been reduced to a minimum. Little is known about the ecological interest of the system and so potential impacts are impossible to determine.

A baseline survey similar to that proposed for the Tamar from Lyd Foot to Gunnislake is required. Site selection must ensure that the considerable variations in the system (ie cascading narrow channels to wide sluggish reaches) are covered. Concentrating on the upper sections of the Leat is also recommended since further down the system some inflows will elevate flows. This cannot be regarded as a priority since changes have already been in operation for some time.

G5.2.5 Torridge Catchment (D16, D11-13)

Table 1 shows that the Torridge system is potentially impacted from Meldon downstream to the estuary. No baseline or monitoring programme is required for the Torridge system above the abstraction point since the potential impact through any modified Meldon regime is small compared with the impacts of periodic acidic pollution incidents.

Since little or no information exists for the communities of plants around, and in, the drawdown zone of Meldon, a survey similar to that proposed for Burrator is required. If no changes in the operating regime are likely, this cannot be justified on the Roadford budget.

Baseline data are lacking for the Torridge estuary. For completeness, therefore, a survey similar to that proposed for the Tamar (D8 and D9) is advocated. It has to be regarded as of very low priority unless undertaken as an integrated survey with other estuaries.

G5.2.6 Taw Catchment (D14)

The abstraction is low down on a system where data are lacking to determine if it has a detrimental impact on ecological interest.

Due to the lack of information a baseline survey and monitoring programme similar to that on the Tamar (D8 and D9) is required. As with other estuaries, this is not a high priority; however since some potential adverse impact is possible, it has a higher priority than the others.

G5.2.7 Roadford (D17)

Once Roadford has filled, marginal communities should begin to develop. The establishment of vegetation should be monitored on an annual basis for the first five years and thereafter every five years.

Birds are already counted through the Warden and Devon Bird Watching and Preservation Society. This should continue to provide an adequate baseline. Future work should centre on analyses of these data to ascertain zones of greatest importance, associations of communities and habitats or activities etc. This information should then be used to influence stratified usage of the reservoir with other, potentially conflicting, interests.

Table G5.1

SUMMARY OF AREAS OF POTENTIAL ECOLOGICAL IMPACT

Site		Data	Significant Interest	Influence of Roadford	Habitats and Spp of Significance at Risk	Baseline and Monitoring Requirements	Priority
D2	Dart d/s Littlehempston	Dart Estuary Study by OPRU - Breeding birds, poor waders and wildfowl counted	Estuary described as 'typical' by OPRU, nothing special known	Reduced low-flow take increasing freshwater flow to esruary. Increased take at high flows.	Not known - Affects not known -No specific concerns.	Baseline survey over 3 years - update/ monitoring every 3 years and during droughts (invertebrates only)	VL
D3	Meavy & Plym d/s Burrator	Mandarin Breed; NTHH macroplyte Survey 1989 & 1990. Casual observatons; NRA invertebrate data (predominately family); limited non-salmonid fish data	Very productive and stable rivers. Good flora due to regulation but spates retained to cleanse substances.	Spilling potentially later from Burrator and less intensive when overtopping.	Not known - probably no major effect but retained winter spillage vital	Baseline survey of inverts and macros - former at 3 sites in spring and autumn for 2 years; latter three 1km sites and transects in year 1. Small fish survey. Repeat every 3 years. Meavy only.	M
D4	Tavy d/s Lopwell	Estuary surveyed by OPRU and birds counted	Very important for birds (pSSSI) (Waders) in winter, not summer	More summer abstractions protecting very low flows through augmentation.	Birds should not be at risk as interest is in winter	As for Dart or None	L
D5	Devonport Leat	Casual observation on plants, birds, fish and inverts (adhoc)	Macrophytes? Stable flow and lack of floods lead to greater growth and habitat for inverts	Reduced flows - could affect velocities and levels considerably	All if velocities change and sections become very shallow	Baseline invert, macros and fish survey - as Meavy - ? too late - None.	L
D6	Lyd Subcatchment	RCS, NTHH Macroplytes, Fish (all SPP) Inverts (detailed to SPP) otters, birds and fluvio-geomorphology	Two regionally important invertebrates - not confined to Wolf	Major elevation of summer flows and increased base-flow; minimal winter flooding, and HEP releases	Some taxa will increase vastly, others decrease; some invert taxa most impacted	Continue invertebrate survey and monitor micro-colonisation of plants in different habitats. Small fish survey every 3 years and monitor fluvial changes Annual Bird and Otter surveys.	VH
D7	Tamar - Lyd to Gunnislake	Few non-salmonid data, NTHH macro sites, RCS, NRA inverts	Locally rare plants only - not major significance	Higher Summer flows for abstraction @ Gunnislake	None known	Baseline invertebrate and small fish survey at three sites - then as for Meavy.	M
D8	Tamar - Gunnislake to weir	Minimal plant data	Nothing of special note.	Minimal except reduced median flows	None known	Baseline invertebrate, plant and fish survey or None	VL
D9	Tamar Estuary	Detailed OPRU study; extensive Bird data; considered for SSSI	OPRU list rare taxa - none in upper zone; very important to birds (ie. Avocet, Bar-tailed Godwit)	Reduced freshwater inputs under median flows - low flows unchanged	Concerns for birds but no impact likely; better understanding of physical impacts required	As for Dart	VL
D10	Okement d/s Meldon	NTHH Macrophytes, Inverts etc	None of special note	Reduced compensation - Minimal cf other factors	None likely	None	-
D11	Torridge-Okement to abstraction.	NTHH Macrophyte sites; Inverts etc	Some regionally rare plants, famous for otters	Reduced Meldon Compensation - minimal	None likely	None	-
D12	Torridge-Abstraction to tide	NTHH Macrophyte sites; Inverts etc	Some regionally rare plants, famous for otters	Reduced abstractions, protection from DO's	None - all should be helped	As for Tamar - Gunnislake	VL

Continued ...

Table G5.1 Continued

Site		Data	Significant Interest	Influence of Roadford	Habitats and Spp of Significance at Risk	Baseline and Monitoring Requirements	Priority
D13	Torridge Estuary	OPRU, bird counts, SSSI	Saline shoreline and waders	Increased summer freshwater; area of interest d/s of influence?	None likely	As for Dart	VL
D14	Taw Estuary	OPRU, bird counts, SSSI	Saline shoreline and waders	Reduced median flow; high pmf	None likely	As for Dart	L
D15	Burrator	Bird counts, casual observations	Goosander roost, Quillwort	Greater drawdown, delayed filling	Quillwort, marginal and shoreline flora and fauna	Baseline plant/habitat survey at low drawdown	VH
D16	Meldon	Bird counts	None	Possibly greater drawdown, no major influence	None likely	As Burrator	L
D17	Roadford	Bird counts	Developing	Not known yet	Not known yet	Baseline plant survey of margins once filled	H

KEY:
- D2-17 Refers to Roadford Final Report, Jan 1992, Ecological Annex, Description of Sites
- OPRU Oil Pollution Research Unit
- Macros Macrophytes
- DO Drought Orders
- Inverts Invertebrates
- RCS River Corridor Survey
- Spp Species
- NTHH Data from Holmes Surveys
- pmf Prescribed Minimal Flow

Priority Classes
- \- None (2)
- VL Very Low (5)
- L Low (4)
- M Medium (1)
- H High (2)
- VH Very High (1)

G6 FLOW MONITORING

G6.1 Support of Environmental Monitoring

G6.1.1 Fisheries

The movement of migratory fish is influenced by many environmental conditions such as water temperature and turbidity. The most critical factor is likely to be freshwater discharge. Therefore, in order to fully investigate the pattern of fish movements and any impacts resulting from the operation of the Scheme, it is essential to know the corresponding river flows. Generally, the existing NRA guaging stations, providing a continuous record of river flows at selected locations, are adequate to fulfil this requirement although gauging or modelling of flows downstream of the major abstractions would be desirable in order to more accurately identify the freshwater inputs to the estuaries.

G6.1.2 Water Quality

As with the fisheries monitoring the existing NRA gauging stations will provide much of the required supporting flow data although flows downstream of the major abstractions would be desirable. In addition, flow data are also required at major effluent discharge locations. For the purpose of this study the discharges of relevance are from Torrington, Totnes and Marshmills Sewage Treatment Works (STW's).

Ideally, river flows should be gauged immediately upstream of these discharges at the same time as water quality sampling is undertaken. The flow of the effluents themselves should also be gauged at the same time. In this context it is important to bear in mind the fact that sewage effluent flows are typically 3 times higher at 11am than they are at 2am; the objective in gauging sewage effluents should be to estimate the mean flow over 24 hours at appproximately the time when water quality samples are taken.

G6.1.3 Ecology

It is considered that the existing NRA gauging stations would be adequate to support the proposed ecological monitoring.

G6.2 Riparian Owner Considerations

During the consultations with the various riparian groups likely to be affected by the Roadford Scheme the issue of flow gauging, particularly in relation to abstraction policing, was raised on numerous occasions.

Several of the riparian groups expressed a desire for the installation of staff gauges downstream of the major abstractions to enable them to monitor compliance with prescribed flow conditions. However, although the idea behind such requests is valid it would be impracticable for several reasons. Whilst the genuine interest and concern of the riparian owners in relation to abstraction policing is accepted it has to be recognised that they are not fully aware of the complexities of the measurement of river flow. Flow cannot be measured from staff gauges - each one would need to be rated by trained hydrometric staff. Even then, because of the possibility of bed

movement, the gauges could not be relied upon and would need to be regularly re-rated, particularly after periods of high flows. This would not only increase the workload for hydrometric staff but could lead to riparian owners reaching totally erroneous conclusions regarding the operation of an abstraction.

Nevertheless, due to the very obvious concern of the riparian owners in relation to this issue there is a need to seriously consider ways in which they could become more involved. Rudimentary guidelines making very clear the shortcomings of staff gauges could be produced in conjunction with the installation of a small number of boards at strategic locations. In this way, good public relations could be maintained whilst making it clear to the riparian owners that the information they gain from the boards will provide only a very rough guide to what the river flow actually is.

The general principle behind the riparian owners comments, ie of measuring flow downstream of the major abstractions should be considered. Many groups, particularly on the Torridge and Taw expressed concern over the location of the gauging stations used to assess the operation of the abstractions - several kilometres upstream. Whilst it is recognised that in many cases there may be no suitable downstream location to install a gauging station it is recommended that serious consideration of possible locations is undertaken. This would go a long way towards satisfying the concerns of the riparian owners and as stated in Section G6.1.1. and G6.1.2 would provide valuable supporting data for the fisheries and water quality monitoring.

Annex H

RESERVOIR OPERATING AGREEMENT

HALCROW