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A RE-ASSESSMENT OF THE PHOSPHORUS LOADING TO LOCH LEVEN, KINROSS (TAYSIDE), 1994

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Report on progress to Scottish Natural Heritage and the Forth River Purification Board (March 1995)

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Background

In 1985-1986 the Freshwater Research Group of The Institute of Terrestrial Ecology (now, The Institute of Freshwater Ecology, Edinburgh Laboratory), led a multi-departmental project to assess the overall loading of phosphorus (P) to Loch Leven (Bailey-Watts, A.E., Sargent, R., Kirika, A. and Smith, M. 1987. *Loch Leven phosphorus loading.* Final Report to the DAFS, NCC, SDD and TRC).The targeting of P in that very extensive and intensive survey (with measurements at 27 sampling sites over 14 months at 8-day intervals) reflected the fact that this was the primary nutrient limiting phytoplankton productivity. Of particular concern then, and now, is the development - in approximately 50% of years - of very large populations ('blooms') of blue-green algae at Loch Leven. Under certain weather conditions, these organisms can form unsightly surface scums which may accumulate on a downwind shore. Moreover, toxins are produced by some species.

The study quantified the contributions of diffuse runoff of P from agricultural land, point sources of effluent from industrial concerns and sewage treatment works (STWs), the input in rain falling directly onto the surface of the loch, and that in wildfowl faeces. The study concluded that approximately 21 t P entered the loch during 1985 - with *ca.* 8 t coming in diffuse runoff, 6.3 t from an industrial source (woollen mill), and a further 5.3 t from STWs.

The report recommended that in order to stem the production of planktonic algae, priority attention should be given to reducing P inputs, and that the material emanating from the mill should be targeted as soon as possible. These recommendations were followed up, and it appears - on the basis of continued surveillance results from the South Queich which received mill effluent - that virtually no P has entered the loch from the mill, since the end of 1987, and possibly even earlier than this. Improvements have also been made as regards the P removal performance of the main STWs in the catchment. As a result, the total P load is now less than that estimated from the 1985 study. In addition, the relative contribution from land runoff is likely to be greater than it was some 10 years ago, and as a consequence, the inputs from point sources is smaller than hitherto. The latter change is of special significance. Relative to most runoff sources, STW effluent is considerably richer in soluble reactive P (SRP) - which is almost certainly the form of P that is most readily taken up by phytoplankton - and woollen mill effluent was relatively rich in soluble P compounds that were rapidly hydrolysed to SRP.

In spite of the reductions in P loading, the loch has continued to produce as dense, and as durable, blooms of phytoplankton as before. Indeed, only in years (such as 1985 itself) in which the summer was very wet, has the loch appeared less characteristically eutrophic. This resulted in rapid flushing which would have mediated against the accumulation of algal cells produced; releases of P from the sediments, and accumulation of the nutrient in the column also are less marked under such conditions.

The relative lack of a response, so far, by the loch to reduced P loading is by no means uncommon in world terms. Nevertheless, it is thought that the current situation as regards the total P loading to the loch and the main sources of this nutrient should be re-assessed. After all, a decade has elapsed since the first study was completed.

Objectives

The main objectives of the study are as follows:

- to assess the total phosphorus loading and the inputs of the particulate and soluble fractions, to the loch for the calendar year 1995.
- to distiguish between the various contributions to the total loading, by means of chemical sampling at 19 sites, on some 12 of which flow data will also be gathered.
- to prepare a short summary of the analytical results by 31 March 1995.
- to prepare a draft final report of the findings, including comparisons with the P loading study of 1985/86, by 28 Feb 1996, and the final version by 31 March 1996.
- to prepare outlines of manuscripts for publication in internationally-refereed journals, by 31 March 1996.

Methods

Chemical sampling commenced on 26 January. This followed (i) a re-inspection of the 1985 sampling sites, (ii) modification of the programme following e.g diversion of all Kinross sewage to the North works, and (iii) instalment of new staff guages. The new programme includes a sub-catchment in the upper South Queich drainage area which was not assessed as a separate entity in 1985/86. The new programme also being executed in parallel with a project led by the Forth River Purification Board which focuses on P inputs in storm events. Such phenomena are often 'missed' in schedules of regularly spaced sampling such as the 8-daily one adopted here. The Board is also responsible for the sampling programme aimed at assessing P loadings derived from the STWs.

Table 1 indicates the overall sampling coverage and the points at which water discharge is also gauged. Eight of the sites are worthy of comment, as they have been added to the list envisaged when the project was first mooted:

- *Sa* on the South Queich facilitates assessment of any differences in nutrient content from that measured upstream of the mill (at *Sc*) due to discharge or overflow from the mill or the old Kinross South STWs.

- *Nb* and *Ne*: *Nb* is on the North Queich, at the furthest point downstream before the confluence with the Hatton Burn; any differences in chemical concentrations between this point and *Ne* at Lathro, could identify discharge from the old Milnathort works.

- *Na*, which lies below the confluence with the Hatton, is included because the eventual outfall from the new Milnathort STWs will be too close to the Hatton for sampling at *Nb* to continue.

- *Ca*, which is situated on the Camel Burn below the outflow pipes from the fishponds, and *Cp* - the pipes themselves: the first accounts for all of the water in the Camel Burn, whilst the second accounts for the water passing through the ponds.

- *Kc* lies on the Kinnesswood Burn in the village above the STWs; comparisons between the samples taken there with those collected at *Kb* - the Grahamstone field drain pump site - will allow some estimation of the STW contribution.

- *Gu* is an easily accessible point on a tributary (the Bog Burn) draining mostly agricultural land on the Gairney.

Table 1. Chemical sampling points (including those monitored by FRPB in the parallel project, and the discharge gauging sites.

Loading source	Chemical sampling site	Flow gauging or recording
STW (FRPB	KINROSS NORTH	?
	MILNATHORT	?
CATCHMENT	S.QUEICH	RECORDER
STORM	N.QUEICH	RECORDER
EVENTS (FRPB)	GAIRNEY WATER	RECORDER
	POW BURN	RECORDER
S.QUEICH	THE HECKS - Sa	**********
	QUEICH BRIDGE - Sc	RECORDER
	CARNBO - Se	STAFF GAUGE
N.QUEICH	BELOW BURGHER BRIDGE - Na	**********
	ABOVE BURGHERBRIDGE - Nb	OLD STAFF GAUGE
	LATHRO - Ne	RECORDER
FOCHY BURN	MILNATHORT - Nf	STAFF GAUGE
HATTON BURN	NEAR OLD RAILWAY BRIDGE - Nh	STAFF GAUGE
URY BURN	BEHIND WILLIE WILSON'S HOUSE - Ua	STAFF GAUGE
GAIRNEY WATER	GAIRNEY BRIDGE - Gb	STAFF GAUGE
	CARSEGOUR BRIDGE - Gc	STAFF GAUGE
BOG BURN	AT MAIN ROAD - Gu	**********
CAMEL BURN	BELOW FISH PONDS - Ca	**********
	LOTHRIES BRIDGE - Cc	STAFF GAUGE
	FISH PONDS OUTFALL - Cp	**********
POW BURN	POWMILL - Pb	RECORDER
KINNESSWOOD BURN	GRAHAMSTONE FIELD DRAIN PUMP SITE - Kb	STAFF GAUGE
	IN KINNESSWOOD - Kc	BUCKET
LOCH LEVEN	AT SLUICES - L	RECORDER

We are also taking note of the water level at the staff gauge in the harbour at Kinross - although that gauge has not yet been levelled.

A single determination of the following is being made on each of two samples collected at each field site: total phosphorus (TP), total soluble P (TSP, which approximates to 'dissolved organic' P), SRP, dissolved silica (SiO_2 or soluble reactive silica - SRS), and nitrate-nitrogen (NO_3-N). Data will be logged, analysed and interpreted as in the earlier study, but they will be presented in keeping with much-improved typescript and computer graphic facilities.

Results

There is relatively little to report at this early stage. There have been only 6 sampling 'tours'. However, as noted in the earlier study, water levels in all of the burns and streams appear to rise

and fall in unison, although the actual and possibly the relative, week-to-week fluctuations vary between the water courses. So far, the majority of the total P concentrations measured at the points corresponding to the lowermost sampling stations on each of 7 inflows (the two Queichs, the Gairney Water, and the Pow, Ury, Camel and Kinnesswood Burns) have come in the range 10 to 120 $\mu g\ l^{-1}$. Some considerably higher values have been recorded, however. These are as follows:

- in the Kinnesswood Burn, approximately 300, 400 and 450 $\mu g\ l^{-1}$ in late January, late February and early March, respectively
- 200 $\mu g\ l^{-1}$ in early February and between 300 and 350 $\mu g\ l^{-1}$ in mid-February in both the Ury and the Pow Burns.

Each of these peaks in total P concentrations are attributable primarily to rises in the levels of SRP.

Stream and burn SRS concentrations are generally high although there is a two-fold range i.e. from *ca* 6 to 12 mg $SiO_2\ l^{-1}$. This is in keeping with the high levels of some 9 mg l^{-1} recorded in the loch at the turn of the year - although diatom growth has reduced the in-loch levels to some 5 mg l^{-1} at the time of writing.

A E Bailey-Watts and A Kirika
11 March 1995