

Environmental Protection Report

IMPACT ASSESSMENT OF A SCOUR VALVE TEST AT ROADFORD RESERVOIR ON WATER QUALITY OF THE RIVER LYD

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IMPACT ASSESSMENT OF A SCOUR VALVE TEST AT ROADFORD RESERVOIR ON WATER QUALITY OF THE RIVER LYD.

SUMMARY

South West Water Services Ltd. released water from Roadford Reservoir on 21 October 1991 to test the operation of the scour valves for dam safety purposes. Flow at Lifton Bridge increased from 2.6 cumecs to a maximum flow of 8.5 cumecs over a period of 3 hours.

Hourly samples were collected at Lifton Bridge on the River Lyd to assess the impact of the release on water quality. Suspended solids and particulate metal concentrations were found to increase as river flow increased. Relevant Environmental Quality Standards for concentrations of total zinc, total iron and suspended solids were exceeded at peak flow. The cause was considered to be the re-suspension of solids from the river bed.

The solids may have been recently deposited during reservoir operation. Alternatively the source of metalliferous solids could be a legacy of the reservoir construction when there was disturbance of mineralised deposits and soils.

Although there was exceedance of EQS's during the dam safety test, the impact on river uses, such as the protection of salmonid fish, is considered to be negligible. This is because the event was short lived.

In addition, the EQS failure for zinc was marginal. High suspended solids concentrations also occurred naturally in the River Lyd prior to the construction of Roadford Reservoir.

It is recommended that geochemical surveys of river sediments are carried out and compared to previous surveys to determine any changes in sediment quality. South West Water Services Ltd. should be notified that future scour valve tests at Roadford Reservoir should be carried out during naturally high river flows in order to ensure any re-suspended solids are flushed from the system and are effectively diluted. This action plan should be developed by SWW in cooperation with the NRA and Riparian Owners and subject to flood defence requirements.

FWI/92/004

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QUALITY OF THE RIVER LYD.

REPORT FWI/92/004.

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CONTENTS.

	Page Number
1. INTRODUCTION.	1
2. STUDY AREA.	1
3. METHODS.	2
4. RESULTS.	2
5. DISCUSSION.	3
5.1 Sources of suspended solids and particulate metals.	3
5.2 Remedial measures.	4
6. CONCLUSIONS.	4
7. RECOMMENDATIONS.	4
8. REFERENCES.	4

IMPACT ASSESSMENT OF A SCOUR VALVE TEST AT ROADFORD RESERVOIR ON WATER QUALITY OF THE RIVER LYD.

1. INTRODUCTION

As part of the safe operation of reservoirs, scour valves are installed at the base of dam walls to ensure that rapid draw-down of water in the reservoir can occur during emergencies. Reservoir operators are required to have these scour valves inspected regularly by civil engineers. Part of the inspection may require the scour valves to be opened fully to make sure they are not blocked and to ensure that they function properly.

This report describes the impact of a scour valve test at Roadford Reservoir on downstream water quality in the River Lyd at Lifton on 21 October 1991 (see Fig. 1).

The approach of the study was to monitor water quality hourly during the safety test and to compare results with Environmental Quality Standards (EQS's). The monitoring site at Lifton was chosen because it was the site of maximum impact during previous test releases.

2. STUDY AREA.

The Rivers Wolf, Thrushel and Lyd have been assigned River Quality Objectives (RQO's) using the National Water Council (NWC) classification of Class 1B. Water quality is routinely monitored at 5 sampling sites (see Fig. 1). Recent classifications are shown in Table 1.

TABLE 1. NWC Classifications (1985 to 1990)

River	Reach upstream of	85	86	87	88	89	90
Wolf	Rexon Bridge	1B	1B	1B	1B	1B	1B
Wolf	Thrushel confluence	1B	2	1B	1B	1B	1B
Thrushel	Tinhay Bridge	1B	1B	1B	1B	1B	1B
Lyd	Lifton Bridge	1B	1B	1B	1B	1B	1B

Routine chemical monitoring started at Newbridge immediately downstream of Roadford Reservoir on 8 October 1991 and as such there is insufficient data for the NWC Classification.

Aquatic invertebrates are sampled at 5 sites (see Fig. 1). During 1990 the river stretch downstream of Roadford Reservoir to Lifton was classified as Class A.

The National Rivers Authority South West (NRA SW) have continued to use the following use-related Environmental Quality Objectives for the Rivers Wolf, Thrushel and Lyd:

- * Protection of Aesthetic Quality
- * Protection of Direct Abstraction for Potable Supply
- * Protection of Salmonid Fish
- * Protection of Other Aquatic Life/Dependant Organisms

- * Protection of Livestock Watering
- * Protection of Irrigation of Crops

The River Wolf prior to the confluence with the River Thrushel down to Lifton Bridge has been designated for the protection of salmonid fish under the EC Freshwater Fish Directive (see Fig. 1 for sampling sites). All sites complied with the EC Freshwater Fish Directive during 1990.

3. METHODS.

Hourly samples were collected at Lifton between 11:00 hrs on 21 October 1991 and 02:00 hrs on 22 October 1991, and analysed for suspended solids, dissolved metals and total metals.

River water quality was recorded at Lifton and Newbridge using continuous water quality monitors. The fixed site monitor at Lifton proved unreliable and was therefore replaced with a portable PHOX 100 DPM monitor. Parameters recorded included dissolved oxygen, temperature, pH, conductivity and turbidity (not at Lifton) every 15 minutes. River flow data was collected from the gauging station at Lifton and Newbridge.

4. RESULTS.

During the test release the flow at Lifton increased from 2.6 cumecs at 13:00 hrs to a peak of 8.5 cumecs at 16:00 hrs (Fig. 2). Maximum flow was higher than the average daily flow (ADF = 4.56 cumecs for 1991).

At peak flow, suspended solid concentrations, total iron and total zinc concentrations exceeded relevant EQS's (see Table 3 and Fig. 2).

Table 3. Exceedence (*) of the EQS at Lifton.

Date	Time	Solids (mg/l)	Total Iron (mg/l)	Total Zinc (mg/l)
21-Oct-91	10:56	6.4	0.25	0.007
	11:57	4.4	0.31	0.006
	12:55	12.0	0.54	0.013
	14:04	32.0	0.43	0.008
	15:02	52.0	0.56	0.009
	16:00	*505.0	*10.90	*0.075
	17:00	*266.0	*4.25	0.021
	18:00	92.0	2.04	0.013
	19:00	22.0	0.89	0.017
	20:00	11.0	0.59	0.010
	21:00	15.0	0.59	0.010
	22:00	26.0	0.97	0.010
	23:00	20.0	0.78	0.009
	23:59	12.0	0.59	0.008
22-Oct-91	01:00	6.9	0.50	0.009
	02:00	5.5	0.42	0.006

Dissolved metals, dissolved oxygen, temperature and pH complied with EQS's at Newbridge and Lifton sites (see Appendix I).

5. DISCUSSION.

The discharge of water during the safety test at Roadford Reservoir had an impact on water quality by increasing concentrations of suspended solids in the River Lyd at Lifton. High concentrations of particulate metals were associated with the suspended solids. Dissolved metals concentrations did not change significantly because the pH remained neutral.

Although there was exceedance of EQS's during the scour valve test the impact on river uses such as the protection of salmonid fish, is considered negligible. This is because the duration of the event was short (approximately 2 hours). In addition, EQS failure for total zinc concentrations was marginal. High suspended solids concentrations (up to 315 mg/l) have also been recorded at Lifton Bridge prior to the construction of Roadford Reservoir (see Appendix II).

It must be noted that the river hardness during this study was just within the 0-50 mg/l hardness band which gives rise to a strict standard (= 0.030 mg/l). If an annual average hardness value had been used then the 50-100 mg/l hardness band would have been used resulting in a more relaxed standard for total zinc (=0.200 mg/l).

Previous work at Roadford Reservoir in 1990 during a scour valve test also demonstrated an increase in suspended solids and metal concentrations at Lifton. Flow from the reservoir was gradually increased from the compensation flow (=0.1 cumecs) to a maximum flow of 7.6 cumecs over a period of 5 hours. During this test concentrations of suspended solids and particulate metals increased downstream of Roadford Reservoir (Ref. 1)(see Appendix III).

5.1. Sources of suspended solids and particulate metals.

The 1990 study did not detect an impact on water quality at Newbridge immediately downstream of Roadford Reservoir (see Appendix III). It is therefore assumed that the source of suspended solids and metals is from re-suspended particles from the river bed and erosion of river banks during the high flow event. The source is therefore not considered to be from bottom sediments in the reservoir.

The presence of metalliferous solids on the river bed could be a legacy of reservoir construction and basin clearance during 1988. Land disturbance resulted in an increase in quantity of fine material in river gravels for up to 5 km below the dam site (Ref 2). Disturbance of mineralized areas also resulted in higher concentrations of zinc in river sediments downstream of the dam (Ref. 3). However, a reduction in the quantity of fine material in river gravels has occurred after one year of operation of Roadford Reservoir (Ref. 4).

Metalliferous sediments can accumulate downstream of reservoirs. When low dissolved oxygen occurs during reservoir stratification, metals are brought into solution. These are then precipitated on the downstream river bed under

highly oxygenated conditions if a discharge is made from the bottom water. It is not known whether the destratification techniques used at Roadford Reservoir prevent solution of very low concentrations of metals. If low concentrations of metals are released from the reservoir these may gradually accumulate in the river bed.

5.2. Remedial measures.

A protocol should be developed to regulate future scour valve releases. This should ensure scour valve testing safety testing at Roadford Reservoir is carried out at a time of naturally high river flows in the catchment when metals and suspended solids concentrations are effectively diluted, and that they are flushed from the river system.

6. CONCLUSIONS.

1. Suspended solids, total iron and total zinc concentrations exceeded relevant EQS's for approximately 2 hours during a scour valve test on 21 October 1991.
2. The impact on river users was considered to be negligible.

7. RECOMMENDATIONS.

1. A repeat geochemical survey of river sediments should be carried out to determine whether there is a change in sediment quality.

Action - Freshwater Officer

2. South West Water Services Ltd should be informed that the scour valve test at Roadford Reservoir should be carried out during naturally high river flows according to a protocol in cooperation with the NRA and Riparian Owners and subject to flood defence requirements.

Action - Freshwater Officer / Quality Regulation Officer / Pollution Officer

8. REFERENCES.

1. Sambrook H. (1990) Roadford Reservoir: Scour Valve Test 1990 Draft Discussion Paper. National Rivers Authority South West.
2. Petts G. E. (1988) Geochemical analysis of fine grained sediment in the Upper Tamar. Phase 2. Loughborough University of Technology.
3. Petts G. E. Hughes N. (1990) Geochemical analysis of fine grained sediment in the Upper Tamar. Phase 4. Loughborough University of Technology.
4. Petts G. E. et al (1991) Sediment sampling in fish spawning grounds in the Upper Tamar catchment. Phase 5. Loughborough University of Technology.

FIGURE 1. Map of the study area

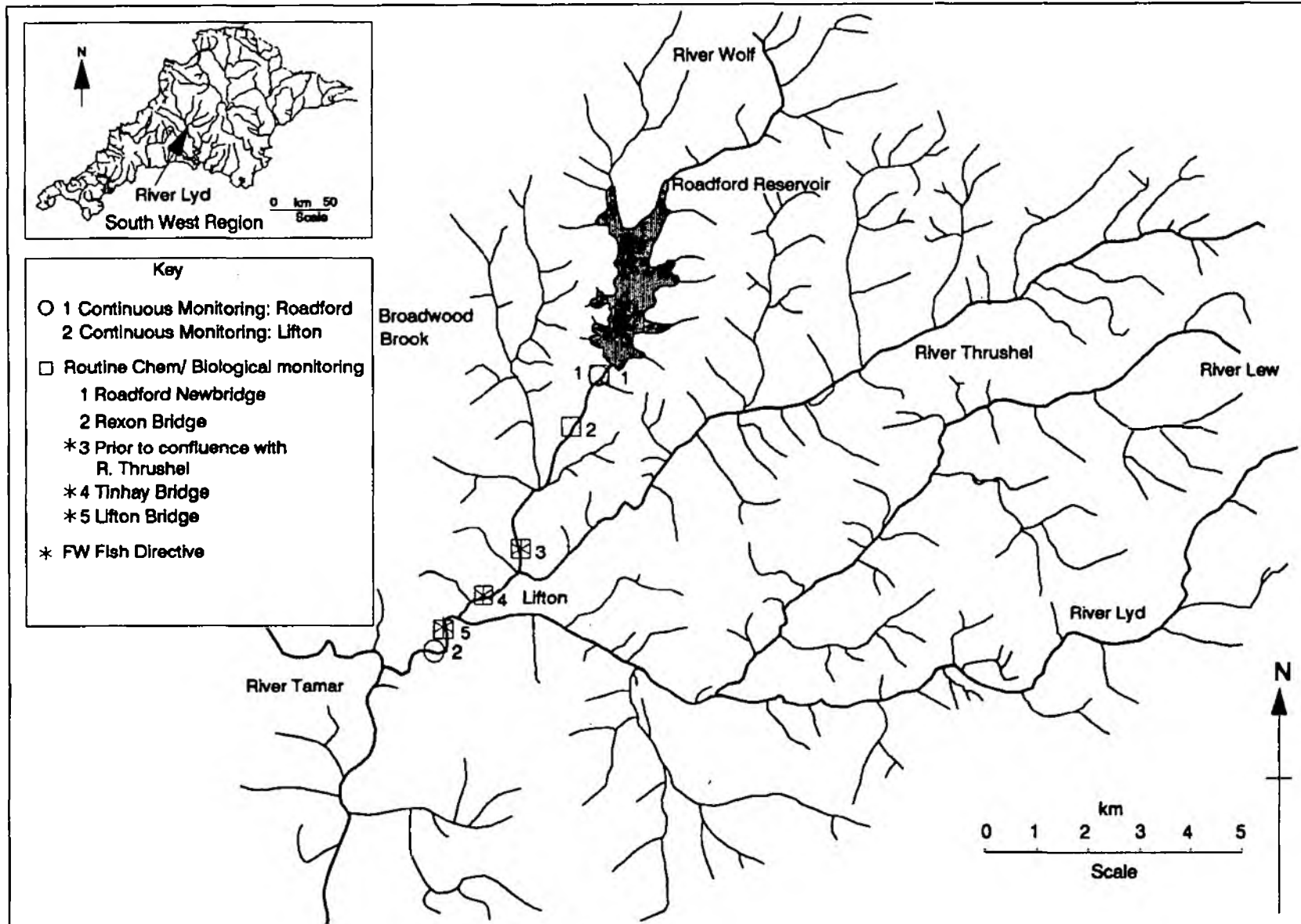
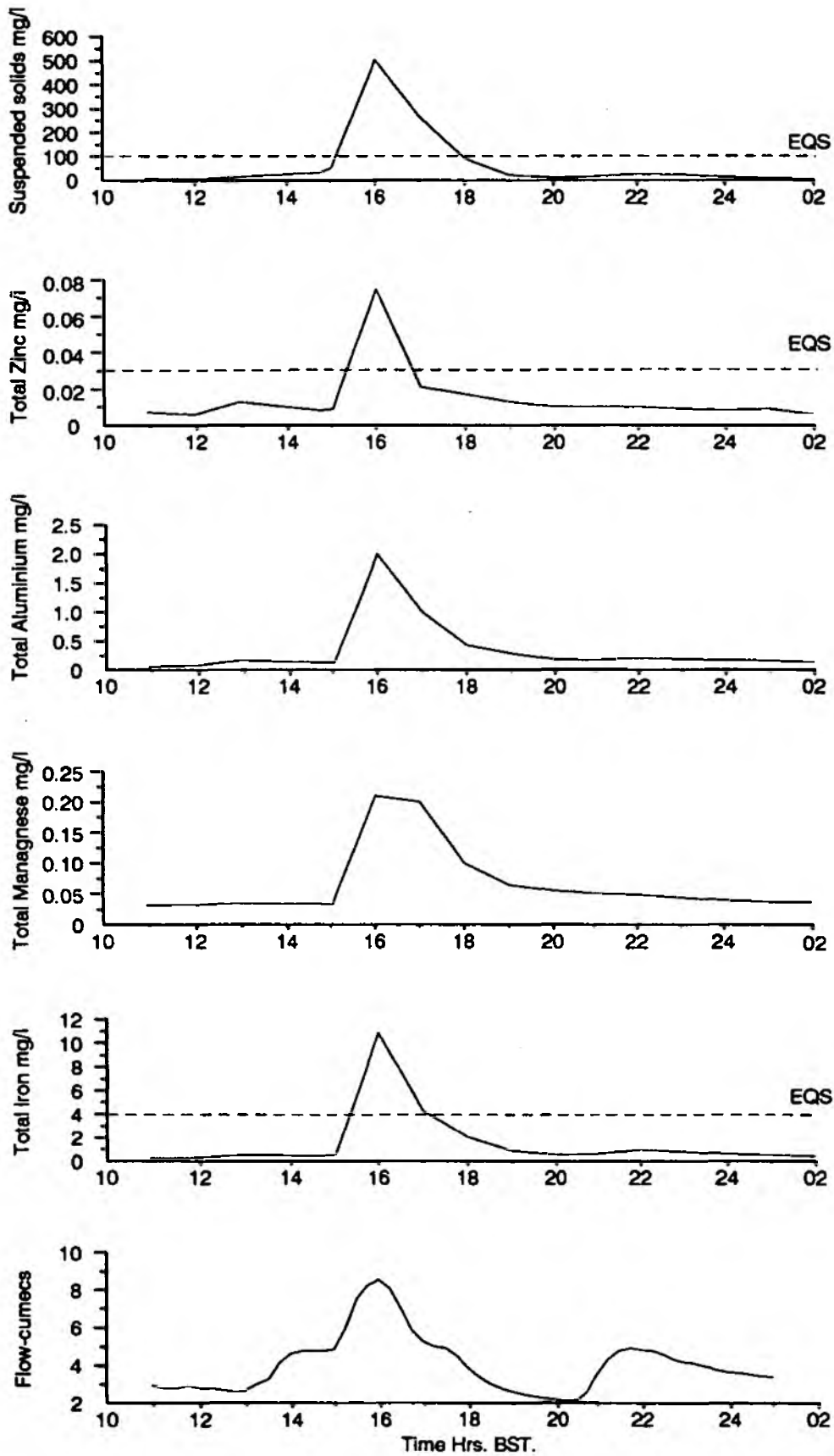


FIGURE 2. Suspended solids, total metals concentrations and flow data collected at Lifton Bridge during 21st October 1991.



EQS's from the EC Freshwater Fish and Dangerous Substances Directive.
EQS given as 95 % ile (= 4 X annual mean standards).

Appendix I. Total and dissolved metals concentrations and suspended solids concentrations collected at Lifton during October 1991.
Continuous monitoring data collected at Lifton and Newbridge October 1991.

Tabular Determinand Results and Basic Statistics Report

Date/Time Sample Taken	0135 SS 105	0158 HARD T	0213 COPPER	0215 COPPER	0237 MG	0241 CALCIU	0243 ZINC D	0245 ZINC	0285 AL DIS
T 21/10/91 10:56	6.4000	43.9000	0.0010	0.0020	3.4000	12.0000	No Result	0.0070	0.0300<
T 21/10/91 11:57	4.4000	44.3000	0.0010	0.0010	3.5000	12.0000	No Result	0.0060	0.0300<
T 21/10/91 12:55	12.0000	51.4000	0.0010	0.0030	4.0000	14.0000	No Result	0.0130	0.0300<
T 21/10/91 14:04	32.0000	45.2000	0.0020	0.0020	3.7000	12.0000	No Result	0.0080	0.0300<
T 21/10/91 15:02	52.0000	41.0000	0.0010	0.0020	3.3000	11.0000	No Result	0.0090	0.0300<
T 21/10/91 16:00	505.0000	53.0000	0.0010	0.0110	4.4000	14.0000	0.0250	0.0750	0.0300<
T 21/10/91 17:00	266.0000	41.0000	0.0010	0.0040	3.3000	11.0000	0.0160	0.0210	0.0300<
T 21/10/91 18:00	22.0000	51.0000	0.0020	0.0020	4.0000	14.0000	No Result	0.0130	0.0300<
T 21/10/91 20:00	11.0000	51.4000	0.0010	0.0030	3.9000	14.0000	No Result	0.0170	0.0300<
T 21/10/91 21:00	15.0000	51.0000	No Result	0.0020	4.1000	14.0000	No Result	0.0100	0.0300<
T 21/10/91 22:00	26.0000	51.8000	0.0020	0.0020	4.2000	13.0000	No Result	0.0100	0.0300<
T 21/10/91 23:00	20.0000	48.9000	0.0020	0.0020	4.0000	13.0000	No Result	0.0090	0.0300<
T 21/10/91 23:59	12.0000	49.7000	0.0010	0.0020	4.2000	13.0000	No Result	0.0080	0.0300<
T 21/10/91 01:00	6.9000	48.1000	0.0020	0.0020	3.8000	13.0000	No Result	0.0090	0.0300<
T 21/10/91 02:00	5.5000	51.4000	No Result	0.0010	4.0000	14.0000	No Result	0.0060	0.0300<

Tabular Determinand Results and Basic Statistics Report

Date/Time Sample Taken	0287 ALUMIN	0401 MANG D	0403 MANGAN	0419 IRON D	0421 IRON	0000	0000	0000	0000
	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	((((
T 21/10/91 10:56	0.0600	0.0310	0.0330	0.1500	0.2500	*	*	*	*
T 21/10/91 11:57	0.0800	0.0320	0.0470	0.1600	0.3100	*	*	*	*
T 21/10/91 12:55	0.1700	0.0350	0.0770	0.1700	0.5400	*	*	*	*
T 21/10/91 14:04	0.1300	0.0330	0.2600	0.2000	0.4300	*	*	*	*
T 21/10/91 15:02	0.1300	0.0320	0.2000	0.1600	0.5600	*	*	*	*
T 21/10/91 16:00	2.0000	0.2100	2.5000	0.1900	10.9000	*	*	*	*
T 21/10/91 17:00	1.0000	0.2000	0.7400	0.2500	4.2400	*	*	*	*
T 21/10/91 17:00	0.2800	0.0640	0.2000	0.1600	0.8900	*	*	*	*
T 21/10/91 18:00	0.4200	0.1000	0.4700	0.1900	2.0400	*	*	*	*
T 21/10/91 20:00	0.1900	0.0550	0.1200	0.1600	0.5600	*	*	*	*
T 21/10/91 21:00	0.1800	0.0510	0.1200	0.1600	0.5900	*	*	*	*
T 21/10/91 22:00	0.2100	0.0490	0.2100	0.1700	0.9700	*	*	*	*
T 21/10/91 23:00	0.1900	0.0440	0.1700	0.1500	0.7800	*	*	*	*
T 21/10/91 23:59	0.1800	0.0400	0.1400	0.1600	0.5900	*	*	*	*
T 22/10/91 01:00	0.1600	0.0370	0.0940	0.1700	0.5000	*	*	*	*
T 22/10/91 02:00	0.1400	0.0360	0.0770	0.1500	0.4200	*	*	*	*

Continuous Monitoring, Newbridge.

Date	Time	Dissolved Oxygen ‰	Temperature Deg. C.	pH	Conductivity uS
21-October-	1991 9: 44	110	14	7.4	160
21-October-	1991 9: 59	107	14	7.4	156
21-October-	1991 10: 14	104	13.8	7.4	160
21-October-	1991 10: 29	103	13.8	7.4	156
21-October-	1991 10: 44	103	13.8	7.4	152
21-October-	1991 10: 59	102	13.8	7.4	152
21-October-	1991 11: 14	102	13.8	7.4	152
21-October-	1991 11: 29	102	13.8	7.4	152
21-October-	1991 11: 44	102	13.8	7.4	152
21-October-	1991 11: 59	102	13.8	7.4	152
21-October-	1991 12: 14	102	14	7.4	152
21-October-	1991 12: 29	103	13.8	7.4	152
21-October-	1991 12: 44	103	13.8	7.4	152
21-October-	1991 12: 59	102	13.8	7.4	152
21-October-	1991 13: 14	103	13.8	7.4	152
21-October-	1991 13: 29	103	13.8	7.4	148
21-October-	1991 13: 44	104	13.8	7.5	148
21-October-	1991 13: 59	105	13.8	7.6	148
21-October-	1991 14: 14	105	13.8	7.6	148
21-October-	1991 14: 29	105	13.8	7.6	148
21-October-	1991 14: 44	104	13.8	7.5	148
21-October-	1991 14: 59	104	13.8	7.4	152
21-October-	1991 15: 14	104	13.8	7.4	148
21-October-	1991 15: 29	104	13.8	7.4	152
21-October-	1991 15: 44	104	13.8	7.4	152
21-October-	1991 15: 59	103	13.8	7.3	156
21-October-	1991 16: 14	102	13.8	7.1	172
21-October-	1991 16: 29	102	13.8	7	176
21-October-	1991 16: 44	102	13.8	7	176
21-October-	1991 16: 59	103	13.8	7.2	176
21-October-	1991 17: 14	102	13.6	7.3	176
21-October-	1991 17: 29	101	13.6	7.3	168
21-October-	1991 17: 44	101	13.6	7.3	164
21-October-	1991 17: 59	101	13.6	7.4	156
21-October-	1991 18: 14	101	13.6	7.4	152
21-October-	1991 18: 29	102	13.6	7.4	152
21-October-	1991 18: 44	102	13.6	7.4	152
21-October-	1991 18: 59	102	13.6	7.4	148
21-October-	1991 19: 14	102	13.6	7.4	152
21-October-	1991 19: 29	102	13.6	7.4	148
21-October-	1991 19: 44	102	13.6	7.4	148
21-October-	1991 19: 59	102	13.6	7.4	148
21-October-	1991 20: 14	102	13.6	7.4	148
21-October-	1991 20: 29	102	13.6	7.4	152
21-October-	1991 20: 44	102	13.6	7.4	152
21-October-	1991 20: 59	102	13.6	7.4	152
21-October-	1991 21: 14	102	13.6	7.4	152
21-October-	1991 21: 29	102	13.6	7.4	152
21-October-	1991 21: 44	102	13.6	7.4	152
21-October-	1991 21: 59	102	13.6	7.4	152
21-October-	1991 22: 14	102	13.6	7.4	152
21-October-	1991 22: 29	102	13.6	7.4	152
21-October-	1991 22: 44	102	13.6	7.4	152
21-October-	1991 22: 59	102	13.6	7.4	152

21-October-	1991	23: 29	102	13.6	7.4	152
21-October-	1991	23: 44	102	13.6	7.4	152
21-October-	1991	23: 59	102	13.6	7.4	152
22-October-	1991	0: 14	102	13.6	7.4	152
22-October-	1991	0: 29	102	13.6	7.4	152
22-October-	1991	0: 44	102	13.6	7.4	152
22-October-	1991	0: 59	101	13.6	7.4	152
22-October-	1991	1: 14	101	13.6	7.3	152
22-October-	1991	1: 29	101	13.4	7.3	156
22-October-	1991	1: 44	101	13.4	7.3	156
22-October-	1991	1: 59	101	13.4	7.4	156
22-October-	1991	2: 14	102	13.6	7.4	156
22-October-	1991	2: 29	102	13.6	7.4	152
22-October-	1991	2: 44	102	13.6	7.4	152
22-October-	1991	2: 59	102	13.6	7.4	152
22-October-	1991	3: 14	102	13.6	7.4	156
22-October-	1991	3: 29	102	13.6	7.4	152
22-October-	1991	3: 44	102	13.6	7.4	152
22-October-	1991	3: 59	102	13.6	7.4	152
22-October-	1991	4: 14	102	13.6	7.4	156
22-October-	1991	4: 29	102	13.6	7.4	152
22-October-	1991	4: 44	102	13.6	7.4	152
22-October-	1991	4: 59	102	13.6	7.4	152
22-October-	1991	5: 14	102	13.6	7.4	152
22-October-	1991	5: 29	102	13.6	7.4	152
22-October-	1991	5: 44	102	13.6	7.4	152
22-October-	1991	5: 59	102	13.6	7.4	152
22-October-	1991	6: 14	102	13.6	7.4	152
22-October-	1991	6: 29	102	13.6	7.4	156
22-October-	1991	6: 44	102	13.6	7.4	152
22-October-	1991	6: 59	102	13.6	7.4	152
22-October-	1991	7: 14	102	13.8	7.4	152
22-October-	1991	7: 29	102	13.6	7.4	152
22-October-	1991	7: 44	102	13.6	7.4	156
22-October-	1991	7: 59	102	13.6	7.4	152
22-October-	1991	8: 14	103	13.8	7.4	156
22-October-	1991	8: 29	102	13.6	7.4	152
22-October-	1991	8: 44	103	13.6	7.4	156
22-October-	1991	8: 59	103	13.8	7.4	152
22-October-	1991	9: 14	103	13.8	7.4	156
22-October-	1991	9: 29	103	13.6	7.4	156
22-October-	1991	10: 14	106	13.8	7.2	164
22-October-	1991	10: 29	106	13.8	7.2	168
22-October-	1991	10: 44	106	13.8	7.3	164
22-October-	1991	10: 59	106	13.8	7.4	168
22-October-	1991	11: 14	105	13.8	7.4	164
22-October-	1991	11: 29	105	13.8	7.4	160
22-October-	1991	11: 44	104	13.8	7.4	156
22-October-	1991	11: 59	104	13.8	7.4	156
22-October-	1991	12: 14	104	13.8	7.4	156
22-October-	1991	12: 29	104	13.8	7.4	152
22-October-	1991	12: 44	104	13.8	7.4	152
22-October-	1991	12: 59	104	14	7.4	152
22-October-	1991	13: 14	104	13.8	7.4	152
22-October-	1991	13: 29	104	13.8	7.4	152
22-October-	1991	13: 44	104	14	7.4	152

Continuous Data, Lifton Site

Date	Time	Dissolved Oxygen %	Temperature Deg.C.	pH	Conductivity uS.
21-October-	1991 11: 51	105	10	6.6	160
21-October-	1991 12: 60	106	10	7	160
21-October-	1991 12: 21	107	10	7.2	160
21-October-	1991 12: 36	107	10.3	7.3	160
21-October-	1991 12: 51	107	10.3	7.3	160
21-October-	1991 13: 60	107	10.3	7.3	160
21-October-	1991 13: 21	106	10.3	7.4	160
21-October-	1991 13: 36	107	10.3	7.4	160
21-October-	1991 13: 51	107	10.5	7.4	160
21-October-	1991 14: 60	107	10.8	7.5	160
21-October-	1991 14: 21	107	11	7.5	160
21-October-	1991 14: 36	108	11.3	7.5	160
21-October-	1991 14: 51	108	11.5	7.5	160
21-October-	1991 15: 60	108	11.8	7.4	160
21-October-	1991 15: 21	107	12	7.4	160
21-October-	1991 15: 36	106	12.3	7.4	150
21-October-	1991 15: 51	106	12.5	7.4	150
21-October-	1991 16: 60	105	12.8	7.4	150
21-October-	1991 16: 21	105	12.8	7.3	140
21-October-	1991 16: 36	105	12.8	7.3	150
21-October-	1991 16: 51	101	12.5	7.3	140
21-October-	1991 17: 60	103	12.5	7.4	140
21-October-	1991 17: 21	107	12.3	7.4	150
21-October-	1991 17: 36	107	12.3	7.4	150
21-October-	1991 17: 51	106	12	7.4	150
21-October-	1991 18: 60	106	12	7.4	150
21-October-	1991 18: 21	105	12	7.4	150
21-October-	1991 18: 36	105	11.8	7.4	150
21-October-	1991 18: 51	105	11.5	7.4	150
21-October-	1991 19: 60	105	11.5	7.4	150
21-October-	1991 19: 21	104	11.3	7.4	150
21-October-	1991 19: 36	104	11.3	7.4	150
21-October-	1991 19: 51	104	11	7.4	150
21-October-	1991 20: 60	104	11	7.4	150
21-October-	1991 20: 21	103	11	7.4	150
21-October-	1991 20: 36	104	10.8	7.4	150
21-October-	1991 20: 51	104	10.8	7.3	160
21-October-	1991 21: 60	104	10.8	7.4	160
21-October-	1991 21: 21	104	10.8	7.4	160
21-October-	1991 21: 36	104	10.8	7.4	170
21-October-	1991 21: 51	104	11	7.4	160
21-October-	1991 22: 60	104	11.3	7.4	160
21-October-	1991 22: 21	104	11.3	7.4	160
21-October-	1991 22: 36	104	11.3	7.4	160
21-October-	1991 22: 51	104	11.3	7.4	160
21-October-	1991 23: 60	105	11.3	7.4	160
21-October-	1991 23: 21	104	11.3	7.4	160
21-October-	1991 23: 36	104	11.3	7.4	150
21-October-	1991 23: 51	105	11.3	7.4	150
22-October-	1991 0 : 60	105	11	7.4	150
22-October-	1991 0 : 21	105	11	7.4	150
22-October-	1991 0 : 36	104	11	7.4	160
22-October-	1991 0 : 51	104	11	7.4	160
22-October-	1991 1 : 60	104	11	7.4	160
22-October-	1991 1 : 21	103	10.8	7.4	150
22-October-	1991 1 : 36	103	10.8	7.4	160

22-October-	1991	1	:	51	103	10.8	7.4	160
22-October-	1991	2	:	60	103	10.8	7.4	160
22-October-	1991	2	:	21	103	10.5	7.4	160
22-October-	1991	2	:	36	103	10.5	7.4	160
22-October-	1991	2	:	51	103	10.5	7.4	160
22-October-	1991	3	:	60	104	10.5	7.4	160
22-October-	1991	3	:	21	104	10.5	7.4	160
22-October-	1991	3	:	36	104	10.5	7.4	160
22-October-	1991	3	:	51	104	10.3	7.3	160
22-October-	1991	4	:	60	103	10.3	7.4	160
22-October-	1991	4	:	21	103	10.3	7.3	160
22-October-	1991	4	:	36	103	10.3	7.3	160
22-October-	1991	4	:	51	104	10.3	7.3	160
22-October-	1991	5	:	60	104	10	7.4	160
22-October-	1991	5	:	21	103	10	7.3	160
22-October-	1991	5	:	36	103	10	7.4	160
22-October-	1991	5	:	51	104	10	7.3	160
22-October-	1991	6	:	60	104	10	7.3	160
22-October-	1991	6	:	21	104	10	7.3	160
22-October-	1991	6	:	36	104	10	7.4	160
22-October-	1991	6	:	51	104	10	7.4	160
22-October-	1991	7	:	60	104	10	7.4	160
22-October-	1991	7	:	21	104	9.8	7.3	160
22-October-	1991	7	:	36	104	9.8	7.3	160
22-October-	1991	7	:	51	104	9.8	7.4	150
22-October-	1991	8	:	60	104	9.8	7.4	160
22-October-	1991	8	:	21	104	9.8	7.4	160
22-October-	1991	8	:	36	104	9.8	7.4	160
22-October-	1991	8	:	51	104	9.8	7.4	160
22-October-	1991	9	:	60	104	9.8	7.4	160
22-October-	1991	9	:	21	104	9.8	7.4	160
22-October-	1991	9	:	36	105	9.8	7.4	160
22-October-	1991	9	:	51	105	9.8	7.4	160
22-October-	1991	10	:	60	105	9.8	7.4	160
22-October-	1991	10	:	21	105	9.8	7.4	160
22-October-	1991	10	:	36	105	9.8	7.4	160
22-October-	1991	10	:	51	105	9.8	7.4	160
22-October-	1991	11	:	60	106	9.8	7.4	160
22-October-	1991	11	:	21	106	10	7.4	160
22-October-	1991	11	:	36	106	10	7.4	160
22-October-	1991	11	:	51	106	10	7.4	160
22-October-	1991	12	:	60	106	10	7.4	160
22-October-	1991	12	:	21	106	10	7.4	160
22-October-	1991	12	:	36	106	10	7.4	160
22-October-	1991	12	:	51	106	10	7.4	160
22-October-	1991	13	:	60	106	10	7.5	160

Appendix II. Data for the NWC Classification 1983-1990.

LYD AT LIFTON BRIDGE

R12F002

DATE	PH	TEMP	DO	BOD ATU	AMMON TOTAL	AMMON UNION	S.S. 105	COPPER	ZINC	ORTHOPHOS	NITRATE
	PH UNITS	CEL	% SATN		MG/L N	MG/L N	MG/L	MG/L Cu	MG/L Zn	MG/L P	MG/L N
10/01/83	7.1000	8.3000	95.0000	1.7000	0.0700	0.0100	7.0000	0.0100	0.0100	0.0400	2.1000
11/01/83	7.1000	9.0000	95.0000	2.2000	0.0700	0.0100	10.0000			0.0400	2.1000
14/01/83	7.0000	8.0000	95.0000	7.6000	0.3200		143.0000	0.0100	0.0310	0.0800	1.6000
26/01/83	7.2000	9.0000	91.0000	1.3000	0.0700		4.0000	0.0040	0.0130	0.0600	2.2000
09/02/83	7.2000	4.0000	97.0000	1.6000	0.0400	0.0100	3.0000	0.0100	0.0100	0.0400	2.0000
10/02/83	7.5000	3.0000	94.0000	2.4000	0.0700		2.8000	0.0030	0.0190	0.0400	2.3000
22/02/83	7.7000	4.0000	98.0000	3.6000	0.0200		5.6000	0.0050	0.0200	0.0400	2.2000
14/03/83	7.6000	9.0000	95.0000	2.7000	0.0700		7.0000	0.0050	0.0140	0.0600	2.0000
15/03/83	7.6000	8.0000	93.0000	1.9000	0.0300	0.0100	6.0000			0.0500	1.8000
22/03/83	7.8000	6.9000	101.0000	2.5000	0.0500	0.0100	4.0000	0.0100	0.0100	0.0900	1.8000
29/03/83	7.6000	8.0000	104.0000	1.5000	0.0400		4.8000	0.0040	0.0140	0.0500	2.2000
06/04/83	7.4000	6.5000	91.0000	3.6000	0.2500	0.0100	21.0000	0.0100	0.0100	0.0800	1.7000
09/05/83	7.4000	11.0000	94.0000	1.3000	0.0500	0.0100	9.2000	0.0050	0.0170	0.0600	2.3000
22/06/83	7.6000	16.3000	105.0000	2.4000	0.0300	0.0100	4.0000	0.0050	0.0100	0.1400	1.6000
25/07/83	7.2000	19.0000	96.0000	2.4000	0.1300	0.0100	5.6000	0.0060	0.0070	0.1800	1.4000
03/08/83	7.7000	15.5000	99.0000	1.1000	0.1000	0.0100	2.6000	0.0050	0.0050	0.3400	1.3000
12/09/83	7.7000	13.0000	88.0000	2.2000	0.0400	0.0100	2.8000	0.0050	0.0420	0.1700	1.3000
12/09/83	7.3000	12.3000	89.0000	2.7000	0.0600	0.0100	2.8000	0.0050	0.0560	0.1900	1.1000
20/10/83	7.2000	8.9000	94.0000	0.8000	0.0900	0.0100	4.0000	0.0050	0.0190	0.0400	2.6000
28/11/83	7.4000	6.6000	84.0000	1.8000	0.1100	0.0100	9.2000	0.0050	0.0160	0.0300	3.7000
06/12/83	7.4000	5.5000	96.0000	2.2000	0.0600	0.0100	1.8000	0.0050	0.0060	0.0400	2.6000
14/12/83	7.1000	9.0000	81.0000	3.0000	0.1000	0.0100	8.0000			0.0300	3.2000
17/01/84	6.7000	7.5000	93.0000	2.1000	0.0900	0.0100	17.2000	0.0050	0.0160	0.0300	3.9000
23/02/84	7.3000	5.6000	97.0000	2.1000	0.1000	0.0100	6.4000	0.0050	0.0140	0.0400	3.1000
06/03/84	7.2000	7.5000	95.0000	0.8000	0.0400	0.0100	2.0000	0.0050	0.0090	0.0200	2.8000
21/03/84	7.1000	5.5000	91.0000	2.5000	0.0400	0.0100	1.6000			0.0300	2.4000
10/04/84	7.5000	6.8000	102.0000	1.8000	0.0300	0.0100	1.2000	0.0060	0.0120	0.0600	2.3000
17/05/84	7.2000	10.3000	89.0000	1.9000	0.1200	0.0100	4.8000	0.0050	0.0140	0.1800	2.1000
14/06/84	7.2000	15.2000	90.0000	1.8000	0.0200	0.0100	5.6000			0.1600	1.5000
26/06/84	7.5000	17.3000	99.0000	0.8000	0.1000	0.0100	4.0000	0.0050	0.0300	0.2600	1.0000
09/07/84	7.1000	17.2000	96.0000	2.1000	0.1700	0.0100	4.8000	0.0050	0.0200	0.2300	1.1000
18/07/84	7.4000						2.0000				
08/08/84	8.0000						0.8000				
16/08/84	7.6000	17.3000	96.0000	1.4000	0.0900	0.0100	3.2000	0.0050	0.0300	0.4400	1.1000
05/09/84	7.5000	14.2000	90.0000	2.1000	0.1000	0.0100	4.6000	0.0070	0.0400	0.2700	0.9000
27/09/84	7.4000						13.0000				
17/10/84	7.1000	11.8000	92.0000	1.6000	0.0600	0.0100	3.0000	0.0050	0.0120	0.1000	1.9000
12/11/84	6.8000	8.7000	80.0000	6.4000	0.2600	0.0100	315.0000			0.1400	1.9000
26/11/84	6.5000	7.5000	92.0000	1.6000	0.0700	0.0100	9.8000	0.0050	0.0160	0.0300	3.4000
03/12/84	6.9000	9.4000	87.0000	1.5000	0.2200	0.0100	31.6000	0.0060	0.0130	0.0500	3.1000
09/01/85	7.2000	3.9000	95.0000	1.1000	0.0900	0.0100	4.6000			0.0500	3.0000
22/01/85	6.6000	4.3000	88.0000	3.2000	0.2300	0.0100	32.8000	0.0050	0.0150	0.0600	2.8000
27/02/85	7.3000	7.5000	98.0000	1.2000	0.0400	0.0100	3.2000	0.0030	0.0080	0.1000	2.4000
11/03/85	7.4000	6.3000	100.0000	2.1000	0.0300	0.0100	3.2000	0.0030	0.0120	0.1000	2.0000
25/03/85	6.7000	5.9000	91.0000	3.1000	0.0800	0.0100	6.8000			0.0500	2.3000
22/04/85	7.2000	8.0000	95.0000	1.7000	0.0500	0.0100	4.4000	0.0030	0.0080	0.0500	2.5000
09/05/85	7.0000	11.4000	105.0000	1.7000	0.0400	0.0100	3.2000	0.0020	0.0130	0.1200	1.7000
17/05/85	7.8000	13.5000	109.0000	2.2000	0.0500	0.0100	3.6000			0.1300	1.6000
04/06/85	6.8000	16.3000	86.0000	1.9000	0.0900	0.0100	3.6000	0.0030	0.0240	0.1800	1.6000

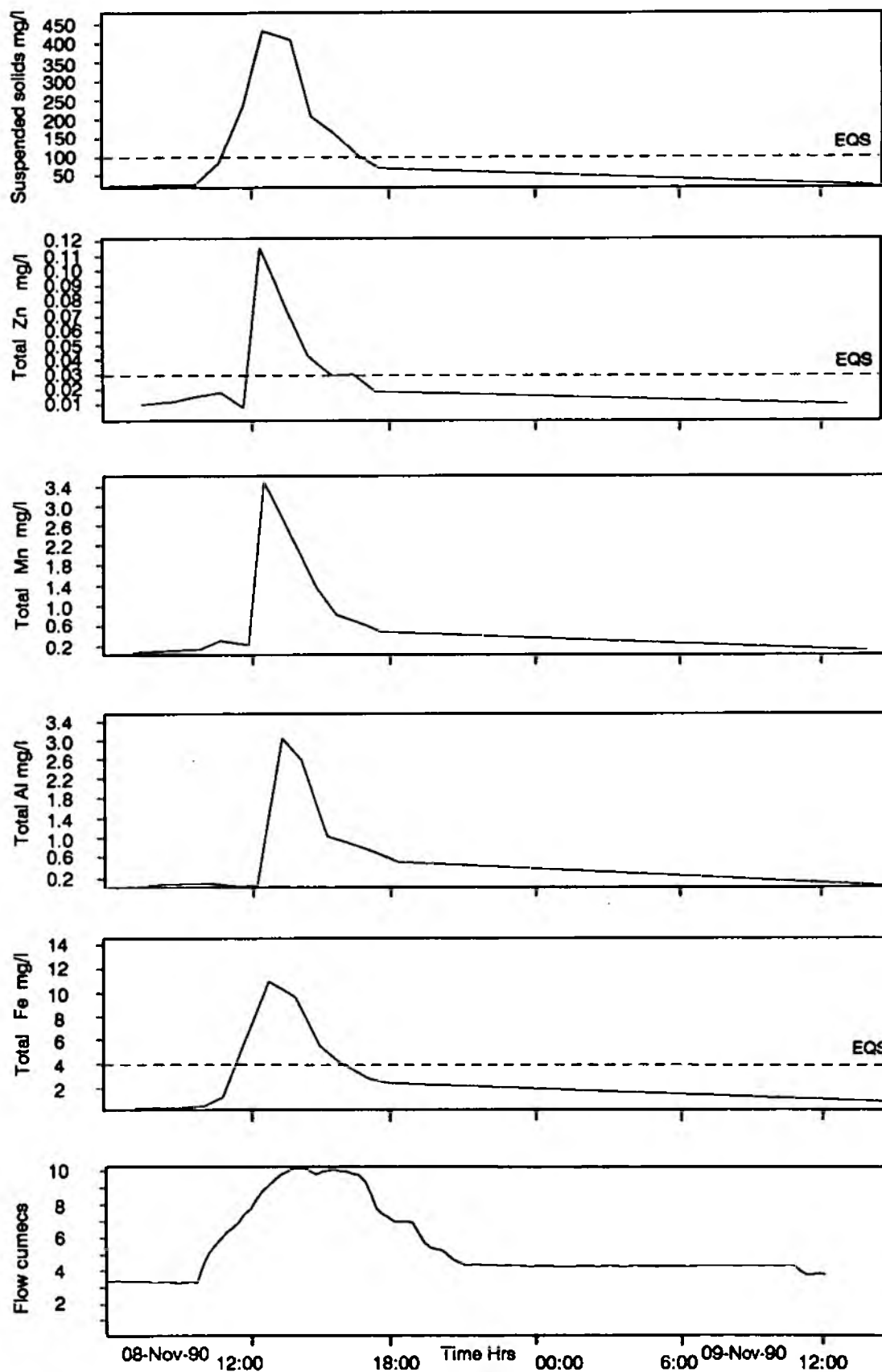
23/07/85	7.3000	15.5000	95.0000	0.8000	0.0400	0.0100	3.8000	0.0040	0.0290	0.1500	1.2000
07/08/85	7.4000	13.3000	91.0000	1.7000	0.0500	0.0100	7.6000	0.0030	0.0100	0.0500	1.7000
11/09/85	7.2000	12.2000	93.0000	0.2000	0.0100		5.8000	0.0040	0.0230	0.0300	2.3000
19/09/85	7.3000	14.0000	92.0000	0.9000	0.0300	0.0100	3.6000	0.0060	0.0150	0.0800	1.9000
07/10/85	6.7000	12.4000	93.0000	2.7000	0.1000	0.0100	42.0000	0.0050	0.0140	0.0800	2.1000
27/11/85	7.3000	5.0000	92.0000	3.0000	0.1300	0.0100	14.8000	0.0090	0.0160	0.1000	2.2000
10/12/85	7.0000	7.2000	93.0000	1.1000	0.0900	0.0100	8.4000	0.0030	0.0110	0.0300	3.2000
17/12/85	7.0000	9.5000	95.0000	2.1000	0.0500	0.0100	9.2000			0.0400	2.8000
21/01/86	7.3000	7.5000	92.0000	2.8000	0.2900	0.0100	54.0000	0.0050	0.0140	0.0900	2.3000
12/02/86	7.1000	3.0000	97.0000	2.1000	0.1200	0.0100	6.6000	0.0030	0.0120	0.0400	2.6000
03/03/86	7.2000	1.0000	95.0000	1.7000	0.0800	0.0100	1.8000	0.0020	0.0170	0.0900	2.2000
20/03/86	7.2000	7.0000	87.0000	2.5000	0.1600	0.0100	6.2000			0.0500	2.1000
28/04/86	7.6000	7.0000	96.0000	2.4000	0.0800	0.0100	8.4000	0.0030	0.0080	0.0600	2.9000
01/05/86	7.7000	8.7000	95.0000	1.7000	0.0400	0.0100	5.8000			0.0300	2.7000
15/05/86	7.3000	8.6000	101.0000	1.8000	0.2600	0.0100	49.0000	0.0040	0.0140	0.0600	2.5000
18/06/86	7.7000	12.7000	104.0000	0.3000	0.0300	0.0100	3.8000	0.0030	0.0060	0.0800	2.0000
03/07/86	7.7000	15.1000	98.0000	0.8000	0.0300	0.0100	3.8000	0.0040	0.0140	0.0900	1.6000
04/08/86	7.6000	11.3000	92.0000	1.7000	0.0600	0.0100	4.0000	0.0040	0.0210	0.1200	1.3000
02/09/86	7.4000	11.7000	98.0000	1.2000	0.0400	0.0100	5.6000	0.0020	0.0080	0.0300	2.6000
25/09/86	7.6000	9.1000	94.0000	1.8000	0.0400	0.0100	4.0000	0.0030	0.0160	0.1000	1.9000
15/10/86	7.5000	10.8000	95.0000	1.4000	0.0100	0.0100	1.2000	0.0030	0.0190	0.0600	1.5000
13/11/86	6.9000	10.6000	91.0000	3.3000	0.1400	0.0100	126.0000	0.0060	0.0190	0.0500	2.1000
09/12/86	7.0000	8.0000	90.0000	3.1000	0.1200	0.0100	25.4000			0.0400	2.6000
15/12/86	6.7000	8.6000	91.0000	3.0000	0.2000	0.0100	289.0000	0.0090	0.0270	0.0900	1.5000
06/01/87	6.8000	6.6000	96.0000	1.0000	0.0900	0.0100	5.6000	0.0030	0.0090	0.0300	2.7000
11/02/87	6.9000	6.1000	90.0000	2.9000	0.1500	0.0100	14.4000	0.0040	0.0110	0.0700	2.3000
04/03/87	6.6000	6.2000	100.0000	2.5000	0.0600	0.0100	12.8000			0.0300	2.7000
26/03/87	7.4000	7.8000	97.0000	2.5000	0.0600	0.0100	11.0000	0.0030	0.0090	0.0300	2.7000
14/04/87	7.3000	10.0000	104.0000	1.4000	0.0500	0.0100	4.4000	0.0020	0.0060	0.0500	2.6000
13/05/87	7.5000	10.5000	100.0000	2.3000	0.0200	0.0100	3.6000	0.0020	0.0140	0.1400	1.7000
20/05/87	7.4000	11.9000	98.0000	2.3000	0.0400	0.0100	5.2000			0.1000	1.6000
18/06/87	7.3000	13.0000	98.0000	1.3000	0.0400	0.0100	3.0000	0.0020	0.0170	0.1000	1.5000
27/07/87	7.6000	15.7000	97.0000	0.9000	0.0500	0.0100	3.0000	0.0010	0.0040	0.1200	1.5000
11/08/87	7.4000	12.9000	92.0000	0.8000	0.0700	0.0100	2.8000	0.0020	0.0090	0.1900	1.5000
14/09/87	7.4000	14.0000	94.0000	1.4000	0.0500	0.0100	4.4000	0.0030	0.0180	0.0800	1.2000
16/09/87	7.5000	13.8000	94.0000	1.7000	0.0600	0.0100	5.2000	0.0030	0.0270	0.1100	1.2000
21/10/87	7.2000	11.8000	95.0000	1.8000	0.0500	0.0100	20.0000	0.0040	0.0090	0.0600	3.1000
09/11/87	7.2000	8.5000	87.0000	3.2000	0.1800	0.0100	36.0000	0.0050	0.0110	0.0700	1.5000
08/12/87	7.0000	5.0000	103.0000	3.8000	0.0500	0.0100	3.0000	0.0020	0.0070	0.0400	2.8000
14/12/87	7.4000	5.0000	92.0000	2.0000	0.0500	0.0100	3.6000			0.0500	2.6000
13/01/88	7.2000	7.1000	88.0000	2.0000	0.1600	0.0100	32.0000	0.0050	0.0220	0.0500	2.5000
17/02/88	7.4000	5.0000	97.0000	2.3000	0.0400	0.0100	7.4000	0.0050	0.0080	0.0200	3.0000
21/03/88	7.2000	6.9000	91.0000	1.7000	0.0800	0.0100	17.2000			0.0400	2.5000
28/03/88	7.4000	7.8000	99.0000	1.6000	0.0900	0.0100	5.0000	0.0050	0.0140	0.0400	2.6000
19/04/88	7.6000	11.0000	103.0000	1.7000	0.0700	0.0100	5.0000	0.0050	0.0050	0.0600	2.0000
04/05/88	7.5000	9.5000	89.0000	3.0000	0.0900	0.0100	14.4000			0.0600	1.7000
18/05/88	7.5000	12.2000	94.0000	1.3000	0.0800	0.0100	3.6000	0.0050	0.0230	0.1000	1.7000
16/06/88	7.6000	16.8000	99.0000	2.6000	0.1000	0.0100	3.2000	0.0050	0.0350	0.2300	1.5000
13/07/88	7.5000	11.9000	84.0000	1.5000	0.0300	0.0100	7.4000			0.0400	1.9000
28/07/88	7.4000	13.3000	93.0000	1.2000	0.0100	0.0100	5.4000	0.0050	0.0120	0.0600	1.8000
09/08/88	7.6000	14.6000	96.0000	1.1000	0.0400	0.0100	2.4000	0.0050	0.0120	0.1000	1.7000
14/09/88	7.4000	10.9000	101.0000	0.4000	0.0100		1.6000	0.0020	0.0110	0.0700	1.8000
23/09/88	7.5000	12.0000	89.0000	2.3000	0.0200	0.0100	5.6000	0.0030	0.0150	0.0500	1.8000
26/10/88	7.3000	13.5000	96.0000	2.0000	0.0300	0.0100	2.6000	0.0050	0.0060	0.0400	2.0000
14/11/88	7.3000	7.1000	99.0000	2.9000	0.0200	0.0100	1.6000	0.0050	0.0130	0.0400	1.7000
07/12/88	7.3000	7.0000	91.0000	1.7000	0.0900	0.0100	12.0000			0.0400	2.8000
14/12/88	7.0000	9.7000	97.0000	1.4000	0.0500	0.0100	2.8000	0.0020	0.0040	0.0400	2.2000
18/01/89	7.4000	5.6000	95.0000	1.1000	0.0400	0.0100	3.8000	0.0020	0.0080	0.0300	2.4000
15/02/89	7.3000	7.8000	96.0000	1.8000	0.0400	0.0100	4.0000	0.0040	0.0180	0.0500	2.0000
13/03/89	6.9000	8.0000	95.0000	3.2000	0.1300	0.0100	20.0000	0.0030	0.0060	0.0600	2.0000
07/04/89	6.5000	8.0000	97.0000	3.1000	0.0800	0.0100	10.8000			0.0500	2.1000
13/04/89	7.4000	6.9000	95.0000	2.6000	0.0600	0.0100	11.6000	0.0030	0.0070	0.0600	2.0000
25/05/89	7.5000	17.5000	102.0000	1.9000	0.0600	0.0100	8.4000			0.1700	1.7000
31/05/89	7.5000	12.0000	100.0000	1.4000	0.0400	0.0100	3.2000	0.0030	0.0190	0.1500	1.6000
21/06/89	7.2000	18.0000	106.0000	1.5000	0.1400	0.0100	3.0000	0.0060	0.0650	0.2000	1.6000

07/07/89	7.6000	17.2000	92.0000	1.5000	0.0800	0.0100	1.8000	0.0060	0.0360	0.3400	1.3000
09/08/89	7.7000	19.5000	107.0000	1.5000	0.0900	0.0100	2.8000	0.0040	0.0770	0.4800	1.1000
07/11/89	7.4000	10.3000	102.0000	0.8000	0.0300	0.0100	6.8000	0.0040	0.0170	0.0200	3.9000
05/12/89	7.4000	3.9000	94.0000	3.4000	0.0200	0.0100	1.0000	0.0020	0.0090	0.0200	2.2000
04/01/90	7.1000	7.8000	98.0000	1.9000	0.0800	0.0100	15.0000	0.0030	0.0110	0.0300	3.8000
19/02/90	7.3000	9.5000	95.0000	1.2000	0.0700	0.0100	7.6000	0.0090	0.0160	0.0300	3.2000
03/03/90	7.3000	9.9000	105.0000	1.3000	0.0500	0.0100	4.8000	0.0030	0.0130	0.0300	2.5000
05/04/90	7.7000	6.7000	116.0000	2.2000	0.0100	0.0100	1.6000	0.0030	0.0170	0.0800	1.7000
21/05/90	7.4000	12.8000	91.0000	1.5000	0.1400	0.0100	2.4000	0.0030	0.0750	0.1200	1.5000
07/06/90	7.3000	16.5000	94.0000	0.8000	0.0300	0.0100	5.2000	0.0020	0.0200	0.1400	1.3000
01/07/90	7.1000	16.2000	100.0000	1.2000	0.1000	0.0100	3.6000	0.0030	0.0050	0.1300	1.2000
09/08/90	7.3000	16.0000	101.0000	1.4000	0.0300	0.0100	2.4000	0.0020	0.0160	0.1400	1.1000
20/09/90	7.4000	14.3000	102.0000	1.5000	0.0100	0.0100	4.8000	0.0020	0.0080	0.1300	0.9000
01/10/90	7.5000	13.0000	110.0000	0.6000	0.0100		3.2000	0.0020	0.0230	0.1800	1.0000
02/11/90	7.2000	12.1000	98.0000	1.8000	0.1200	0.0100	6.4000	0.0020	0.0130	0.0600	1.8600
05/12/90	7.0000	5.2000	107.0000	2.1000	0.0300	0.0100	4.4000	0.0020	0.0160	0.0600	2.5000

Appendix III.

Total and dissolved metals concentrations and suspended solids concentrations collected at Lifton and Newbridge during a scour valve test at Roadford Reservoir during November 1990.

Total metals, suspended solids concentrations and flow data collected at Lifton Bridge during 8 November 1990.



EQS's from the EC Freshwater Fish and Dangerous Substances Directive.
EQS given as 95 % ile (= 4 X annual mean standards).

Total metals, suspended solids concentrations and flow data collected at Roadford during 8 November 1990.

