Technical Note NC 297 (12/85)

ACID RAIN PROJECT BIOSURVEYS OF STREAMS IN THE WASTWATER CATCHMENT

by R.F. Prigg.

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Object

This note forms part of a series on component biological investigations, identified by location or topic, within the acid rain project. Reporting of the Wastwater catchment data would not have been given priority ordinarily, but it has been brought forward to coincide with J. Robinson's reporting of his investigations of land use and liming in the catchment.

Background

Sites on Lingmell Beck (ptc Mosedale Beck) and on Mosedale Beck (down in the Dale Bridge) featured in our fish, invertebrate and chemical sampling of 75 upland stream sites in the Lake District National Park reported as BN 77-2-83. Subsequently detailed studies on a number of acidified subcatchments (including e.g. upper Tarn Beck, Blea Beck (Lune), upper Brathay, upper Glenderamackin, Doddknott Gill) have demonstrated substantial chemical and faunal changes over short linear distances within the stream systems, associated with geological and/or land use changes within the catchment, and in the cases noted resulting in the most upstream sites having markedly more acidic conditions and acid-resistant faunas. It is, of course, appreciated that moving up a stream system into progressively lower-order watercourses results in the imposition of biological constraints associated with altitude, slope,absolute channel dimensions, and drought susceptibility.

However, in the exemplary acidified catchments noted above, the short distances over which major changes are detectable (even in those cases where discrete modifying inflows are not discernible) and the existence of sites in better buffered catchments with broadly comparable physical attributes which are not similarly faunistically impoverished, rule out the general restrictions imposed by low stream order as the main cause for our observations, and focus attention on the chemical regime, where values of acidification-related determinands correlate well with the types of biological communities present.

Since the Lingmell Beck and Mosedale Beck sites sampled in 1982 were both well down their catchments, and included drainage from areas of improved valley bottom land, it was decided to investigate, during 1985, sites above the influence of such inputs likely to ameliorate any acidification stress on these catchments. At the same time observations in the Wastwater area were extended to encompass Lingmell Gill, Nether Beck and Over Beck, thus contributing to our extensive coverage of fish and invertebrate distribution in the western mountain mass of the Lake District.

Methods

The sites sampled were as follows:-

Site Name	Location	Grid Reference
Lingmell Beck (lower)	ptc Mosedale Beck	NY 185 077
Lingmell Beck (upper)	u/s Wasdale Head near Moses Trod	NY 199 092
Lingmell Beck (lower)	ptc Wastwater	NY 183 074
Lingmell Beck (upper)	1 km u/s Wastwater	NY 190 073
Mosedale Beck (lower)	d/s Down in the Dale Bridge	NY 184 082
Mosedale Beck (upper)	u/s Wasdale Head	NY 185 094
Over Beck	u/s Overbeck Bridge	NY 168 068
Nether Beck	u/s Netherbeck Bridge	NY 161 067

Note that for practical purposes, the biological sample points listed above are equivalent to the chemical sample points (S.P.T.'s) of similar description. The main point of difference noteworthy is that the Biologist's Mosedale Beck (lower) site is chosen to be above the Lingmell Beck confluence, whereas the downstream SPT on Mosedale Beck is Mosedale Beck ptc Wastwater, which is below the confluence.

In relation to the biological sampling which involved invertebrate sampling and electric fishing it should be noted that in the case of Lingmell Beck (lower) site, the electric fishing took place in a tributary or meander off the main stream. This was a more productive and less erosive situation than the unstable main stream channel.

Sampling methods employed were as previously described in BN 77-2-83.

Results and discussion

Invertebrate kick sample data are presented in Appendix 1, major acidification-related chemical parameters from 1985 sampling in Appendix 2, electric fishing data in Appendix 3 and a general summary of biological and chemical measures in Appendix 4.

It is clear that all sites fished have a trout population, and evidence of successful recruitment in the 1985 season as judged by the presence of fry of the year.

Differences between the sites based on acidification related chemical variables do not seem substantial, ranging from the least acidified, Mosedale Beck ptc Wastwater with mean pH 6.6, alkalinity 5.8 mg/l $CaCo_3$ and Calcium 2.3 mg/l through to Over Beck and Nether Beck with mean pH of 6.4 and 6.2 respectively, alkalinity 3.2 and 3.8 mg/l $CaCO_3$ respectively, and calcium 1.6 and 1.7 mg/l respectively.

However, these means exclude a sampling under flash conditions on 4.10.85, are based on only about 5 samples during 1985, and the samples are not on the same dates for all sites.

It seems likely to me, given the importance of acidic episodes in influencing stream biota, that the limited chemical data set we have for these streams is inadequate to represent their relative susceptibilities to extreme pH depression under winter or spring high flow conditions.

I am not contending that any of these streams are, in fact, grossly acidified, but rather that the difference in chemical regime (particularly the relative frequency of significant pH and calcium level reduction) is more marked as between e.g. Lingmell Beck (upper) and lower Mosedale Beck than our limited chemical data suggests. Furthermore, I would expect that our invertebrate data, with its integrative effect over a long exposure period of the community, would more effectively show up such differences.

Before passing from the discussion of the chemical data it is worth noting the significant pH depression brought about by a flash flood, during a thunderstorm on 4.10.85. On this occasion Nether Beck, Over Beck and Mosedale Beck were particularly influenced by the torrential downpour.

These streams were in high spate and carrying very high suspended solid loads. This suspended material accounts for the exceptionally high total aluminium recorded, and also provided high total levels of Chromium and Nickel in the Over Beck and Nether Beck samples (note that toxic heavy metals are not normally present in significant amounts at any of our Wastwater catchment sites).

In contrast, the Lingmell Beck catchment was less affected by the short burst of high intensity rainfall, and the beck was running fresh but clear. However, the pH recorded at the upper Lingmell Beck Site was, at 5.6, the lowest for the year at that site.

The dilution effect of lowered calcium is seen in the 4.10.85 samples; this effect also showed up markedly in a sample batch taken on 12.8.85 following heavy rain, though on this occasion although the Ca levels and conductivities were well down the pH levels were not notably depressed - evidently neutralisation within the catchment had been more effective on this occasion than in response to the extreme short term inputs of 4.10.85.

Differences in the invertebrate populations of the sites are, as discussed above, more clear than the chemical comparisons. Faunal diversity is markedly lower, and acidification sensitive Ephemeroptera lacking in e.g. the upper Lingmell Gill and Lingmell Beck sites in contrast to e.g. Lower Lingmell or Mosedale Beck (see Appendices 1 and 4).

Those sites lacking mayflies also have no salmon juvenile (less tolerant of acid conditions than brown trout) present, whereas those with mayflies present have juvenile salmon, except for the Mosedale Beck (upper) site. This site is unlike the rest in being above significant waterfalls obstructing the passage of migratory fish. Furthermore, we have seen salmon parr in Mosedale Beck at Wasdale Head.

Lingmell Beck (upper) is notable for its low fish density and a trout biomass density largely influenced by the presence of a couple of old, large fish. However, it is noteworthy that despite these 'negative' indications, the fish appeared in reasonable weight for length condition, and one trout fry was found at the site, a testimony to at least limited recruitment. It should also be said that this site is particularly erosive, with a very large particle size stream bed, which in itself is an adverse factor in terms of fish productivity.

The order of listing of streams in Appendix 4 is in some degree a ranking in terms of extent of biolgical acidification symptoms, with Mosedale (lower) the least influenced. Several provisos should be added, besides that re. influence of uncontrolled seasonal variation noted in Appendix 4. Firstly, the single sample from Lingmell Gill (lower) site lacked mayflies, but one specimen of the caddis *Hydropsyche instabilis* was present. This species is relatively intolerant of acidic conditions and should tend to push this site up the ranking.

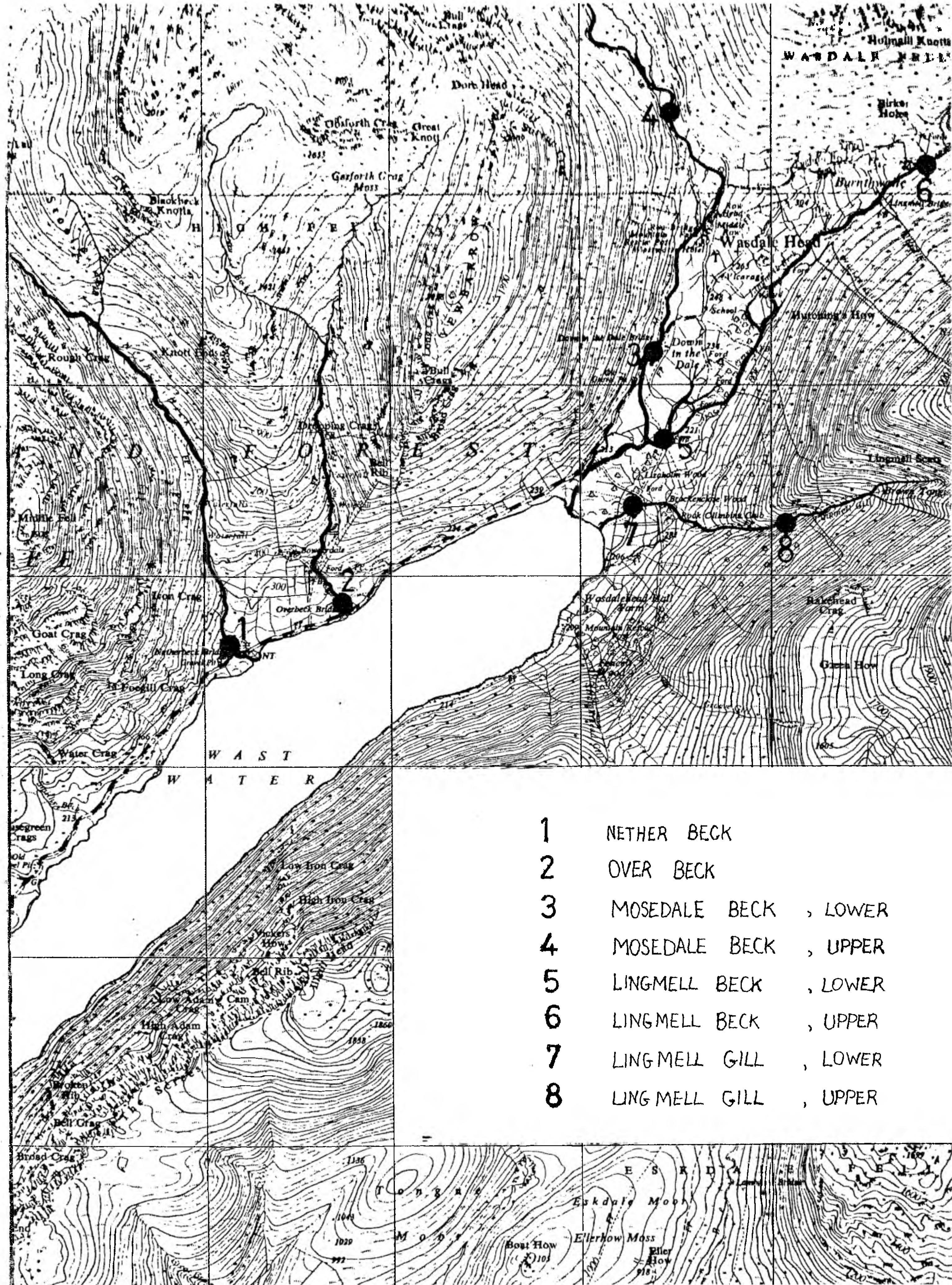
The detailed fish density data has not been used in the ranking. The Lingmell Beck (upper) site was referred to earlier as having a particularly low fish density, but it is clear that in general all these Wastwater catchment sites have relatively low fish productivity (c.f. Appendix A.7 of report BN 77-2-83); the notably better density at the Lingmell (lower) site than any of the others is an artefact resulting from the fishing site being situated in a more productive side channel as explained under methods.

Conclusions

The extension of our earlier observations on Lingmell Beck and Mosedale Beck to upper catchment sites and to nearby catchments has not revealed any evidence of gross acidification symptoms such as fishlessness or recruitment failure of trout populations which we have seen in some of the most sensitive sub-catchments we have examined, such as parts of the upper Esk or upper Duddon.

However, it is clear that faunal distinctions, probably largely attributable to the acidification complex of restrictive factors, can be made between the Wastwater catchment sites, and that in this instance the available chemical data set does not adequately reflect relative susceptibility of these sites to limiting episodic acidic conditions.

LOCATIONS OF BIOLOGICAL SAMPLE POINTS IN WASTWATER CATCHMENT



1 NETHER BECK
2 OVER BECK
3 MOSEDALE BECK , LOWER
4 MOSEDALE BECK , UPPER
5 LINGMELL BECK , LOWER
6 LINGMELL BECK , UPPER
7 LINGMELL GILL , LOWER
8 LINGMELL GILL , UPPER

INVERTEBRATE KICK SAMPLES AT WASTWATER CATCHMENT SITES

RELATIVE ABUNDANCE SCALE.

1	1	specimen in sample
2	2-5	" " "
3	6-20	" " "
4	21-100	" " "

Group	Taxon	Lingmell Beck - lower				Lingmell Beck - upper		Lingmell Gill - lower	Lingmell Gill - upper	Mosedale Beck - lower				Mosedale Beck - upper		Over Beck		Nether Beck	
		1-2 82	26-5 82	3-9 82	17-5 85	17-5 85	16-10 85	16-10 85	17-5 85	1-2 82	26-5 82	3-9 82	17-5 85	17-5 85	2-10 85	17-5 85	2-10 85	17-5 85	2-10 85
Stoneflies	Nemouridae														2				
	Protonemura praecox									2									
	Protonemura meyeri			1	1		1	2		3		3	2		2	2	3		3
	Amphinemura sulcicollis		3		3	3		2	3	3	2	2	3			3		3	
	Leuctra sp.			2	2	2		2			2							2	
	Leuctra fusca			2								1							
	Leuctra hippopus	1						1							1				
	Leuctra inermis	2	2		2	2			2	3			2	2		2		2	
	Chloroperla torrentium		2								2		3	2		2		2	
	Chloroperla tripunctata	2	2		3	2			3		2		2			2	1	2	
	Isoperla grammatica	1	1		2							1	2	2	2				2
Mayflies	Ephemerella ignita														2				
	Baetis scambus										1	2							
	Baetis rhodani	3	2	2	3					2	1	3	2	2	3				
	Rhithrogena semicolorata				3														
	Heptagenia sp.				2								1			2	1		
	Heptagenia lateralis		3		2						1								
Caddis	Glossosoma sp.									1		1							
	Rhyacophila dorsalis			1	2	2		1						2	3	1	2		2
	Wormaldia sp.																		2
	Polycentropidae		1		2							3	2	2	2		2		
	Plectrocnemia conspersa			1					2			2			2	1		2	
	Polycentropus flavomaculatus				2									2	2				
	Hydropsyche sp.				2								2	2					
	Hydropsyche siltalai				2					2	2		2	2					
	Hydropsyche instabilis							1											
	Hydrophilidae											2							
	Limnephilidae		1		2					1	1	3	2	2					1
	Lepidostoma hirtum										2								
	Sericostomatidae											1	3					2	
Damselflies	Pyrrhosoma nymphula										1								
Beetles	Curculionidae			1								1							
	Dytiscidae		1											1					
	Elmis aenea											2							
	Esolus parallelepipedus											1							
	Limnius volckmari										1								
	Oulimnius sp.											1							
Diptera	Tipulidae											2					1	1	
	Dicranota sp.	2			2					2		2	1					1	1
	Empididae										2	2	1	1	2				1
	Simuliidae			2				2		1	1	2			2	3	2		2
	Chironomidae		2	2	3	2		2			2	2	3	3	3	3	2		2
Mites	Mites									1	2	2	2		2				
Molluscs	Sphaeridae											1							
Worms	Naididae		‡								2	3	2	2	3		2	2	3
	Tubificidae										2	2		2					
	Lumbriculidae												1						
	Lumbricidae										2	1	1						
Flatworms	Polycelis felina			2						2	2	3	2	2					
	Phagocata vitta									2			2		2			2	
	Crenobia alpina			2								2							
Number of taxa		6	11	11	19	6	1	8	4	13	20	28	22	16	16	10	9	11	10

Appendix 2

SUMMARY OF 1985 WATER CHEMISTRY SAMPLING IN WASTWATER CATCHMENT AND COMPARISON WITH RESULTS OF A VIOLENT RAINSTORM

Site	Samples	pH	alkalinity mg/l $CaCo_3$	Mg mg/l	Ca mg/l	Al µg/l	unacidified Al µg/l
Lingmell Beck, lower	5	6.3	4.4	.66	2.2	90	10
	range	6.0–6.5	3–7	.49–.75	1.3–2.6	<10–10	<10–10
	1(4.10.85)	6.1	4	.55	2.3	10	10
Lingmell Beck, upper	5	6.4	4.6	.65	2.0	18	20
	range	6.2–6.7	3–7	.45–.78	1.2–2.5	<20–25	<20–25
	1(4.10.85)	5.6	3	.5	1.7	20	10
Lingmell Gill, lower	4	6.5	4.8	.68	1.9	15	13
	range	6.4–6.8	3–7	.54–.83	1.1–2.5	<20–20	<20–20
Lingmell Gill, upper	5	6.5	4.0	.67	1.8	14	15
	range	6.2–6.9	2–7	.53–84	1.0–2.4	<20–20	<20–20
Mosedale Beck, ptc Wastwater	4	6.6	5.8	.68	2.3	173	19
	range	6.6–6.7	5–7	.6–.75	1.9–2.6	20–630	<20–40
Mosedale Beck, lower	1(4.10.85)	6.0	4	.6	1.8	450	10
Mosedale Beck, upper	5	6.5	5.0	.66	1.9	15	10
	range	6.2–6.8	4–7	.54–.77	1.2–2.3	<10–30	<20–15
	1(4.10.85)	5.5	3	.5	1.0	2400	20
Over Beck	5	6.4	3.2	.65	1.6	41	27
	range	6.2–6.5	2–5	.5–.75	1.4–1.9	<10–110	<20–60
	1(4.10.85)	5.2	3	.5	1.0	2700	30

Site	Samples	pH	alkalinity mg/l $CaCo_3$	Mg mg/l	Ca mg/l	Al µg/l	unacidified Al µg/l
Nether Beck	6 range	6.2 5.9–6.6	3.8 2–6	.68 .55–.75	1.7 1.5–1.9	44 <10–190	24 <10–80
	1(4.10.85)	5.9	4	.55	1.6	890	30

Note that mean pH's are derived by transforming to and from H^+ concentrations.

Lingmell Beck (lower - but see text) 3.9.82

	1st	2nd	tot.	est.	eff.
TO+	15	6	21	25	60%
T1++	16	3	19	20	81%
SO+	3	2	5	8*	40%
S1++	4	3	7	11*	40%
eels	16	9	25		
lampreys	4	2	6		
minnows	0	5	5		

*assume conservative low overall efficiency

Length fished 36 m Mean width 4.27 m Area fished 153.7 m^2

	Density, fish/m^2	Biomass density, gms/m^2
TO+	0.163	0.27
T1++	0.130	1.31
SO+	0.052	0.09
S1++	0.072	0.50
total salmonid	0.417	2.17

Lingmell Beck (upper) 16.10.85

	1st	2nd	3rd	tot.	est.	eff.
TO+	0	1	0	1	1	
T1++	3	2	1	6	8	41%

Zippin stats. conditions not fulfilled for TO+

Length fished 56 m Mean width 5.28 m Area fished 295.7 m^2

	Density, fish/m^2	Biomass density, gms/m^2
TO+	0.003	0.003
T1++	0.027	0.992
total salmonid	0.030	0.995

Lingmell Gill (lower) 16.10.85

	1st	2nd	tot.	est.	eff.
TO+	5	2	7	8	60%
T1++	10	5	15	20	50%

Length fished 53 m Mean width 4.13 m Area fished 218.9 m^2

	Density, fish/m^2	Biomass density, gms/m^2
TO+	0.037	0.059
T1++	0.091	1.937
total salmonid	0.128	1.996

Mosedale Beck (lower) 3.9.82

	1st	2nd	tot.	est.	eff.
TO+	3	1	4	5	67%
T1++	0	1	1	2*	40%
SO+	3	3	6	9*	40%
S1++	4	3	7	11*	40%
eels	9	2	11		

*assume conservative low overall efficiency

Length fished 25 m Mean width 4.61 m Area fished 115.3 m^2

	Density, fish/m^2	Biomass density, gms/m^2
TO+	0.043	0.09
T1++	0.017	0.09
SO+	0.078	0.17
S1++	0.095	0.95
total salmonid	0.233	1.30

Mosedale Beck (upper) 2.10.85

	1st	2nd	tot.	est.	eff.
TO+	4	1	5	5	75%
T1++	9	2	11	12	78%

Length fished 36 m Mean width 4.97 m Area fished 178.8 m^2

	Density, fish/m^2	Biomass density, gms/m^2
TO+	0.028	0.117
T1++	0.067	1.270
total salmonid	0.095	1.387

Over Beck 2.10.85

	1st	2nd	tot.	est.	eff.
TO+	9	4	13	16	56%
T1++	4	1	5	5	75%
S1++	0	1	1	1	–
eels	2	2	4		

Length fished 33 m Mean width 4.26 m Area fished 140.6 m^2

	Density, fish/m^2	Biomass density, gms/m^2
TO+	0.114	0.349
T1++	0.036	0.405
S1++	0.007	0.100
total salmonids	0.157	0.854

Nether Beck 2.10.85

	1st	2nd	tot.	est.	eff.
TO+	4	1	5	5	75%
T1++	5	2	7	8	60%
eels	2	2	4		

Length fished 35 m Mean width 2.73 m Area fished 95.7 m^2

Nether Beck (contd)

	Density, fish/m²	Biomass density, gms/m²
T0+	0.052	0.261
T1++	0.084	1.348
total salmonid	0.136	1.609

Appendix 4

SUMMARY INVERTEBRATE, FISH AND CHEMICAL DATA FOR WASTWATER CATCHMENT SITES

Site	No. of invert. samples	Mean no. taxa per invert. samples	Mean no. mayflies sp. per invert samples	Trout fry presence	juvenile Salmon presence	Salmon fry presence	total salmonid density nos/m^2	salmonid 1++ density nos/m^2	salmonid biomass density gms/m^2	Mean pH	Mean Ca mg/l
Mosedale lower	4	21	2.00	√	√	√	.233	.112	1.300	–	–
Lingmell lower	4	12	1.75	√	√	√	.417	.202	2.170	6.5	1.9
Mosedale upper	2	16	1.5	√	x	x	.095	.067	1.387	6.5	1.9
Over Beck	2	10	1.0	√	√	x	.157	.043	0.854	6.4	1.6
Nether Beck	2	11	0	√	x	x	.136	.084	1.609	6.2	1.7
Lingmell Gill lower	1	8	0	√	x	x	.128	.091	1.996	6.5	1.9
Lingmell Gill upper	1	4	0	–	–	–	–	–	–	6.5	1.8
Lingmell Beck upper	2	4	0	√	x	x	.030	.027	0.995	6.4	2.0

Note: Attention is drawn to the small number of observations of invertebrate fauna summarised above for several sites, and resulting noise from seasonal variation which is uncontrolled in some comparisons.

The mean chemical values are from 1985 sampling, excluding a special spate sampling of 4.10.85.