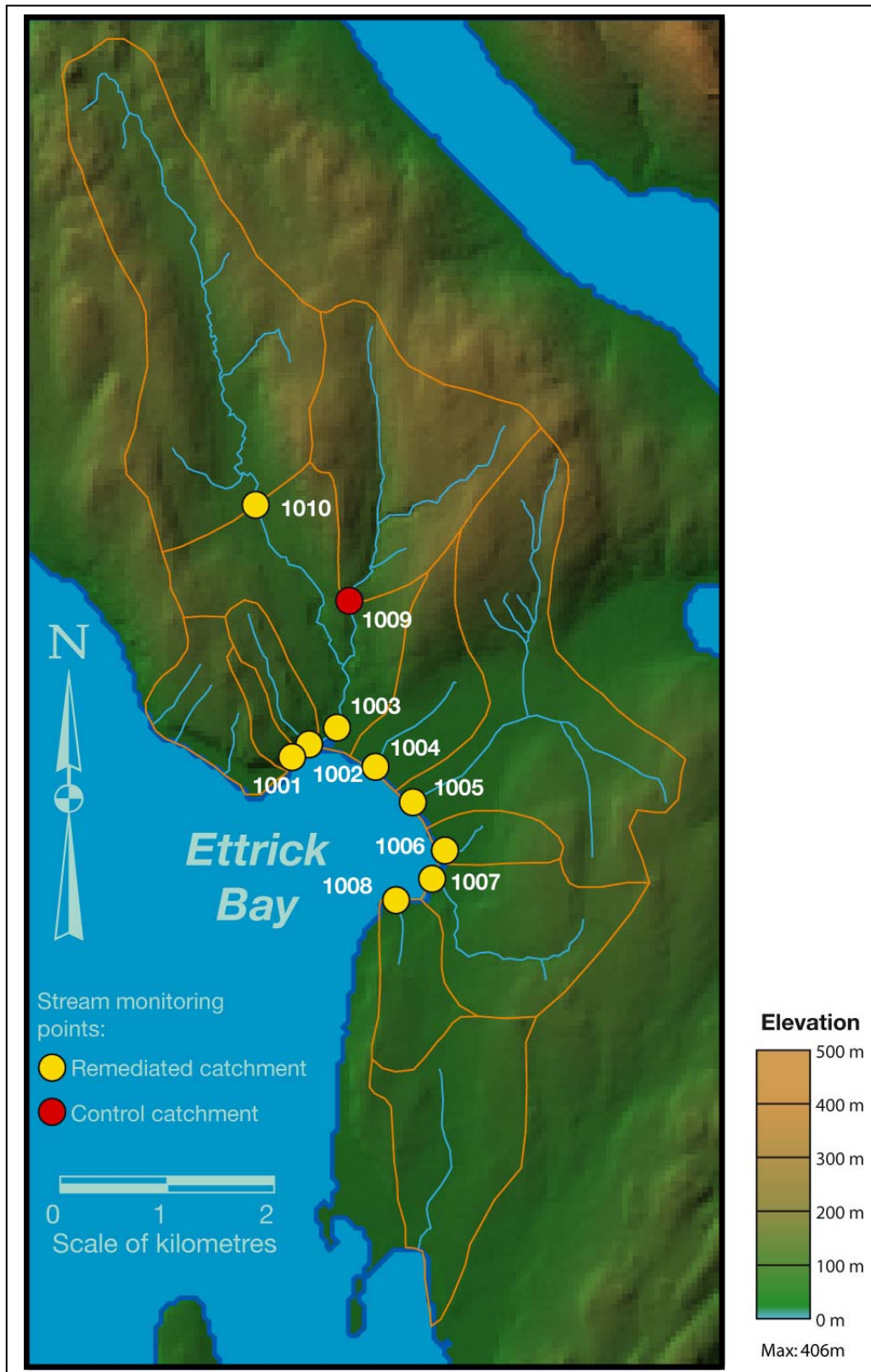


2 Results of the Ettrick Bay monitoring

Figure 2.1 Ettrick Bay monitoring sites



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2.1 Catchment characteristics

2.1.1 Monitoring sites

The Ettrick Bay monitoring sites covered a range of catchment areas and characteristics. For example, Site 1001 was a small field drain receiving some flow from farm hardstanding areas. Site 1002 was also a small field drain and this site experienced considerable erosion damage during the major storm experienced on the 11th August 2004. Site 1008 was also somewhat unusual, as it received flows from a ponded marsh area and flowed via a vegetated flush zone to the foreshore. All other sites were distinct stream channels with clearly defined hydrological catchment areas. Site 1010 was added to the sampling locations during the post remediation period at the request of the Steering Group. Site 1009 was therefore the most appropriate stream 'control' site since it had an unmodified catchment. Table 2.1 shows land use in the Ettrick Bay subcatchments.

Table 2.1 Area and percentage of different land use types (for selected sites) within the Ettrick Bay subcatchments studied

Subcatchment	Area (ha)*	Percentage land use				
		Improved pasture	Rough grazing	Forest	Arable	Built-up
1001	25.46	85.38	1.08	5.80	0.00	7.74
1002	52.15	85.63	12.73	1.15	0.00	0.49
1003	1,216.40	25.49	58.91	14.16	0.76	0.68
1004	138.37	75.45	7.96	6.48	7.18	2.92
1005	465.40	63.78	29.71	0.73	4.34	1.44
1006	51.65	64.28	3.45	2.03	26.64	3.61
1007	204.10	70.70	14.10	3.12	10.17	1.90
1008	95.14	No data				
1009**	334.74	10.17	83.34	6.50	0.00	0.00
1010	601.13	14.25	62.88	22.68	0.00	0.19

* As these catchments were nested, the area of all subcatchments summed together is greater than the total study area, this is true of each of 4 study sites.

** Control site.

The total study area of 2,440 ha contained fifteen livestock enterprises which were mainly dairy with some sheep and beef activity. On thirteen of these, steading-based measures were installed. The bathing water compliance point has failed to achieve the mandatory standards specified in Directive 76/160/EEC in every year since sampling began in 1999 (i.e. six years). The human population is sparse and there are no adjacent urban sewage discharges which might be responsible for this pattern of non-compliance.

2.1.2 Steading-based remedial measures

Table 2.2 shows the intensity of steading-based measures implemented in the Ettrick Bay subcatchments.

2.2 Data analysis

In Figure 2.2, the horizontal dotted lines define the upper and lower 95% confidence intervals (CI) for the mean \log_{10} presumptive *E. coli* (EC) concentration for site 1009, the control catchment outlet. Plots for coliforms and intestinal enterococci are presented in Appendix II Where the CIs for any pair of sites do not overlap there is a significant difference in the two site means at $p \leq 0.05$. There is no clear pattern in the low flow bacterial concentrations. However, in rural catchments, the key period for this comparison is during high flow conditions when faecal indicators are transported and commonly impact on bathing beach compliance. Preliminary inspection of Figure 2.2 (see the lower high flow plots) suggests that:

- geometric mean values at high flow, at all sites, increased between the two sampling phases (pre- October to November 2002; post- July to August 2004);
- five of the six Etrick remediated ‘stream’ sites had significantly higher mean \log_{10} concentrations of presumptive *E. coli* in the pre-remediation period than the control site (1009); and
- in the post remediation period, no major stream site exhibited a statistically significantly elevated concentration of presumptive *E. coli* when compared to the control site.

Table 2.2 Steading-based measures implemented in the Etrick Bay subcatchments

Subcatchment	Number of steadings	Number of steadings km ⁻²
1001	1	3.93
1002	0	0.00
1003	3	0.25
1004	2	1.45
1005	2	0.43
1006	1	1.94
1007	2	0.98
1008	0	0.00
1009*	0	0.00
1010	0	0.00

* Control site

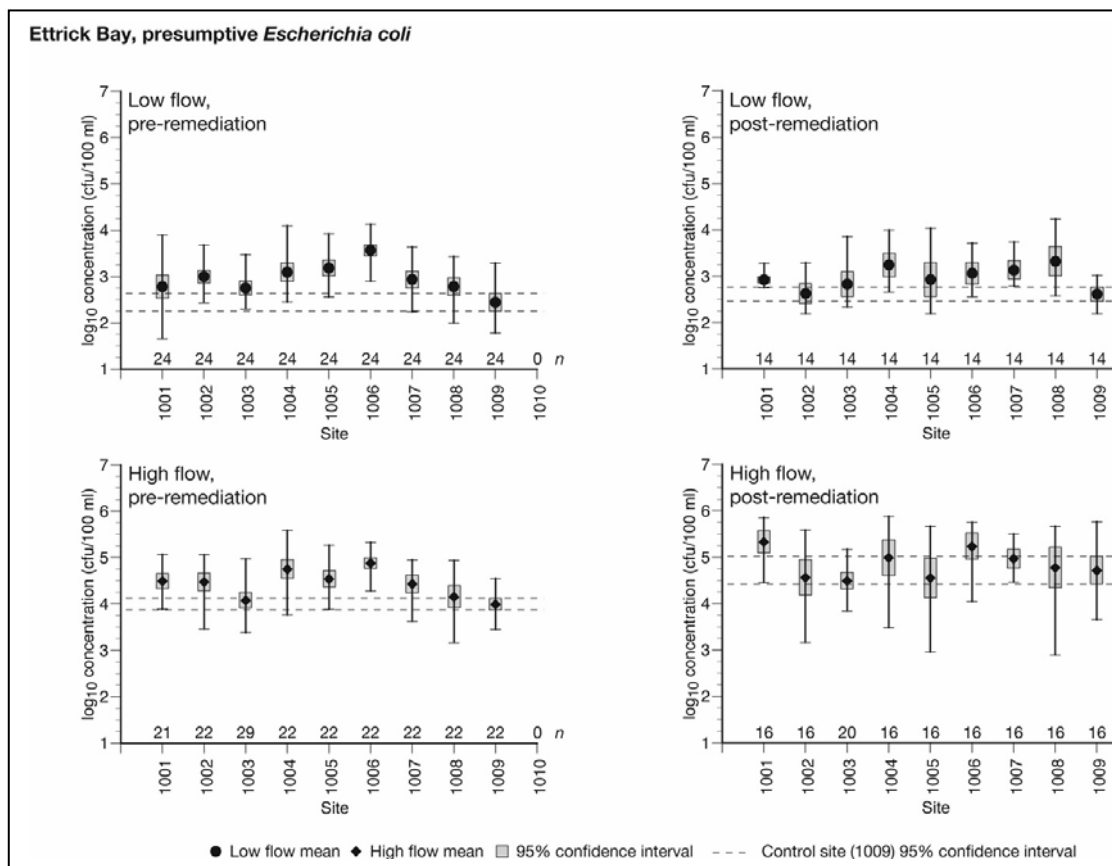
** Only farms with significant steading improvements are included.

Table 2.3 shows the geometric means of pre-and post-remediation sampling for each site and the post-remediation value predicted by the ‘shift’ analysis using site 1009 as the control (see Figure 1.4). The difference between this predicted value and the observed post-remediation geometric mean is the ‘improvement’ value where negative values indicate deterioration in water quality. This appears to indicate a general improvement in water quality relative to the unmodified control catchment for

all significant ‘stream’ sites monitored (i.e. excluding the small standing drainage at site 1001 and the pond drainage sampled at site 1008).

Figure 2.3 presents a plot of the ‘improvement’ in Ettrick subcatchments against the intensity of remedial measures. With the exception of one point (i.e. the standing drainage picked up at site 1001) seen on the lower right hand side of this plot there is some suggestion of a relationship between the number of steadings remediated km⁻² and the degree of improvement in *E. coli* geometric mean value. However, the reservations noted in Section 1.5 and in the Executive Summary (Section 4v Page viii) should be kept in mind when assessing the policy and operational utility of these tentative observations.

Figure 2.2 Seasonal shift analysis plots for Ettrick Bay sites, presumptive *E. coli*¹



¹ *E. coli* data are presented in this Figure and throughout the main body of this report. Similar plots for total coliform organisms and intestinal enterococci are located in Appendix II which commences on Page 67 of this report.

Figure 2.3 Plot of inferred improvement in high-flow GM *E. coli* concentrations (-ve values indicate a deterioration in water quality) based on log₁₀ shift analysis against the number of steadings with significant improvements (km⁻²) in Ettrick region

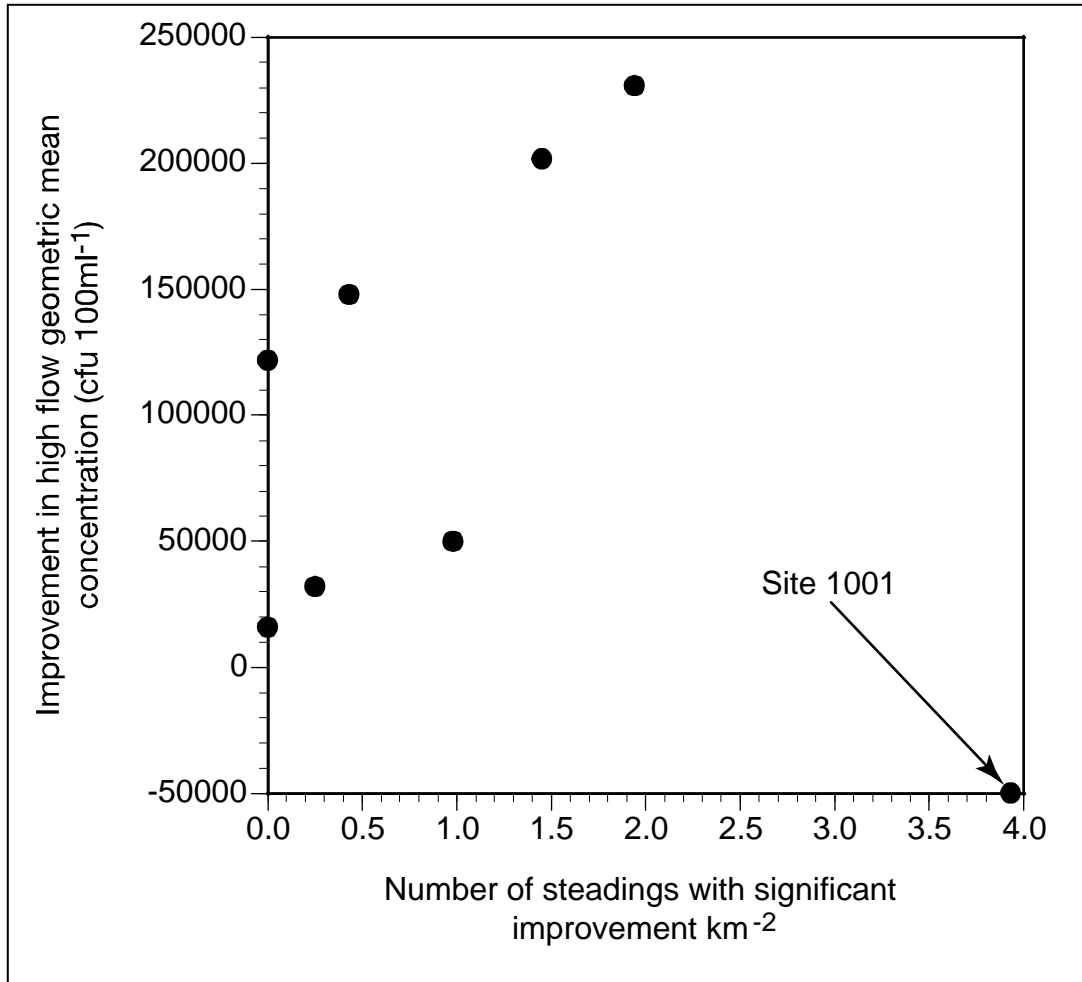


Table 2.3 Log₁₀ seasonal shift analysis for high flow data from Ettrick Bay*

SITE	PARAMETER	PRE		POST		Predicted cfu100ml ⁻¹	Improvement cfu100ml ⁻¹
		<i>n</i>	GM cfu100ml ⁻¹	<i>n</i>	GM cfu100ml ⁻¹		
1001	total coliform	21	125,810	16	238,171	318,291	80,120
	<i>E. coli</i>	21	31,183	16	215,274	165,604	-49,670
	enterococci	21	30,233	16	34,955	144,216	109,262
1002	total coliform	22	73,230	16	48,180	185,266	137,086
	<i>E. coli</i>	22	29,868	16	36,628	158,620	121,992
	enterococci	22	4,152	16	14,302	19,805	5,503
1003	total coliform	29	21,052	20	41,790	53,261	11,471
	<i>E. coli</i>	29	11,943	20	31,148	63,427	32,279
	enterococci	29	2,532	20	6,339	12,076	5,736
1004	total coliform	22	152,792	16	100,885	386,553	285,668
	<i>E. coli</i>	22	56,439	16	97,802	299,737	201,935
	enterococci	22	8,468	16	13,835	40,393	26,557
1005	total coliform	22	122,250	16	42,943	309,285	266,341
	<i>E. coli</i>	22	34,650	16	35,907	184,019	148,111
	enterococci	22	11,377	16	7,264	54,272	47,008
1006	total coliform	22	182,505	16	249,056	461,726	212,670
	<i>E. coli</i>	22	75,839	16	171,827	402,762	230,935
	enterococci	22	20,424	16	45,832	97,423	51,591
1007	total coliform	22	72,728	16	121,837	183,996	62,159
	<i>E. coli</i>	22	27,040	16	93,435	143,603	50,169
	enterococci	22	6,770	16	17,793	32,294	14,500
1008	total coliform	22	39,010	16	130,412	98,692	-31,720
	<i>E. coli</i>	22	14,279	16	59,703	75,835	16,132
	enterococci	22	2,212	16	32,563	10,551	-22,012

* This analysis was completed using log₁₀ transformed data throughout but geometric mean values in cfu 100ml⁻¹ are reported here. Negative values in the improvement represent a deterioration relative to the controls. NB All values are for presumptive organisms. See Figure 1.4 for an explanation of how these estimates are derived.