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A RECONNAISSANCE OF POLLUTION OF THE KING RIVER IN THE COMSTOCK-CROTTY AREA, WEST TASMANIA

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ABSTRACT

In November 1974, an investigation was made of the King River through the stretch from just above its junction with Comstock Creek to just above its junction with the Governor River. Sampling stations were selected at nine sites, six on the King River, one on Linda Creek, one on Comstock Creek and one on the Governor River. At each station, samples were taken of the water, of the sediments and of the benthic macroinvertebrates. Analysis of the sediment samples provided good evidence that the King River is polluted from Comstock Creek downstream, with copper and, to a lesser extent, lead and zinc. This pollution is clearly indicated in the distribution of the riffle-dwelling macroinvertebrates and of trout. The Governor River and the King River upstream of Comstock Creek are not polluted. A 24-hour sampling of the drift fauna in the King River just above and just below the entry of Comstock Creek showed a surprising drop in the abundance of the drift with the entry of pollution. The results of the survey are discussed in the light of overseas work on stream sediments and Australian and overseas work on the effects of metal pollution on stream fauna. The pollution, even if steps are made to abate it, is likely to persist for a very long time.

INTRODUCTION

In Australia as a result of past or current mining operations, a number of freshwater bodies have been seriously polluted by "heavy metals". Published ecological investigations of such polluted water bodies in Australia are few and deal with either the Molonglo River-Lake Burley Griffin system near Canberra, A.C.T. (Weatherley, Beevers and Lake 1967; Weatherley and Dawson 1973; Joint Technical Committee on mine waste pollution of the Molonglo River 1974), or with the South Esk River in north-east Tasmania (Tyler and Buckney 1973; Thorp and Lake 1973).

Pollution of the King River, as a result of it receiving effluents discharged into the Queen River, is well known (Lynch 1969, Parliament of the Commonwealth of Australia 1970, Anon. 1975). Both Lynch (1969) and the Senate Select Committee on Water Pollution (Parliament of the Commonwealth of Australia 1970) have written about the pollution of the King River by material from the abandoned copper mine at Comstock in the past tense. Written statements on the pollution of the King River by Linda Creek are difficult to find. It is interesting to note that Williams (1967) refers to a "small copper-polluted stream near Queenstown" in which he "was unable to recover a single living macroscopic animal ..... in February 1963." The photograph accompanying the text shows clearly that the creek in question is Linda Creek. The deposition of "heavy metal" - containing sediments in Macquarie Harbour is well known and has been investigated by the Tasmanian Department of Environment (Anon. 1975).

In freshwater systems "heavy metals" may exist in seven different forms; (i) free metal ions, (ii) inorganic ion pairs and inorganic complexes, (iii) as organic complexes, (iv) metal species bound to organic material, (v) metal species in the form of highly dispersed colloids, (vi) metal absorbed on colloids, (vii) precipitates and crystalline solids (Stumm and Bilinski 1973; Whitton and Say 1975). It is largely in the last three forms that heavy metals occur in sediments.

In unpolluted rivers the concentrations of "heavy metals" in suspended sediments are higher than those of dissolved "heavy metals" (Perhac 1972; Angino, Magnuson and Waugh 1974), while the amounts of "heavy metals" transported in solution and in suspended sediments appear to differ considerably from river to river and from metal to metal (Perhac 1972; Gibbs 1973; Angino *et al.* 1974). Sediments, because of their higher concentrations of "heavy metals" than those of the surrounding water, may be used to indicate pollution (Hamence 1967; Förstner and Müller 1973; Aston and Thornton 1975). As pointed out by Förstner and Müller (1973), sediments are composed of numerous individual layers, each of which corresponds to a distinct regime of water flow and thus "fine grained sediments built up of a large number of individual layers should therefore represent an average value for certain contaminants over a long period of time". It is because sediments can give an average value of "heavy metal" pollution rather than an instantaneous value as gained in the analysis of a water sample, that sediments were sampled in this investigation. Examples of studies using sediment to assess "heavy metal" pollution are afforded by Collinson and Shimp (1972), Förstner and Müller (1973), Falk, Miller and Kostiuk (1973) Mathis and Cummings (1973), Iskandar and Keeney (1974), Mathis and Kevern (1975), Aston and Thornton (1975), and Thornton, Watling and Darracott (1975).

The use of benthic macroinvertebrates to assess the extent of pollution in rivers is now widely accepted (e.g. Hynes 1960; Goodnight 1973; Gaufin 1973). In a somewhat similar fashion to the use of sediments to assess pollution, the use of macroinvertebrate distribution allows an appraisal to be made of the long-term nature of the pollution.

The idea of carrying out an investigation of the King River in the Comstock-Crotty area came as the result of a preliminary sampling of the river with Zoology Honours students in April 1974. The results reported in this paper were gained from a survey of the river on 4-6 November 1974 by a party consisting of P.S. Lake, D. Coleman, B. Mills, R. Norris, R. Swain, B. Knott, R. Mawbey, A.M. Richardson, P. Suter and R. Rose.

REGIONAL GEOMORPHOLOGY AND GEOLOGY OF THE STUDY AREA

The area is dominated by a line of rugged peaks that form the West Coast Range. The peaks rise from an undulating plain. The mountains lie along a longitudinal belt of rough terrain that is characterized by extensive areas of hard siliceous conglomerate.

The mountain range is flanked on either side by significant river valleys, the more prominent of which are the King River valley to the east and the Queen River valley to the west.

The King River is the largest river in the area. It rises in the north near Eldon Peak and flows southward to near Crotty. It then flows south-westward where it is joined by the Queen River and finally enters Macquarie Harbour 4 km south-east of Strahan.

The West Coast Range has been subjected to glaciation on both its western and eastern slopes. Valley glaciation can be seen in both the Comstock and Linda Valleys and also along the upper parts of the King River.

The topography and drainage of the area is controlled by the geology. The Owen Conglomerate largely controls the drainage pattern. The major rivers are confined to the underlying or overlying softer formations. The Gordon Limestone immediately overlying the conglomerate is very susceptible to erosion. Much of the lower King and Queen Rivers are cut in Gordon Limestone. The general geology and economic geology of the area has been discussed by Bradley (1954), Wade and Solomon (1958), Solomon and

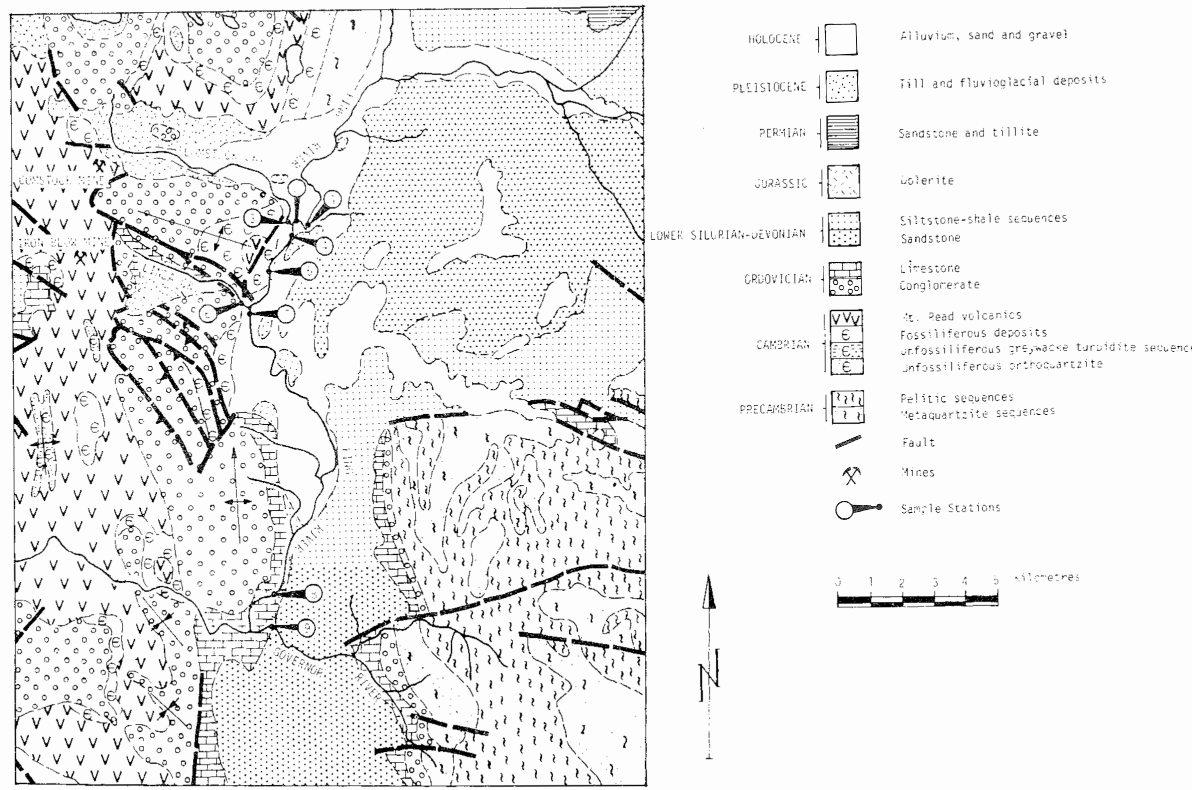

FIG. 24- Map of study area depicting basic geology of the area. (Adapted from Tasmanian Geological Atlas Series, 1:250,000; Sheet SK55-5 "Queenstown").

Elms (1970). The regional geology of the study area is depicted in figure 24 and discussed in more detail by Corbett in this volume.

HISTORY AND MINERALOGY OF THE COMSTOCK MINE AND THE IRON BLOW MINE

From its beginning in 1901 until 1912, exploration and development of the Comstock mine were at a relatively low level (see plate 27). In 1913 the mine was purchased by the Mount Lyell Mining and Railway Co. Ltd. From this time to 1921 mining activity, including stoping and ore production increased. Work was suspended from 1922 to 1929. Active mining recommenced in 1929 and continued until 1942 at which time the mine had reached a depth of 395 m (Wade and Solomon 1958). From 1955 to 1971 small amounts of copper were gained from the mine as precipitate on waste iron.

The ore from this mine consisted of disseminated chalcopyrite with some bornite in schist. Pyrite is present with small amounts of magnetite, galena, copper carbonate and free gold. Aluminium phosphate has also been found in the ore (Wade and Solomon 1958; Solomon and Elms 1970).

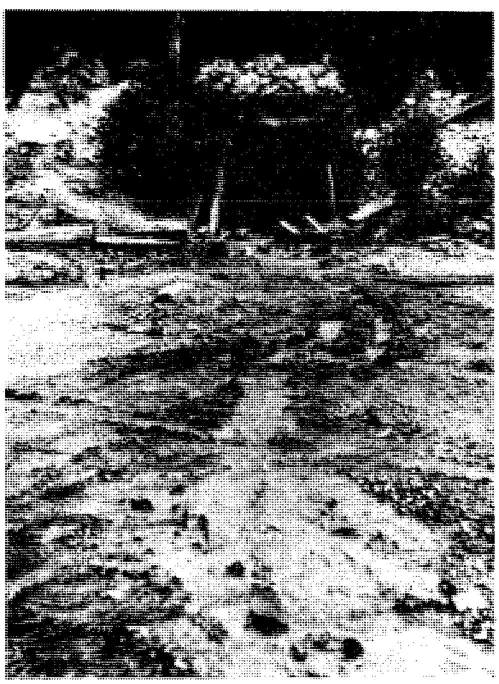

PLATE 27. Comstock Mine, showing a tributary of Comstock Creek.

Gold from an ironstone outcrop was discovered at Mt Lyell in 1883 by a party of prospectors consisting of Steve Karlson and Mick and Bill McDonough. They started the Iron Blow Mine (Blainey 1967). The Mt Lyell Gold Mining Company No Liability was formed in 1888 and ore crushing commenced in 1889. This company failed and went into liquidation in 1891. In 1892 the Mt Lyell Mining and Railway Company Limited was formed and it erected a smelter in 1896. Ore grades and reserves were somewhat poor and the company amalgamated with the North Lyell Company in 1903. From 1903, until the Iron Blow Mine or Mt Lyell Mine ceased working in 1929, the mine produced flux pyritic ore which was blended for smelting with the rich siliceous North Lyell ore.

The mineralized composition of the ore was about 87% pyrite with chalcopyrite, enargite, tetrahedrite, bornite and chalcocite with smaller amounts of galena and sphalerite. The gangue was quartz, barite and schist (Wade and Solomon 1958; Solomon and Elms 1970).

BRIEF DESCRIPTION OF THE SAMPLING SITES

The King River and its tributaries were all at a low level when sampled. This is an unusual condition for this time of the year. The low level of the river and the reduced current speed may be regarded as being ideal for the settling out of suspended sediments in quieter stretches of the river and thus allowing the collection of undisturbed sediment samples. The sampling sites are shown on figure 1.

Station 1 (Plate 28a)

This was on the King River just above a small gravel-extraction site. The gravel-extraction operation has resulted in a lack of trees on the left bank. The right bank had a dense scrub with *Acacia* spp. Tea-tree and Leatherwood being dominant. The river bed consisted of coarse gravel and stones with small discrete patches of sand and mud. The macroinvertebrates were collected in an extensive riffle stretch just downstream of a deep pool in which the sediments were collected. No fish collecting was carried out at Station 1, although many small trout were seen.

Station 2

This station was on the King River 30 metres upstream from the river's junction with Comstock Creek. Both banks supported a low scrub vegetation of *Acacia* spp., *Hakea* sp., Tea-tree and Paper-bark, sedges and *Restio* spp. The river bed consisted of coarse gravel, medium-sized stones and sand. The section consisted of one long run, following the definition of a "run" by Allen (1951).

Station 3

The station was on Comstock Creek just above its entry into the King River. The creek bed was made up of unstable mixture of gravel, sand and mud. The creek water was of a grey-brown colour. The bank vegetation was similar to that of Station 2. The section sampled consisted of two short sections and two short runs.

Station 4 (Plate 28b)

This station was on the King River 40 metres below the entry of Comstock Creek into the King River. The left bank which was undercut by the river, supported a tall scrub with *Acacia* spp. and Leatherwood, Tea-tree and *Hakea*. The stretch sampled consisted of a long riffle section, a long run and then a shallow pool, in which the sediment samples were collected.

Station 5

This station was just downstream of the point where the Lyell Highway crosses the King River. The river bed consisted largely of stones and gravel with some coarse sand. The stretch sampled consisted of a deep pool beneath the bridge followed by a run and then a long riffle.

Station 6 (Plate 28c)

The station was on Linda Creek just above its entry into the King River. The banks had a low shrub vegetation with a scattered ground cover of *Juncus* spp. and *Restio* sp.. Both of these genera appear to be quite tolerant of "heavy metal" pollution. The river bed consisted of stones and gravel coated with a fine reddish-brown sediment. The stretch sampled consisted of a shallow run and a riffle. The creek water was of a reddish-brown hue.

Station 7

This station was situated 120 metres below the entry of Linda Creek into the King River. The bank vegetation was depauperate with scattered shrubs and a ground cover of *Juncus* spp. and *Restio* spp.. The river bed consisted of fine sand, clay and mud with small scattered patches of gravel. The section sampled was made up of a short riffle followed by a deep run.

Station 8 (Plate 28d)

This station was just downstream of where the railway bridge of the old Crotty to Kellys' Basin line crossed the King River. The bank vegetation was quite dense and contained mature specimens of Blackwood, Leatherwood, Huon Pine and Myrtle. The river bed consisted of large boulders, stones and gravel. The section sampled consisted of long run followed by a deep pool.

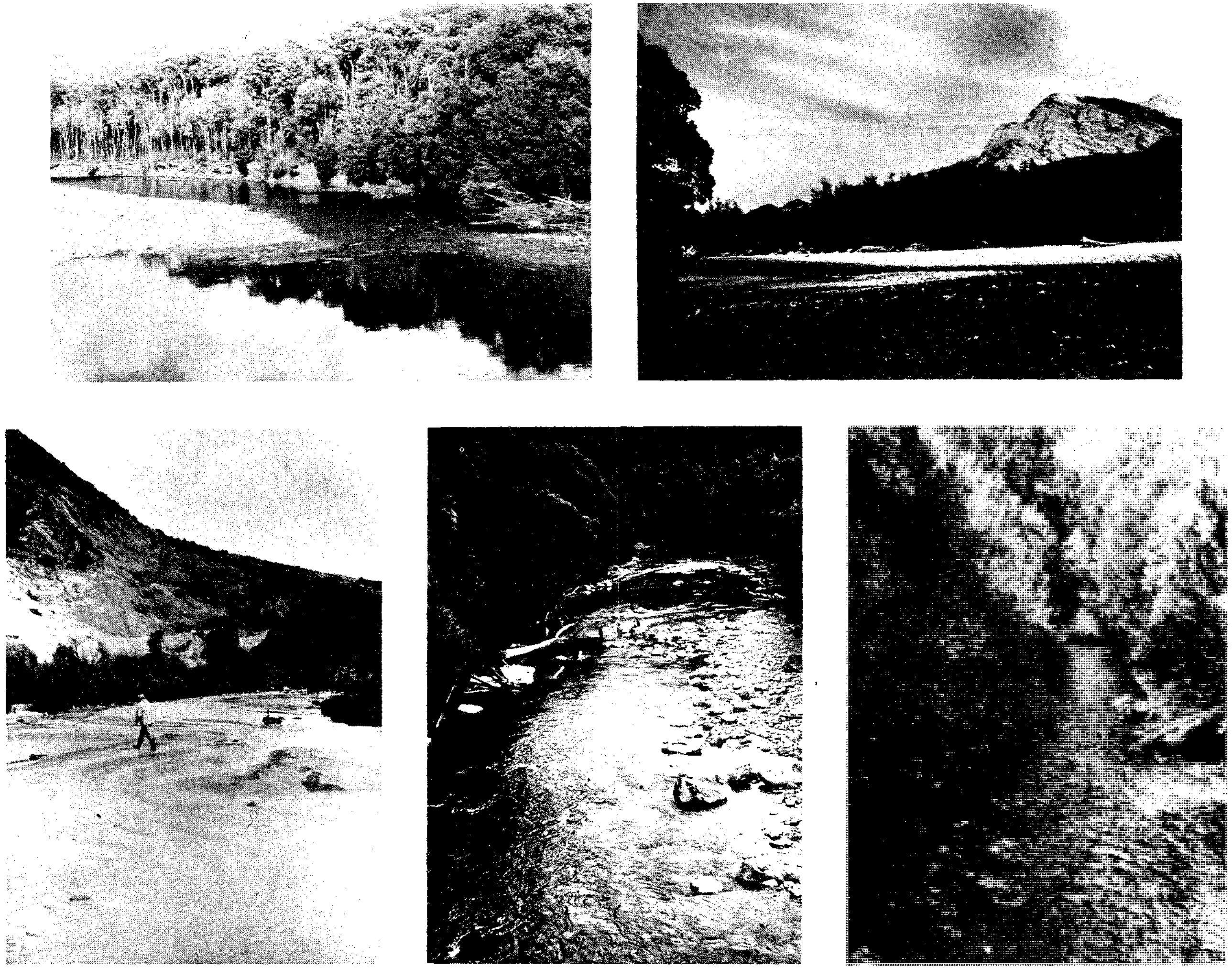

PLATE 28-(a) Station 1 on the King River, (b) Station 4 on the King River 40 metres below the entry of Comstock Creek into the King River; at this Station drift sampling was carried out, (c) Linda Creek (Station 6) just above its entry into the King River; note the low level of the creek, (d) Station 8 on the King River, (e) Station 9 on the Governor River.

Station 9 (Plate 28e)

This station was at the point where the railway bridge of the old Crotty to Kellys' Basin line crosses the Governor River. The river bank vegetation was dense and contained Tea-tree, Paperbark, wattles and Leatherwood. The river bed was a stable mixture of boulders, stones and gravel with small patches of coarse sand. The section sampled was made up of a short, shallow pool followed by a long riffle.

MATERIALS AND METHODS

At each sampling station, five sediment samples were collected by hand from the top few centimetres of bottom sediment. The sediment was collected in regions of low current speed. Each sample was placed in a cleaned 200 ml "Duranol" plastic vial. Water samples were collected at each sampling station in 1 litre, acid-washed plastic bottles. The water samples were taken from 30 cms below the surface, and were acidified with HNO_3 to be at a pH of less than one. At each sampling station, water temperature, pH, dissolved oxygen concentration, free CO_2 concentration, and alkalinity were measured. Concentrations of sodium, potassium, calcium and magnesium in the water were determined by atomic absorption spectrophotometry. Chloride concentrations were determined with a chloride ion-specific electrode.

ANALYSIS OF SEDIMENTS

Mercury concentrations were determined in wet bottom sediments. For analysis of the non-volatile metals, wet sediment samples were first weighed then dried at 105°C for 24 hours and then re-weighed.

The sediment samples being analysed for mercury were first cold-digested in acid permanganate in a sealed flask, decolourised with hydroxylamine and reduced with stannous chloride. The mercury vapour generated was measured by atomic absorption spectrophotometry.

Cadmium, zinc, copper, lead, iron, manganese, nickel and cobalt were determined in dried and finely ground sediment samples which had been digested by boiling with concentrated nitric acid. The concentrations were measured in a Pye Unicam SP1950 atomic absorption spectrophotometer coupled with an automatic deuterium lamp for correction of non-atomic absorption.

SAMPLING OF FAUNA

At each sampling site, five samples of the fauna of a riffle or run were taken with a Surber Sampler. The Surber Sampler encloses an area of one square foot of river bottom and the animals in this area are swept into the net after being dislodged from the bottom. The mesh size of the sampler was 900 microns. Hughes (1975) in comparing the qualitative and quantitative composition of catches of stream macroinvertebrates obtained with four different samplers, concluded that the Surber Sampler was quite suitable for studies on the structure of the communities of stream macroinvertebrates.

Each sample was sorted on site and preserved in 70 per cent ethanol plus 5 per cent glycerine. In the laboratory the samples were sorted into taxa; the taxa identified and counted.

Drift samples were taken in two drift nets, one positioned at Station 2 and one at Station 4. The opening of each net was 300 mm by 300 mm with a net mesh size of 470 microns. Current speed measurements were carried out using a velocity head rod. The samples from each net were collected every two hours for 24 hours; commencing at 1200 on 4 November 1974. Each sample was preserved in 70 per cent ethanol plus 5 per cent glycerine and sorted into taxa in the laboratory.

Table 14

Physical and chemical characteristics of the water of the King River

			←	p.p.m.	→	←		μeq/L		→
Station	Temp.°C	pH	Dissolved O_2	Free CO_2	Alkalinity	Na	Mg	Ca	K	Cl
1	10	6.2	10.8	3	14.5	248	49.4	20	5.1	214
2	11.1	6.7	9.4	3	16	204	49.4	12.5	5.4	228
3	13.5	5.4	9.8	9.5	10	261	98.7	32.4	7.7	270
4	12.8	6.1	11.6	7	10	204	65.8	22.5	7.7	201
5	11.0	6.5	10.5	3	13.5	269	57.6	20	5.6	206
6	11.5	2.8	10.4	-	-	304	144	5	14.8	323
7	11.0	4.7	10.8	14	9	287	69.9	22.5	6.9	228
8	12.4	6.1	10	2	15.5	248	61.7	25	5.6	253
9	13.0	6.8	9.7	3.5	23.5	402	78.2	72.4	9.0	521

for Station positions see map (figure 1).

Table 15

Results of the analysis of the sediments from the King River, Comstock Creek, Linda Creek and Governor River. Values in μg/g dry weight. n.d. = not detectable.

Station	Hg	Cd	Zn	Cu	Pb	Fe	Mn	Co	Cr	Ni
1	0.03	1.57	40.52	21.97	46.88	15,303	1670	10.69	2.04	12.02
2	n.d.	n.d.	33.36	15.00	34.63	8,639	438.3	4.10	8.86	39.36
3	0.08	0.68	125.98	1007.48	404.40	40,379	115.48	2.19	1.83	3.00
4	0.19	1.26	195.46	1015.88	267.20	16,449	235.82	2.95	5.38	2.40
5	0.11	0.83	135.74	211.22	101.12	14,489	728.24	11.14	3.17	7.50
6	0.30	n.d.	128.22	1013.92	92.60	143,680	132.24	3.80	7.17	5.50
7	0.81	n.d.	147.58	934.96	306.98	99,920	130.34	4.90	4.30	7.99
8	0.23	0.48	198.74	1465.12	134.58	27,523	704.06	19.84	1.94	11.00
9	0.03	n.d.	21.60	17.27	40.47	9,770	275.27	3.6	1.54	5.16

Electro-fishing was carried out, using electro-fishing apparatus operating with a pulsed D.C. current (100 pulses/sec.) generated by a Honda E800U generator. Electro-fishing was carried out at all stations except Station 1. At Station 5, after fishing began, the apparatus broke down.

RESULTS AND DISCUSSION OF PARTICULAR ITEMS

The results of the analysis of the water collected from each sampling site are presented in table 14. It is unfortunate that sulphate ion levels were not determined as sulphate levels can be expected to be high in Linda Creek and possibly Comstock Creek. As experience has shown that the titrimetric method for free carbon dioxide determination is inapplicable for samples containing acid mine wastes (American Public Health Association 1971), the results obtained for Linda Creek have been rejected and the results for Comstock Creek and Station 7 should be treated with caution.

The results indicate that the unpolluted parts of the King River and Governor River are acidic streams with a sea water order of cationic dominance Na Mg Ca K. These results differ somewhat from those of Buckney and Tyler (1973) who found a cationic dominance order for the King River of Na Ca Mg K. They found an anionic dominance order of Cl HCO SO .

Linda Creek is markedly acid and the entry of the creek into the King River lowers the pH of the river. Comstock Creek has a moderately acidic character.

The results of the analysis of the sediments for mercury, cadmium, zinc, copper, lead, iron, manganese, cobalt, nickel and chromium for the nine sampling stations are given in Table 15.

While the samples were analysed for ten metals, it may perhaps have been instructive for concentrations of some other elements such as arsenic, antimony and selenium to also have been determined.

Mercury

Mercury levels in the sediments do not indicate serious pollution by this element. Bowen (1966) gave an average mercury concentration in unpolluted soil of 0.03 p.p.m. with a range from 0.01 to 0.3 p.p.m. At Stations 7 and 8 the mercury levels do suggest some mercury pollution as the levels at these stations approach those found in river systems and lakes receiving industrial effluent and domestic sewage (Förstner and Müller 1973; Bloom 1975).

Cadmium

There are no indications that cadmium pollution is present in this stretch of the King River.

Zinc

Bowen (1966) gave a mean concentration of 50 p.p.m. Zn in unpolluted soil, with the range being 10 to 300 p.p.m. Zn. While the present data suggest the addition of zinc to the King River by Comstock Creek especially, but also by Linda Creek, the concentrations of zinc in the sediments of the King River do not indicate that zinc is the principal cause of pollution. In freshwater bodies known to be polluted by zinc from mining operations, much higher concentrations in the sediments have been reported (Falk *et al.*, 1974; Joint Government Technical Committee on Mine Waste Pollution of the Molonglo River 1974; Bloom 1975; Aston and Thornton 1975; Pita and Hyne 1975).

Copper

In view of the past mining activity for this metal on the catchments of Comstock Creek and Linda Creek, it is not surprising to find that copper is a significant metal in the sediments and appears to be the major cause of pollution. The mean concentration of Cu on unpolluted soils is 20 p.p.m. with up to 100 p.p.m. being regarded as normal (Bowen 1966). In streams with non-industrial catchments, copper concentration in sediments in the range of 3.5-11.2 p.p.m. have been reported (Collinson and Shimp 1972; Mathis and Cummings 1973). Cu concentrations over 1,000 p.p.m. have been reported by Falk *et al.* (1973) in sediments of lakes receiving drainage from silver-copper mines; and by Thornton, Watling and Darracott (1975) in rivers receiving drainage from copper-tin mines.

In the King River pollution by copper begins with the entry into the river of Comstock Creek and continues downstream, after augmentation by Linda Creek, to Station 8.

Lead

The concentrations of lead in the sediments of the Governor River and the King River at Stations 1 and 2 are similar to those reported in the sediments of unpolluted bodies of fresh water elsewhere (Shimp *et al.* 1971; Collinson and Shimp 1972; Mathis and Kevern 1975). There is considerable increase in the concentrations of lead in the sediment of the King River with the entry of Comstock Creek. The concentrations of lead in the sediments of the King River from Station 4 downstream indicate significant pollution by lead. The concentrations are above the concentration of lead in sediments reported by Pita and Hyne (1975) in reservoirs located downstream of lead-zinc mining and milling areas. The pollution by lead in the King River is, however, probably of less serious nature than that pollution caused by copper.

Iron

As concentrations of iron in unpolluted soils range from 7,000 to 550,000 p.p.m. (Bowen 1966) the concentrations of iron in the sediments of the study cannot be regarded as being high. Nevertheless, it is apparent that Linda Creek has quite high levels of iron in its sediments. This high level of iron accounts for red ochreous colour of the creek bed and the water.

Manganese, cobalt, nickel, chromium

Concentrations of these four metals in the sediments of the study are not high in comparison with the levels given by Bowen (1966) for unpolluted soils.

In summary; of those metals in the sediments which were measured, there is a strong indication that copper is a major pollutant of the stretch of the King River studied, with lead and to a lesser extent zinc also being causes of pollution. Comstock Creek and Linda Creek appear to be important inputs of pollution to the King River.

FAUNAL SAMPLES

The results of the analysis of the samples taken by Surber Sampler at each station are given in Table 16.

The results indicate that the riffle fauna of the "unpolluted" stretches of the King and Governor Rivers is not a rich one either in terms of density of individuals or numbers of species. However, it is clear that the riffle fauna of the King River below the entry of Comstock Creek is a greatly depleted one, and that even when Station 8 is reached, 12 km downstream from Linda Creek the riffle fauna shows no signs of a recovery. As could be expected, both Linda Creek and Comstock Creek have no riffle fauna. In terms of individual taxa it is interesting to note that nymphs of *Atalophebioides* SP.A. (Leptophlebiidae:Ephemeroptera) appear to be partly tolerant of the pollution. Brown trout *(Salmo trutta)* was the only fish species collected. Only four individuals were caught, three at Station 2 and one at Station 9 in the Governor River. The lack of fish in the King River below Comstock Creek appears to be well known to local fishermen.

At Station 2 and Station 4, drift samples were taken every two hours for 24 hours. At Station 2 the current speed was about 0.55 m/sec. and at Station 4 the current speed was about 1.0 m/sec.. The number of individuals caught every two hours at both stations is shown in figure 2 5. There is a great difference in the abundance of drift fauna at Station 2 in comparison with the paucity of drift fauna at Station 4. This difference becomes more marked when the numbers of drift animals are adjusted to equalise differences in current speed. This adjustment is necessary as it is well known that the size of the catch of a drift net increases with increase in volume of water filtered (Elliott 1970).

At Station 2 the net filtered approximately 4,390 metres^3 in 24 hours, whilst at Station 4 the drift net filtered approximately 8,006 metres^3 in 24 hours. The mean

Table 16

Macroinvertebrates collected by Surber Sampler at each station

TAXA	STATIONS 1	2	3	4	5	6	7	8	9
Number of samples	5	5	5	5	5	5	5	5	4
Annelida:Oligochaeta	1	4	-	-	-	-	-	-	1
Insecta									
Ephemeroptera									
Atalophlebioides SP. A.	24	30	-	4	8	-	-	1	6
Plecoptera									
Eusthenia spectabilis	-	1	-	-	1	-	-	-	2
Riekoperla triloba	1	-	-	-	-	-	-	1	-
Leptoperla beröe	-	-	-	-	1	-	-	-	-
Trinotoperla zwicki	-	-	-	-	-	-	-	1	6
Cardioperla nigrifrons	-	-	-	-	-	-	-	-	2
Trichoptera									
Rhyacophilidae SP. A.	2	1	-	1	-	-	-	-	2
Leptoceridae SP. A.	3	-	-	-	-	-	-	-	1
Diptera:Simuliidae									
Austrosimulium SP. A.	12	-	-	-	-	-	-	-	7
Total No. of individuals	43	36	0	5	10	0	0	3	27
Mean No./sample ± S.D.	8.60 ± 3.36	7.20 ± 2.39		1 ± 1.22	2 ± 1	0	0	0.6 ± 0.55	6.75 ± 3.92
Total No. of Taxa	6	5	0	2	3	0	0	3	8

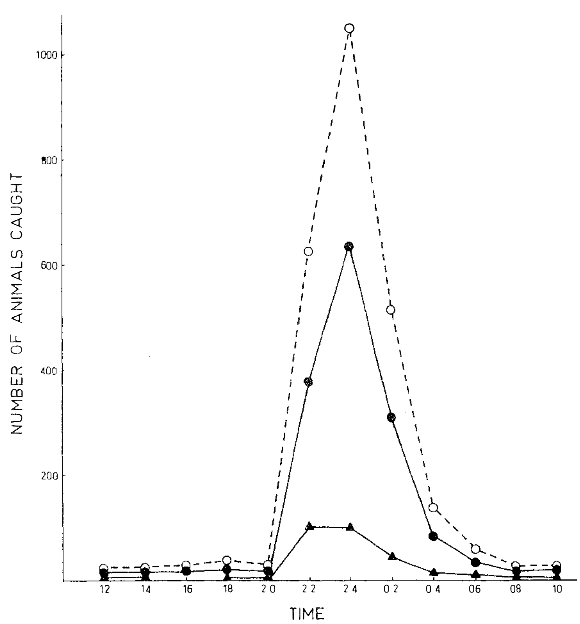

FIG. 25. - Results of the drift sampling at Station 2 and Station 4 on 4-5 Nov.

●—● : Numbers of animals caught every two hours at Station 2.

o--o : Numbers of animals caught every two hours at Station 2 when current velocities at Stations 2 and 4 are both 1.0 m/sec.

Δ—Δ : Numbers of animals caught every two hours at Station 4.

drift density (Elliott 1967) at Station 2 is 0.35 animals/m^3 and at Station 4 is 0.037 animals/m^3.

In Table 17 the night-time catches and the day-time catches in the two drift nets of the five most numberically important constituents of the drift fauna are presented.

Table 17

Catches of the five most numerically important animal taxa in the drift fauna at Stations 2 and 4 at night (from 2200 to 2000 and 0800 to 1000).

	NIGHT		DAY	
	Station 2	Station 4	Station 2	Station 4
Ephemeroptera:				
Atalophlebioides SP.A. (Nymphs)	619	148	16	4
Coleoptera:				
Helminthidae (adults)	419	1	4	2
Trichoptera:				
Rhyacophilidae SP.A. (Larvae)	105	48	13	1
Plecoptera:				
Gripopterygidae*(Nymphs)	107	29	0	0
Diptera:				
Austrosimulium SP.A. (Larvae)	85	17	17	4

*This entity comprises the following; *Trinotoperla zwicki*, *Dinotoperla* spp., *Leptoperla* spp., *Cardioperla nigrifrons*.

All five taxa show night-active drift periodicities and all show a marked decline in number in the polluted section (Station 4).

The very marked decline in drift fauna numbers between the two stations is difficult to explain. The two stations are only separated by a distance of about 70 m. and are in the same stretch of fast running water. The results suggest that the drift fauna may detect and avoid the pollution. Possibly the animals in the drift sense that they are near a polluted stretch and do not drift into the polluted section; or possibly the animals of the drift move into and detect the pollution and as soon as they detect the pollution they sink and clamber back along the bottom to the unpolluted section. The first hypothesis is most unlikely as in the situation of this study, it is well-nigh impossible for the pollution from Comstock Creek to move upstream and thus act as an early warning signal. The second hypothesis has some support in that (a) the distance drifted by animals is generally quite short (e.g. mean daily distance of drift fauna in a New Zealand stream was 10.7 m (McLay 1970); in a Lake District stream it was 20 m (Elliott 1971)) and thus as the animals only drift for a short distance they may not have far to move to be out of the pollution, and (b) many animals comprising drift fauna can and do actively move upstream (*vide* Waters 1972; Bournaud and Thibault 1973), and thus may be able to move for short distances out of the polluted section. Also possibly the numbers of animals drifting in any one spot in a stream may be strongly dependent on the density of the benthos immediately upstream of that spot and thus the numbers of drift animals are low when the immediate benthos is low in density. However, as Waters (1972) summarises, "the relationship of drift to bottom population densities has not been clearly determined.".

Nevertheless the phenomenon observed in this study is most unusual and clearly needs to be more closely examined. This brief study has also revealed the lack of work on the drift fauna in polluted streams.

GENERAL DISCUSSION

From the analysis of the sediments from the stretch of the King River studied, it is clear that the river is polluted downstream of Comstock Creek by copper, with lead and zinc also contributing to the pollution. This pollution is clearly reflected in the distribution of the riffle-dwelling macroinvertebrates. The King River at Stations 1 and 2 and the Governor River harbour a rather poor riffle fauna, yet the fauna is a rich one in comparison with the fauna of the King River below Comstock Creek. The King River shows no signs of faunal recovery downstream, even when Linda Creek is reached.

The pollution of the King River like other cases of "heavy metal" pollution is likely to persist for a considerable period of time after active mining and extraction have ceased. The Ystwyth River in Wales was polluted in the early part of the century by zinc from a silver-lead mining operation (Jones 1940). The pollution was still very evident 35 years after cessation of all mining activity (Jones 1958). The Molonglo River near Canberra was polluted predominantly by zinc from mining operations which ceased in 1962 (Weatherley, Beevers and Lake 1967). The river remains badly polluted to this day (W.L. Nicholas, A.N.U., pers. comm. 17 Sept. 1976). Such persistence of metal pollution appears to be the obligatory legacy of past unconstrained mining.

As stated in the description of the Stations, at Station 8 the banks are lined with Huon Pine *(Dacrydium franklinii)*. There are a number of mature trees. This conifer is known to be very long-lived, and some of the trees along the King River undoubtedly predate white settlement. Trees along water courses have been used for the reliable long-term monitoring of "heavy metal" contamination (Sheppard and Funk 1975; Faucherre and Dutot 1976). In view of this it would be most interesting to analyse small samples from live, mature Huon pines at Station 8 for heavy metals, and to compile a scheme of the history of "heavy metal" pollution of the King River. The Huon Pines *should not be damaged* in the taking of the samples.

It is known that the Hydro Electric Commission is considering the possibility of constructing a dam, called the Tofft Dam, across the King River in the King River Gorge (see Ashton, this volume). The expanse of water created by such a dam is intended to be confluent with water in the Franklin River valley backed up behind a dam in the Franklin River Valley.

The water of the dam in the King River Valley is likely to be polluted with soluble heavy metals. Because of the large amounts of soluble humic materials that can be expected to come from the button grass plains in the area, much of the soluble "heavy metal" may be in the form of soluble organic complexes or chelates. Such a situation may particularly apply for copper which readily forms soluble complexes and chelates readily with naturally occurring ligands (Stiff 1971). If the water containing ionic, chelated and complexed forms of copper, zinc and lead moves into the water dammed up in the Lower Gordon and Franklin River valleys, it is likely to cause pollution and to adversely affect the aquatic flora and fauna of a vast area of water.

Lake and reservoir sediments are known to be "sinks" for heavy metals (Iskandar and Keeney 1974; Pita and Hyne 1975). It is possible that much of the "heavy metals" in the postulated impoundment may eventually be deposited in the sediments. The "heavy metals" in the sediments may be accumulated by aquatic invertebrates, e.g. oligochaetes, bivalve molluscs, dipteran larvae, trichopteran larvae and subsequently accumulated in trout as a result of them feeding on "heavy metal"-enriched invertebrates. It may also be possible that the copper, zinc and lead may be remobilized after sedimentation as has been shown to occur in river sediments by De Groot *et al.* (1971). Thus the construction of a dam on the King River in the King River Gorge may well create some deleterious and long-lasting effects due to "heavy metal" pollution.

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