Storys Creek Water Quality Monitoring Results

7 July 2004

August 2004

A Report to Mineral Resources Tasmania

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Technical Advice on Water

1 Introduction

Mineral Resources Tasmania (MRT) has implemented large-scale remediation works at the historic Storys Creek mine site in eastern central Tasmania, including the removal of the contents of a precipitation dam, closure of adits, removal of some tailings and implementation of an anoxic limestone drain. A 3-year water quality monitoring program was initiated in September 2003 to determine the concentrations and fluxes of pollutants and evaluate the efficacy of the remediation works.

This report summarises the results from the fifth water quality-monitoring run completed on July 14, 2004 and compares results to previous findings.

2 Sampling details

Water quality and flow monitoring was completed on 14 July 2004 by L. Koehnken of Technical Advice on Water and Rohan Church, a work experience student from Friends School. All sites in Table 1 were visited and at each of these sites pH, conductivity and temperature were measured *in situ* and a water sample was collected for subsequent analysis of metals, sulphate, and alkalinity. No water sample was collected from Side Creek because there was no flow from the wetlands into Storys Creek, and only a trickle in the creek above the wetlands.

At the Storys below Precipitate Dam site, Storys below Nisbet Creek, Storys at Managers, Storys above Aberfoyle and Aberfoyle above Storys site, the dimensions of the channel were measured (width, depth at various points) and flow measurements were made at 1 – 3 points across a transect at a depth of 0.6 of the water depth (from the surface). The flow estimates were used to establish fluxes at each of the sites. The 'Storys below Precipitation Dam' site flow measurement was used in the flux calculations for three sites (Storys Creek above mine, Storys below PPT dam, and Storys above Side Creek) because the site yields the most accurate flow estimate due to the presence of bedrock, resulting in a stable channel with confined flow.

Flow from the ALD was measured using a calibrated bucket and stopwatch. Flow from the Precipitate Dam was measured using the flow meter and measuring the cress-section of a small pool immediately below the outfall and above Storys Creek. This approach was necessary because flow from the dam was not confined to the outflow pipe. Flow from the Eastern Adit was determined using the height of the water in the V-notch weir, and a USGS equation for calculating V-notch flow. Sedimentation of iron floc in the portal of the Eastern Adit is presently affecting the accuracy of the V-notch.

Conditions during sampling were fine, and followed several weeks of seasonal rainfall, with ~26 mm of rain falling in the region during the preceding two weeks, based on rainfall at Fingal (25.8 mm) and Powranna (27.7 mm).

Table 1. Site number and location of monitoring points.

Site Number	Site Location	Justification
ALD	Anoxic Drain outflow at Storys Creek	Provide indication of alkalinity input to underground workings
2	Storys Cr above mine workings	Provides background water quality and indication of upstream changes
5	Storys Cr below Precipitation Dam	Provide record of changes since dam removal – should continue to change as groundwater 'flushes' through system
7	Storys above Side Creek	Indicate pollutant load from upstream tailings vs downstream Side Creek
8	Storys Cr below Side Creek	Significant pollutant load enters via Side Creek-should reduce due to remediation works
10	Eastern Adit outflow	Adit plugged, monitoring of pH indicated effectiveness of works
13	Storys below Nisbet	Indicates inputs from diffuse sources downstream of Side Creek
14	Storys at Managers*	Continue best long-term data collection point; indicates diffuse load entering between Nisbet and Pumphouse
21	Storys Above Aberfolye	Final measurement of pollutant load in Storys Creek
23	Storys below Aberfoyle	Indicative of water entering South Esk
22	Aberfoyle Creek	Water is important for diluting Storys, and has elevated zinc values
24	South Esk above Storys	'Background' water quality in South Esk River
25	South Esk d/s Storys	Estimate of Storys Creek impact on S. Esk
4	Precip. dam outflow	Historic pollutant source
6	Side Creek	Historic pollutant source

***This site has been referred to as both Storys below Pumphouse and Storys at Manager's. In this and subsequent reports 'Storys at Manager's' will be used.**

3 Results and discussion

Water quality results are presented in Table 2 and Table 3, and discussed in the following sections.

3.1 Flows

On July 14, flow in Storys Creek was ~300 L/s at the mine workings, ~400 L/s at the Managers Residence, and ~1000 L/s above the confluence with Aberfoyle Creek. This flow is the second highest recorded since September 2003, but is only about half of the September flow level. Flows at the Managers Residence have been used to catagorise flows as low, medium or high for plotting purposes, with high flows being anything that exceeds 350 L/s. The 400 L/s estimate exceeds this value, so results are plotted as 'high' in Figure 3.3 and Figure 3.8 (green bars).

Photos 1, 2 and 3 compare flow in July 2004 (Photo 3) with low flow conditions in November 2003, and high flow conditions in September 2003. In July the flow was well contained within the channel at all monitoring sites, although the channel

continues to have a more braided nature upstream of the Managers Residence site as compared to before the large flood event in January 2004.

Flow was present from the Precipitate Dam, and the Eastern adit, although very low, measuring 002 l/s and <0.05L/s, respectively. In Side Creek there was a trickle of water in the creek bed, but no standing water in, nor discharge from the wetlands. This is somewhat surprising given the relatively high flow in the river, and again highlights that flow from Side Creek is more closely related to groundwater conditions than surface water inputs.

Photo 1. & Photo 2 Storys Creek at Managers Residence, view upstream. Photo 1 (left) shows lowest flow during monitoring (50 L/s) recorded at Managers site in February 2004, and Photo 2 (right) shows highest flow during monitoring (1,000 L/s), recorded in September 2003, looking upstream Feb 2004 (left) and in May 2004 (right).

Photo 3. Storys Creek at Managers Residence, view upstream, 14 July 2004. Flow rate 400 L/s

The flow in lower Storys Creek (990 L/s) was over twice the flow at the Managers Residence site (400L/s), indicating that a large amount of runoff was entering the river from the catchment below Rossarden. The flow in lower Storys Creek was also about twice that of the flow in Aberfoyle Cr (410 L/s).

3.2 Water quality results – concentrations

Water quality results for July 2004 are presented in Table 2 and Table 3.

3.3 Anoxic Limestone Drain (ALD)

The alkalinity in the water emanating from the ALD continues to be higher than background concentrations in Storys Creek as shown in Figure 3.1 which compares background alkalinity levels in Storys Creek with the discharge from the anoxic drain. The concentration of alkalinity has roughly reflected surface water flow conditions, with the lowest levels (Sept 03) associated with the highest flow rates in the river, and the higher concentrations associated with very low flows (Nov, Feb, May). This may suggest that during higher flows, additional water is entering downstream of the drain, or the residence time of water within the drain is lower, resulting in dilution and lower concentrations.

The alkalinity flux from the drain (Figure 3.2) has also varied considerably over the past five monitoring runs, due to both variations in alkalinity (range = 45 – 104 mg $CaCO_3$) and discharge (range = 0.1 L/s – 0.5 L/s). Discharge from the drain does not reflect flow trends in Storys Creek, as flow conditions in the river were identical in November 2003 and February 2003, yet the alkalinity output of the drain was over three-times greater in February. The reasons for this variability are unknown.

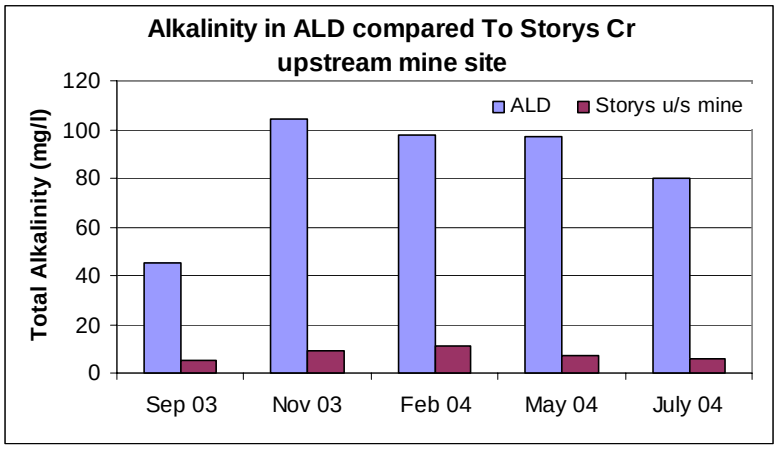

Figure 3.1. Alkalinity levels in water from the ALD compared to alkalinity levels in Storys Creek above the mine site.

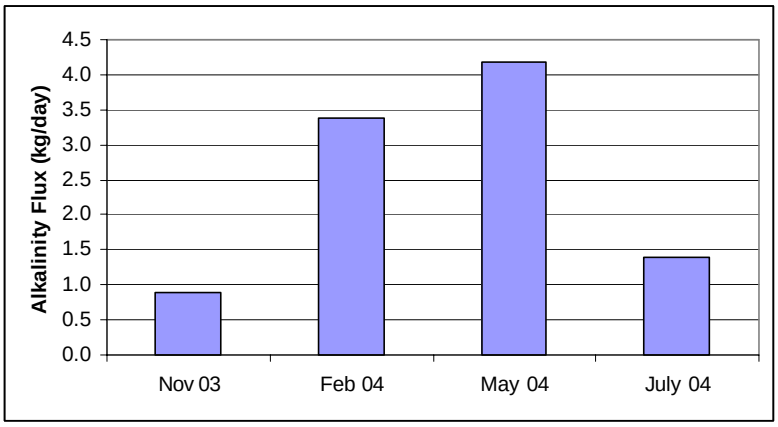

Figure 3.2 Alkalinity flux from ALD at Storys Creek.

Table 2. Water quality results and flow for Storys Creek monitoring, February 26, 2004. All units µg/L except Fluoride, Sulphate and Alkalinity, which are mg/l/

		Storys Ab Mine	Precip Dam Outflow	Storys Bel Precip	Storys Ab Side Cr	Storys Bel Side Cr	Storys Bel Nisbet	Storys at Manager	Storys Ab Aber	Storys Bel Aber	Aber Ab Storys	S. Esk Ab Storys	S. Esk Bel Storys
Date		14 July 04 0925	14 July 04 0945	14 July 04 1000	14 July 04 1020	14 July 04 1040	14 July 04 1110	14 July 04 1210	14 July 04 1330	14 July 04 1400	14 July 04 1345	14 July 04 1300	14 July 04 1420
Alkalinity Total	mg/l $CaCO_3$	6	8	5	4	2	5	4	3	8	17	11	11
Sulphate	mg/l	0.3	74	2	4	13.9	8.7	9.5	8.4	16.9	32.8	<2	<2
Al Dis	µg/l	<20	39	<20	27	88	41	96	104	66	26	57	53
Al Total	µg/l	<20	333	41	357	492	282	225	303	264	190	267	282
As Dis	µg/l	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
As Total	µg/l	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Cd Dis	µg/l	<1	348	6	43	47	27	29	21	16	9	<1	<1
Cd Total	µg/l	<1	350	7	43	47	27	31	21	17	9	<1	<1
Co Dis	µg/l	<1	24	<1	2	3	1	<1	<1	<1	<1	<1	<1
Co Total	µg/l	1	25	<1	2	3	1	1	<1	<1	<1	<1	<1
Cr Dis	µg/l	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Cr Total	µg/l	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Cu Dis	µg/l	<1	9	<1	112	104	35	45	26	20	13	<1	<1
Cu Total	µg/l	<1	16	1	149	146	71	61	31	27	18	<1	1
Fe Dis	µg/l	<20	<20	<20	<20	74	88	197	90	63	41	102	103
Fe Total	µg/l	<20	84	<20	98	918	460	303	182	197	255	248	262
Mn Dis	µg/l	<5	1620	26	59	207	109	84	31	27	26	<5	7
Mn Total	µg/l	<5	1640	26	60	211	109	89	31	29	27	9	12
Ni Dis	µg/l	<1	31	<1	1	3	2	2	2	1	2	<1	<1
Ni Total	µg/l	<1	31	<1	2	4	3	3	2	2	3	<1	<1
Pb Dis	µg/l	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Pb Total	µg/l	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Zn Dis	µg/l	<1	9450	189	944	1120	665	700	503	427	342	3	23
Zn Total	µg/l	<1	9570	190	963	1150	673	748	509	466	359	3	28
Flow	l/s	298	0.5	298	298	305	409	401	987	1395	408		

Table 3. Flow, pH conductivity and temperature results collected in situ, 14 July 2004 and flux calculations based on flows and analytical results.

		Storys Ab Mine	Precip Dam Outflow	Storys Bel Precip	Storys Ab Side Cr	Storys Bel Side Cr	Storys Bel Nisbet	Storys at Manager	Storys Ab Aber	Storys Bel Aber	Aber Ab Storys	S. Esk Ab Storys	S. Esk Bel Storys
Parameter	Unit	14 July 04 0925	14 July 04 0945	14 July 04 1000	14 July 04 1020	14 July 04 1040	14 July 04 1110	14 July 04 1210	14 July 04 1330	14 July 04 1400	14 July 04 1345	14 July 04 1300	14 July 04 1420
Flow	l/s	298	0.2	298	298	305	409	401	987	1395	408		
pH (field)	pH units	7.1	6.4	6.9	5.9	3.9	6.2	6.5	6.6	6.9	6.7	6.7	7.0
Conductivity	µS/cm	18.6	201	22.7	33.4	352	44.6	46.5	44.0	64.3	102	65.2	67.5
Temp	°C	3.1	2.9	3.1	3.9	5.6	5.0	5.6	5.6	5.6	6.8	6.9	6.5
Zn tot flux	kg/d	<0.03	0.41	4.89	24.79	30.30	23.78	25.92	43.41	56.17	12.66		
Cd tot flux	kg/d	0.01	0.02	0.18	1.11	1.24	0.95	1.07	1.79	2.05	0.32		
Mn tot flux	kg/d	<0.13	0.07	0.67	1.52	5.45	3.85	2.91	2.64	3.25	0.92		
Fe tot flux	kg/d	<0.5	<0.01	<0.5	2.52	24.19	16.26	10.50	15.52	23.74	8.99		
SO_4 flux	kg/d	7.7	3.2	51.5	103	366.3	307.4	329.1	716.3	2037	1156		

*Flow estimate from Storys below Precip dam used.
#Calculated based on Storys above Aberfoyle & Aberfoyle above Storys

		ALD	Nisbet Cr	Side Creek	Eastern Adit
Date		14 July 04 0910	14 July 04 1100	14 July 04 1030	14 July 04 1125
Flow		0.2		no flow	<0.05
pH (field)	pH units	7.1	6.1	3.9	5.8
Conductivity	µS/cm	159.5	25.5	352	240
Temperature	°C	3.8	5.8	8.4	7.7

3.4 Metal concentrations in Storys Creek

The water quality monitoring results from July 2004 show similar trends as previous runs:

- Arsenic, chromium and lead are present at or below the limit of detection at all sites;
- Cobalt and nickel concentrations are very low except for the discharge from the Precipitate Dam;
- There is a pH and alkalinity minimum in Storys Creek downstream of Side Creek;
- The trickle of water in Side Creek has low pH, high conductivity and elevated temperature compared to ambient conditions indicative of sulphide oxidation;
- Due to the relatively high pH in Storys Creek, most aluminium occurs as particulate material Aluminium concentrations increase downstream through the mine site with major inputs between Storys bel Precipitate Dam and Storys above Side Creek. Dissolved Al increases at Storys downstream of Side Creek, consistent with the lower pH values at this site;
- Cadmium, copper and zinc are all present predominantly as dissolved metals, and concentrations of the three metals show similar trends-large increases at the sites both above and below Side Creek, with a general decrease between the mine site and the mouth of the river;
- With the exception of total iron concentrations, all metals are present in Aberfoyle Creek at lower levels than in Storys Creek.

Zinc and cadmium results for the Precipitate Dam, Storys below Side Creek and Storys at the Managers Residence are shown graphically in Figure 3.3.

Levels of zinc and cadmium at all three sites are consistent with previous monitoring periods, with concentrations inversely proportional to flow. In July, cadmium and zinc values decrease between the Storys below Side Creek site and Storys at Managers monitoring site. This is consistent with the results from the first three monitoring runs (Sept 03, Nov 03, Feb 04) but in contrast to the May 04 results, when concentrations increased at the downstream site. Concentrations of zinc and cadmium also decrease between the Managers site and Storys Creek above Aberfoyle Creek site, as noted in the above dot points and in Table 2.

Sulphate concentrations obtained in July 04 show similar trends to the zinc, cadmium and copper results, with the highest concentrations in Storys Creek recorded below Side Creek and concentrations decreasing downstream of this site. Compared to the May 04 results (Figure 3.4) values are lower, and show decreasing, rather than increasing concentrations below Side Creek.

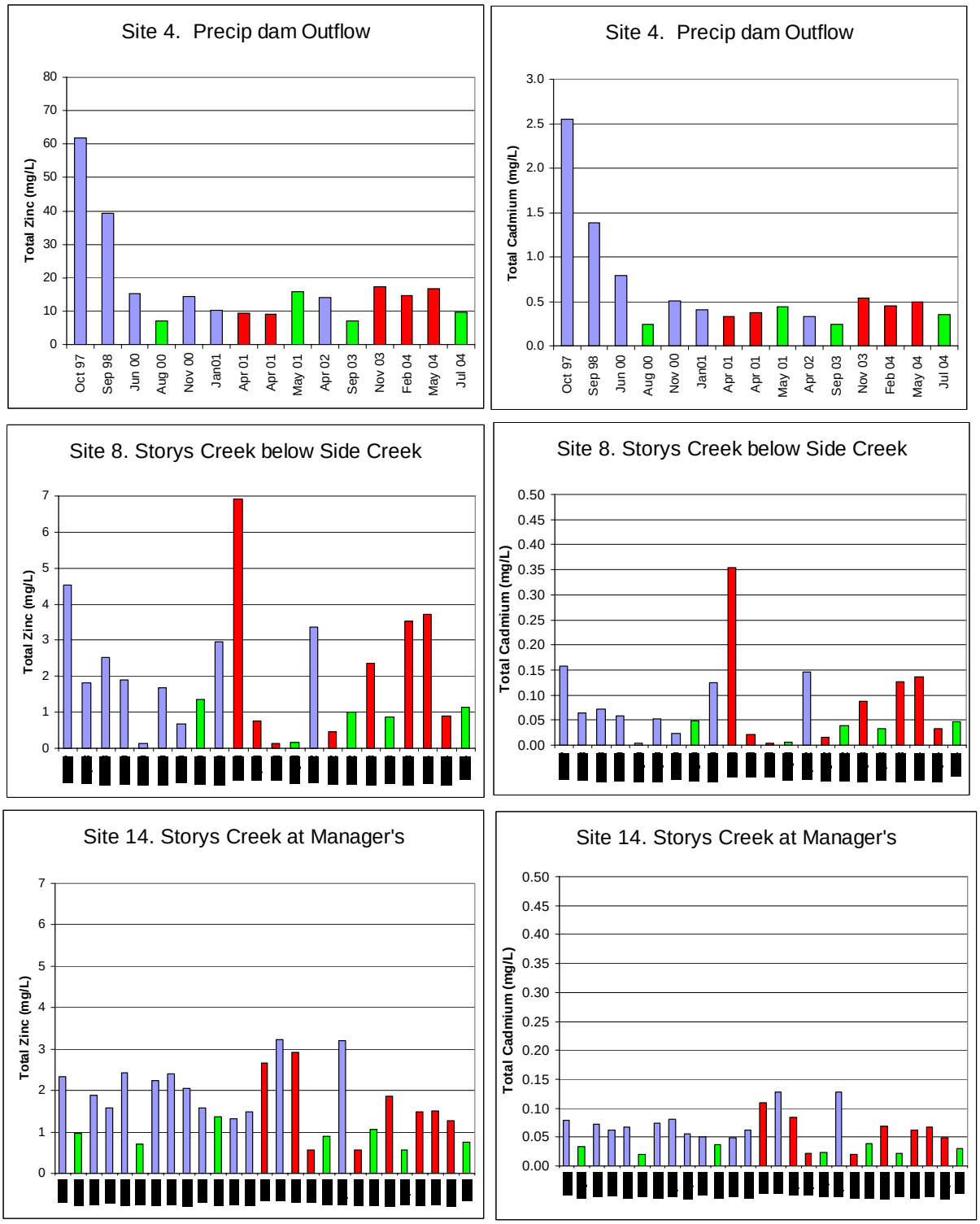

Figure 3.3 . Total zinc (left) and total cadmium (right) graphs comparing the July 2004 results with previous monitoring results. Red bars denote low flow (<250 L/s), blue bars denote medium flows (250 – 350 L/s), and green bars denote high flow (>350 L/s). Note different scale for the Precipitate dam results.

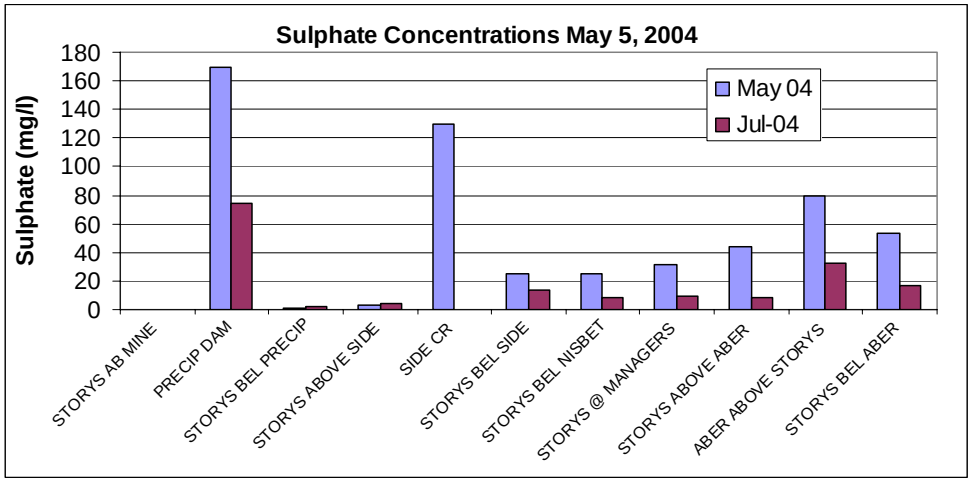

Figure 3.4. Sulphate concentrations at all monitoring sites n May 2004 and July 2004.

The zinc load from Storys Creek increased zinc concentrations in the South Esk from 3 µg/L to 28 µg/L (Table 2). This is a moderate increase compared to previous monitoring periods, when increases between the sites have ranged from 11 µg/L to 70 µg/L.

3.5 Water quality – fluxes

Using the flow estimates and water quality results, fluxes for zinc, cadmium, iron, manganese and sulphate were determined, and are presented in Table 3. Figure 3.5 Figure 3.6 and Figure 3.7 show zinc, cadmium and sulphate fluxes at each of the monitoring sites in Storys Creek compared to previous results.

Figure 3.5 shows that in July 2004, the largest zinc flux from the mine site entered in the area downstream of the Precipitation Dam inflow, and upstream of Side Creek. This area contains the remaining tailings deposit, and a large amount of mine derived material in the river channel. This flux of ~25 kg/day remained relatively stable at the Below Nisbet and Managers site. Similar to May, but dissimilar to the September, November and February results, zinc fluxes increased between the Managers Residence site, and the Storys above Aberfoyle site. This suggests that the flood derived sediments which were deposited during the large flood event in late January are continuing to have an input to the river. The total zinc flux at the Storys Creek above Aberfoyle Creek site, 43 kg/day, is the highest recorded since September 2004, with 40% of the flux derived from downstream of the Managers Residence monitoring site.

The contribution of zinc to lower Storys Creek from Aberfoyle Creek is ~13 kg/day or about 30% of the contribution from Storys above Aberfoyle. This is a relatively larger contribution as compared to the May results, when Aberfoyle only contributed <15% of the Storys Creek load, but smaller than the preceding three monitoring periods, when Aberfoyle Creek contributed~50% of the Storys Creek load. It could be interpreted that the contribution from the flood deposited material is decreasing with time, and the river is slowly returning to pre-flood conditions.

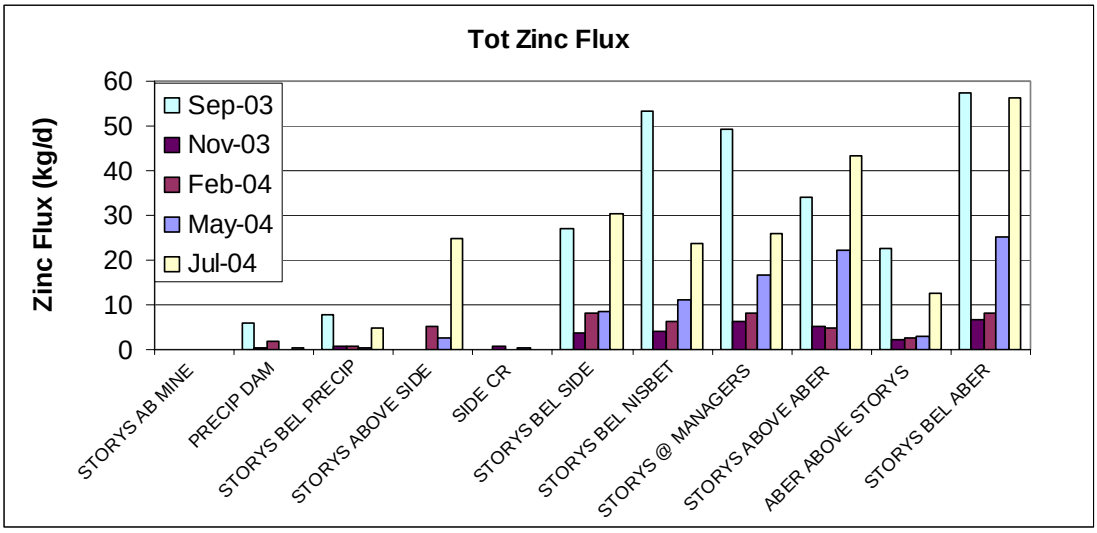

Figure 3.5. Total zinc fluxes for sites in Storys Creek for all sampling runs since September 2003. Note, Storys above Side Creek was not monitored in September 2003.

July results for cadmium fluxes show similar trends to zinc, with the fluxes increasing downstream of the 'Managers Residence' site (Figure 3.6). The cadmium flux in July 2004 at Storys below Aberfoyle was very similar to the flux recorded in September 2003, under high flow conditions. A major difference between Sept 2003 and July 2004 however, is that in September the majority of the flux was derived from the mine site, whereas in July the catchment below the mine was a major contributor.

Prior to May 2004, the sulphate flux from Aberfoyle had consistently exceeded the flux from Storys Creek to the lower river (Figure 3.7). In May, Storys contributed a higher flux, but in July, the flux from Aberfoyle again exceeded that from Storys Creek. This is interesting because it indicates that the sulphate and metal fluxes are probably not derived from the same source, or there are additional sulphate sources in Aberfoyle Creek.

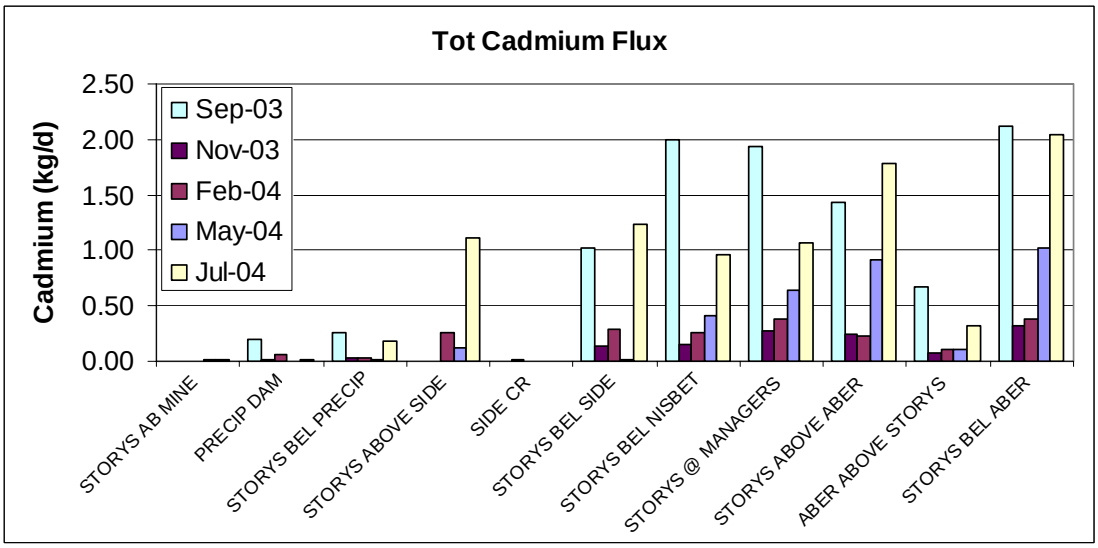

Figure 3.6. Total cadmium fluxes in Storys Creek since September 2003.

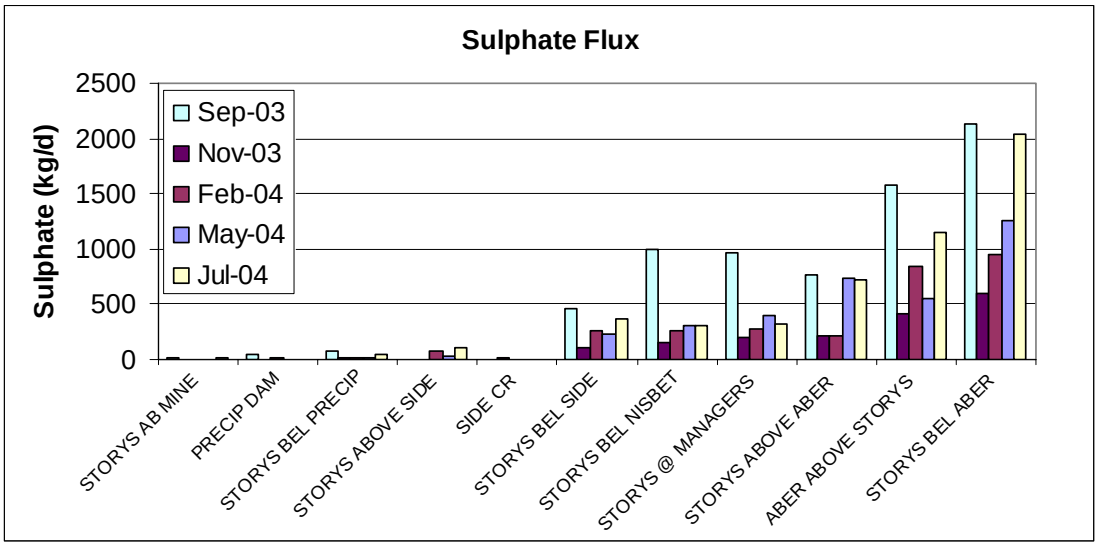

Figure 3.7. Sulphate fluxes in Storys Creek since September 2003. Storys above Side cr was not monitored in September 2003.

Figure 3.8 shows the July zinc, cadmium and sulphate fluxes at the Managers Residence sample site compared to all historic monitoring results from this site. The colour of the bars indicate the flow regime, with flows over 350 L/s shown as green bars. The July zinc and cadmium fluxes are within the previously documented range for high flows, but sulphate is low compared to previous data.

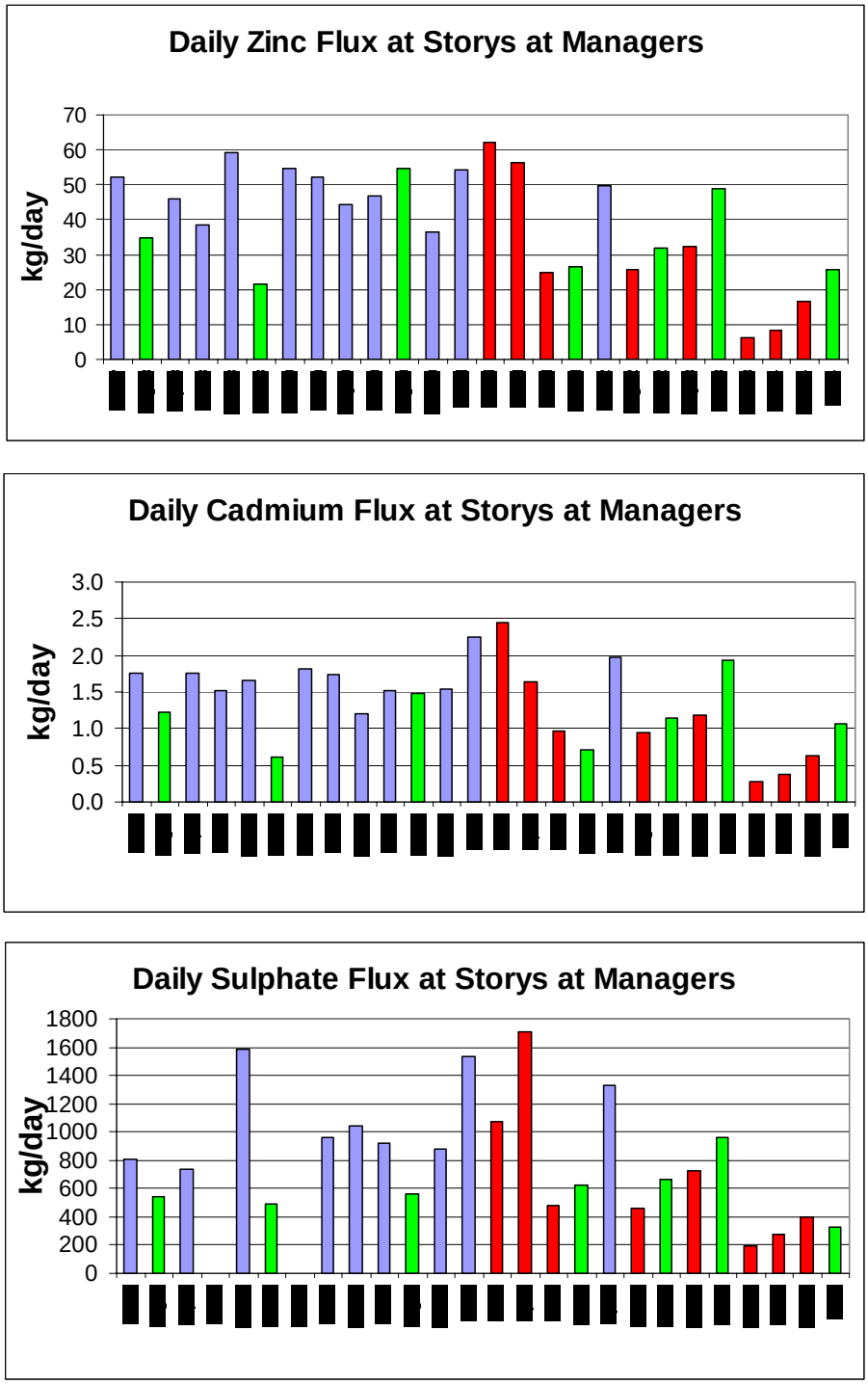

Figure 3.8. Daily total zinc, total cadmium and sulphate fluxes at Managers Site. Red denotes low flow (<250 l/s); blue denotes moderate flow (250 -350 l/s) and green denotes high flow (.350 l/s)

3.6 Impact of remediation works

The five monitoring runs completed between September 2003 and July 2004 have shown that metal release from the mine site is related to flow regime, with very low base flows transporting 5 – 10 kg/day zinc, and high flows transporting 25 – 50

kg/day. Under both high and low flows, the majority of metal and sulphate is derived from the mine workings between the Storys below the Precipitate Dam monitoring site, and Storys below Side Creek site. The Precipitate Dam is a very small source compared to these downstream inputs.

The zinc and cadmium fluxes since September 2003 have been lower compared to historic monitoring results, especially when it is recognised that the September high flow event was the largest flow event ever monitored.

The monitoring results have also shown that the remediation works have not prevented the transport and deposition of metal rich sediments from the upper catchment to the lower catchment, as occurred during the January 2004 flood event. It is also plausible that the earth works undertaken near and in the Storys Creek river channel during the remediation phase actually promoted the additional release of this material under flood conditions through the excavation and straightening of the channel and destabilisation of banks. The release of metal from this redeposited material in the river downstream of the Managers Residence site is presently a very large source, contributing ~50% of the total zinc load. Before the flood, virtually no additional zinc or cadmium was added to the river between the Managers Residence and the Storys above Aberfoyle site.

3.7 Future monitoring

The monitoring runs have shown that the inputs to the river from both the mine site and the downstream flood-deposited material are greatest at high flows, so these conditions should be targeted in the future. It is recommended that one additional monitoring run be completed during a wet period in the winter/spring of 2004. The aim of this would be to obtain an additional medium or high flow discharge from the mine site, and to monitor the input of metals to the river downstream of the Managers Residence. Also, this will assist in establishing the time frame for deposited flood material to work its way through the river which is important for the long-term management of the mine site and river catchment. An additional sampling run during this wet season would indicate how quickly this input is diminishing.

In the longer term, it is recommended that one low flow monitoring be completed towards the end of the 2004/2005 dry summer season, which can be compared to the November 2003 and February 2004 low flows. Following this, several samplings should be completed next winter, with the exact timing dictated by the occurrence of flood events in the catchment. Ideally, a high flow before a major flood event and a high flow following a major flood event should be targeted, to provide information about pollutant loads from the mine site and the lower river.

Related References

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