
Storys Creek Water Quality Monitoring Results

19 May 2005

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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 leaving the site and evaluate the efficacy of the remediation works.

This report summarises the results from the seventh water quality-monitoring run completed on May 19th, 2005 and compares results to previous findings.

2 Sampling details

Water quality and flow monitoring was completed on May 19, 2005 by L. Koehnken of Technical Advice on Water and Brett Stewart of Mineral Resources Tasmania. All sites in Table 1 were visited and where flow was present pH, conductivity and temperature was measured *in situ* with a water sample collected for subsequent analysis of metals, sulphate, fluoride and alkalinity from most of the sites.

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 using a flow-meter at 2 – 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 flow varies little between the sites and 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 not able to be measured due to the very low flow rates, and leakage of flow around the ALD outflow pipe. The flow value in Table 2 was visually estimated.

The very low flow conditions on the day restricted the sites from which measurements and surface samples could be collected, as there was no outflow from the Precipitate Dam, or surface flow in Side Creek.

Flow from the Eastern Adit was determined using the height of the water in the V-notch weir, and a generalised 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 on May 19th were fine, and followed an extended dry period, with only 3.4 mm and 1.8 mm of precipitation recorded in the three weeks prior to monitoring at Fingal and Powranna, respectively.

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 tailings deposit located upstream Side Cr
8	Storys Cr below Side Creek	Significant pollutant load enters via Side Creek
10	Eastern Adit outflow	Adit plugged, monitoring of pH indicates effectiveness of works
13	Storys below Nisbet	Indicates inputs from diffuse sources downstream of Side Creek and dilution from entrance of Nisbet Cr
14	Storys at Managers*	Continue best long-term data collection point; indicates diffuse load entering between Nisbet and Pumphouse
21	Storys Above Aberfoyle	Final measurement of pollutant load in Storys Creek
23	Storys below Aberfoyle	Indicative of water entering South Esk
22	Aberfoyle Creek	Has elevated zinc levels and contributes to loads entering S. Esk
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 -**Error! Reference source not found.**, and discussed in the following sections.

3.1 Flows

Flows in Storys Creek during the May sampling was the lowest ever monitored, with only 10 L/s recorded at the mine site, and 30 L/s at the Managers Residence. These values should be considered as rough estimates only as it is very difficult to accurately measure flows at these low levels in gravel rivers.

Photos 1 and 2 compare the low flow in May 2005 (Photo 1) with flow in February 2004, which was the lowest flow previously recorded, and with the highest flow monitoring, in September 2003.

Flow in lower Storys Creek and Aberfoyle Creek were similar, at about 30 L/s each, showing there was very little pick up in the catchment. These flow estimates are consistent with the zinc and Sulphate concentrations measured in Storys above Aberfoyle, Aberfoyle Creek and Storys below Aberfoyle, indicating the relative proportion of flow from each catchment is correct.



Photo 1. & Photo 2 Storys Creek at Managers Residence, view upstream. Photo 1 (left) shows conditions on May 19th, 2005, which is the lowest flow ever monitored (30 L/s). Photo 2 (right) shows the previously lowest flow conditions (50 l/s) recorded in February 2004,



Photo 3 (right) shows highest flow monitored (1,000 L/s), recorded in September 2003.

3.2 Water quality results – concentrations

Water quality results for May 2005 are presented in Table 2, and Table 3. Table 2 contains the water quality results from the regular monitoring sites on Storys Creek, Aberfoyle Creek and the South Esk River. Table 3 shows the pH, conductivity and temperature data collected in the field, and an estimate of metal and sulphate fluxes for each of the regular monitoring sites.

3.3 Anoxic Limestone Drain (ALD)

Alkalinity concentrations in the ALD and upper Storys Creek for May are shown in Figure 3.1 along with previous results. The alkalinity concentration in May in the

ALD was similar to results prior to February 2005, which was affected by a lack of inflow due to a broken feed pipe to the system. The alkalinity concentration in upper Storys Creek was consistent with previous results. In spite of the feed pipe to the ALD feed pond being fixed, the flow rates remained very low in May, resulting in a very low flux (Figure 3.2). The actual flux may have been greater due to the seepage of water around the discharge pipe which was not able to be included in the flow estimate.

Recent surface drainage works at Storys Creek have resulted in the alkaline discharge from the ALD joining surface flow directed towards the Side Creek catchment, rather than into the underground workings.

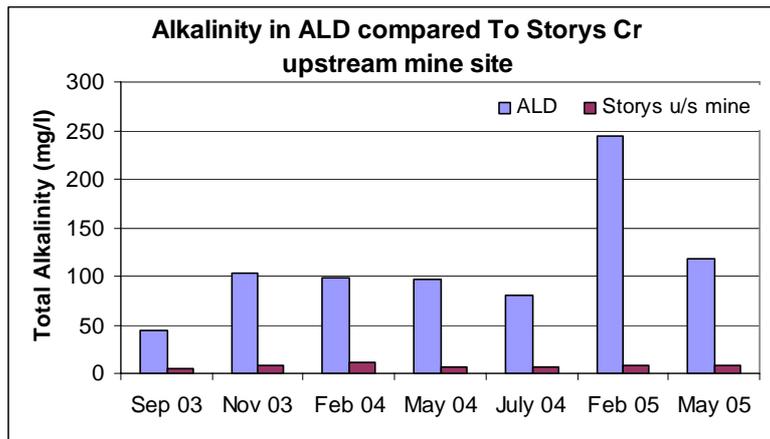


Figure 3.1. Alkalinity levels in water from the ALD compared to alkalinity levels in Storys Creek above the mine site.

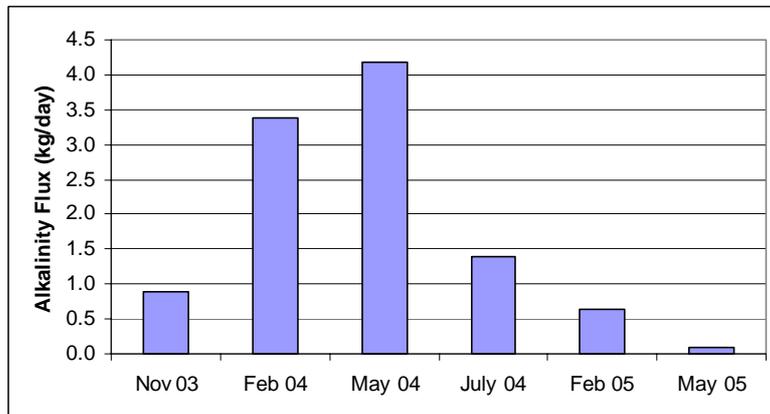


Figure 3.2 Alkalinity flux from ALD at Storys Creek township.

Table 2. Water quality results and flow for Storys Creek monitoring, May 19, 2005. All units µg/L except Fluoride, Sulphate and Alkalinity, which are mg/l.
*Flow calculated by adding Storys above Aberfoyle, and Aberfoyle Creek flows

		Storys Ab Mine	Precip Dam Outflow	Storys Bel Precip	Storys Ab Side Cr	Storys Bel Side Cr	Storys Bel Nisbet	Storys at Manage r	Storys Ab Aber	Storys Bel Aber	Aber Ab Storys	S. Esk Ab Storys	S. Esk Bel Storys
Date		19 May 05	19 May 05	19 May 05	19 May 05	19 May 05	19 May 05	19 May 05	19 May 05	19 May 05	19 May 05	19 May 05	19 May 05
Alkalinity Total	mg/l CaCO ₃	9		11	9	<2	3	<2	<2	11	26	19	18
Fluoride	mg/l	<0.02		0.09	0.33	1.8	0.64	0.37	0.31	0.63	0.99	0.04	0.06
Sulphate	mg/l	0.4		4	15	89	73	77	67	78	90	1.7	5.6
Al Dis	µg/l	<20		<20	<20	1470	23	308	104	33	<20	<20	<20
Al Total	µg/l	22		20	219	2390	459	390	113	46	20	27	25
As Dis	µg/l	<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
Cd Dis	µg/l	<1		5	56	116	89	139	100	55	13	<1	2
Cd Total	µg/l	<1		6	61	122	96	146	105	59	14	<1	2
Co Dis	µg/l	<1		<1	<1	11	5	<1	<1	<1	<1	<1	<1
Co Total	µg/l	<1		<1	2	10	5	1	<1	<1	<1	<1	<1
Cr Dis	µg/l	<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
Cu Dis	µg/l	<1		<1	68	129	20	133	41	12	2	<1	<1
Cu Total	µg/l	<1		<1	111	145	53	140	43	14	3	<1	<1
Fe Dis	µg/l	<20		<20	<20	1780	<20	<20	<20	<20	<20	121	148
Fe Total	µg/l	24		<20	95	5530	1130	82	<20	28	20	207	210
Mn Dis	µg/l	<5		11	42	885	380	102	26	12	7	<5	<5
Mn Total	µg/l	<5		12	46	928	405	108	28	14	8	<5	<5
Ni Dis	µg/l	<1		<1	<1	14	13	9	6	3	<1	<1	<1
Ni Total	µg/l	1		1	3	17	12	12	7	5	2	<1	1
Pb Dis	µg/l	<5		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Pb Total	µg/l	<5		<5	<5	6	<5	<5	<5	<5	<5	<5	<5
Zn Dis	µg/l	<1		180	1120	3040	2530	3510	2520	1380	385	<1	52
Zn Total	µg/l	<1		195	1230	3200	2720	3690	2650	1480	414	<1	59
Flow	l/s	10	0	10	10	10	20	30	30	60	30		

Table 3. Flow, pH conductivity and temperature results collected in situ, May 19, 2005 and flux calculations based on flows and analytical results.

*Flow estimate from Storys below Precip dam used to estimate fluxes.

#Calculated based on Storys above Aberfoyle & Aberfoyle above Storys

		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	19 May 05	19 May 05	19 May 05	19 May 05	19 May 05	19 May 05	19 May 05	19 May 05	19 May 05	19 May 05	19 May 05	19 May 05
Flow	l/s	10	0	10	10	10	20	30	30	60	30		
pH (field)	pH units	7.4		7.2	6.9	6.0	6.6	5.8	6.3	7.3	7.4	7.1	7.6
EC	µS/cm	17		27	44	136	123.2	125	115	153	201	63.7	71
Temp	°C	5.9		6.3	6.7	7.6	7.4	8.6	9.3	10.7	12.2	9.7	10.3
Zn tot flux	kg/d	0.00		0.17	1.06	2.76	4.70	9.56	6.87	7.67	1.07		
Cd tot flux	kg/d	0.00		0.01	0.05	0.11	0.17	0.38	0.27	0.31	0.04		
Mn tot flux	kg/d	<0.03		0.01	0.04	0.80	0.70	0.28	0.07	0.07	0.02		
Fe tot flux	kg/d	<0.12		<0.01	0.08	4.78	1.95	0.21	<0.05	0.15	0.05		
SO₄ flux	kg/d	0.35		3.5	13.0	76.9	126.1	199.6	173.7	404.4	233.3		

		ALD	Nisbet Cr	Side Creek	Eastern Adit
Date		10 Feb 05	10 Feb 05	10 Feb 05	10 Feb 05
Flow		0.01		0	0.02
pH (field)	pH units	7.3	6.9		6.0
EC	µS/cm	165	26		287
Temperature	°C	8.3	6.1		8.5

3.4 Water quality trends in Storys Creek

The water quality monitoring results from May 2005 displays the following trends:

- Arsenic, chromium and lead are present at or below the reporting limit of the laboratory at all the regular monitoring sites.
- Cobalt is below the reporting limit with the exception of the Storys below Side Creek and Storys below Nisbet sites. Levels return to the reporting limits at the Manager's site and other downstream sites;
- Similar to previous monitoring, there is a decrease in pH and alkalinity through the mine site, with the greatest changes occurring between the Above Side Creek and Below Side Creek sites;
- Sulphate, aluminium, iron and manganese concentrations are consistent with the pH and alkalinity trend, and increase substantially between the Above Side and Below Side Creek sites;
- A white floc coated the bed of Storys Creek downstream of the entrance of Side Creek, and based on the water quality results, was the result of acidic groundwater entering Storys Creek from the Side Creek catchment, with metal precipitating upon contact with the higher pH water in Storys Creek. The gelatinous floc was mobile, and is likely to be washed downstream during higher flow events. The white floc is shown in Photos 4 and 5.
- Zinc, copper and cadmium trends differed from aluminium and iron, with major increases occurring between the Below Precipitate Dam and Above Side Creek sites and between the Above Side Creek and Below Side Creek sites. Approximately 30% of the zinc and 50% of the cadmium and copper entered Storys Creek upstream of Side Creek;
- The sulphate, iron, aluminium, zinc and cadmium trends suggest that zinc and cadmium are entering Storys Creek from the historic tailings deposits and mine workings upstream of Side Creek. This drainage only marginally affects the pH of Storys, and does not contribute large amounts of sulphate suggesting it is near neutral drainage. The groundwater input from Side Creek substantially lowers the pH of the river, and contributes sulphate, iron and aluminium in addition to zinc and cadmium;
- Figure 3.3 - Figure 3.5 shows the increases in zinc, cadmium and sulphate concentrations at the Storys above Side Creek and Storys below Side Creek monitoring sites. The lack of surface inflows in the catchment during the very dry period prevents dilution of these parameters which remain elevated at the Manager's Residence monitoring site, and in the lower river;
- Aluminium, cadmium, copper and zinc levels exceed ANZECC trigger values for the protection of aquatic ecosystems (95th percentile) at the Managers Residence monitoring site, and cadmium, copper and zinc are above trigger values at Storys below Aberfoyle, just upstream from where the river enters the South Esk.



Photos 4&5. White metal-precipitates on bed of Storys Creek downstream of Side Creek.

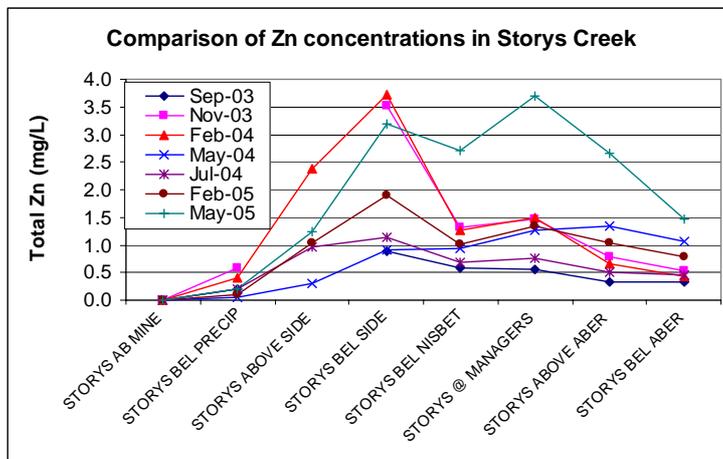


Figure 3.3. Total zinc concentrations at monitoring sites in Storys Creek by date.

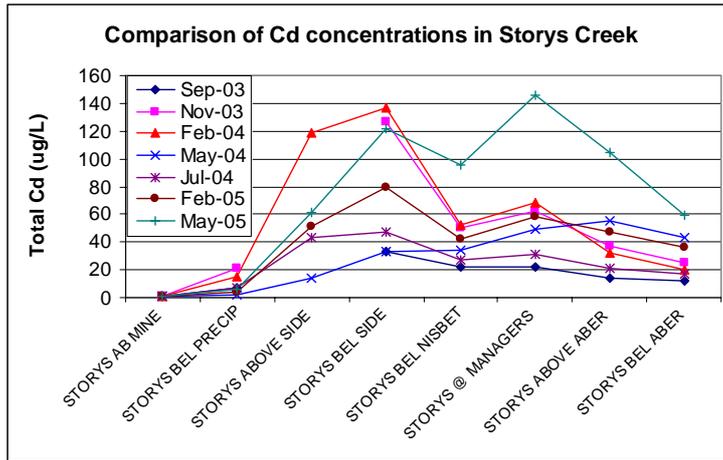


Figure 3.4. Total cadmium concentrations at monitoring sites in Storys Creek by date.

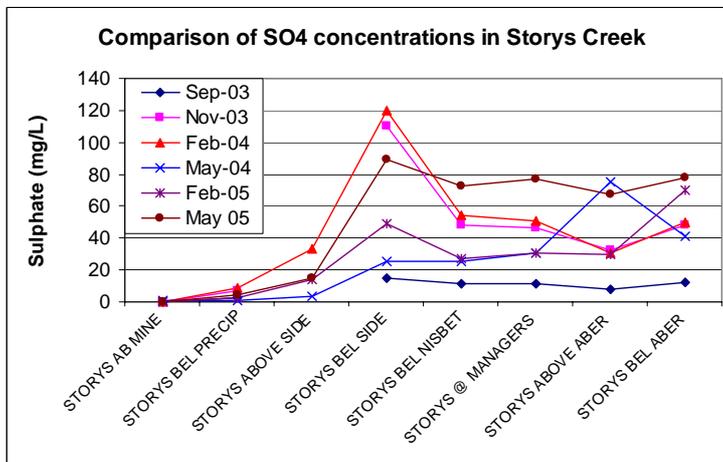


Figure 3.5. Sulphate concentrations at monitoring sites in Storys Creek by date

The zinc and cadmium concentrations measured in May 2005 are compared with previous zinc results for the Precipitate Dam, Storys below Side Creek and Storys at the Managers Residence in Figure 3.6. No results for May 05 are available for the Precipitate dam, as there was no discharge from the storage. Photos of the dam are shown in Photos 6 and 7. Levels of zinc and cadmium at the all three sites are elevated, but consistent with previous low flow monitoring periods.



Photos 6 and 7. Precipitate dam showing low water levels in May 2005.

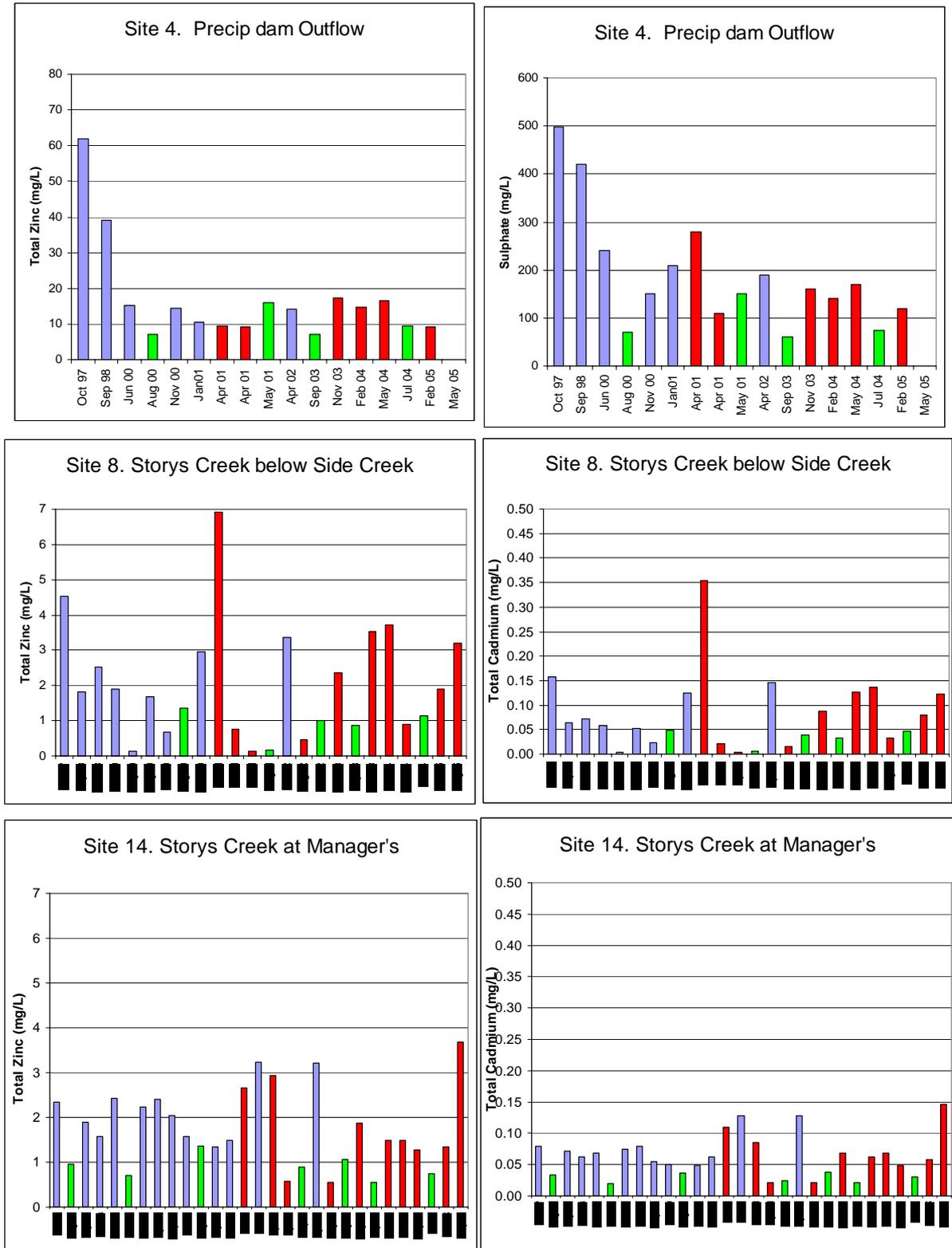


Figure 3.6 . Total zinc (left) and total cadmium (right) graphs comparing the May 2005 results with previous monitoring results. Red bars denote low flow (<250 L/s), blue bars denote medium flows (250 – 350 L/s), and green bars denote high flow (>350 L/s). Note different scale for the Precipitate dam results. No results shown for Precip Dam because there was no flow from the dam

The zinc load from Storys Creek increased zinc concentrations in the South Esk from <1 µg/L to 59 µg/L (Table 2). As shown in Figure 3.7, this increase is similar to previous low flow monitoring results. The increase elevates zinc levels in the South Esk to above ANZECC (2000) trigger levels for the protection of aquatic ecosystems, but still well below irrigation or stock watering guidelines.

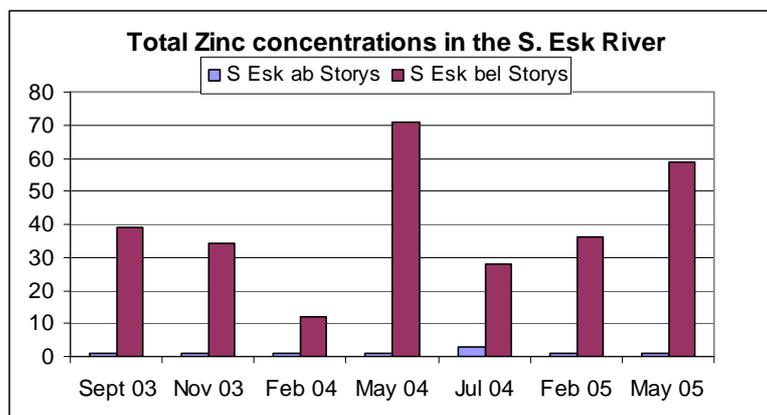


Figure 3.7. Comparison of total zinc concentrations in the South Esk River upstream and downstream of the confluence with Storys Creek.

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 3.8, Figure 3.9 and Figure 3.10 show zinc, cadmium and sulphate fluxes at each of the monitoring sites in Storys Creek compared to previous results since September 2003. Figure 3.11 compares the fluxes from May 2005 with results between 1997 and the present.

The flux plots show that in spite of the very high concentrations measured at the mine site, the overall fluxes in Storys Creek were very low due to the low flow rates. Metal fluxes were similar to November 2003 and February 2004 levels, which were also low flow periods.

Figure 3.11 shows that the zinc flux in May 2005 at the Managers Residence site is consistent with low flow monitoring results since September 2003, but considerably lower than pre-remediation low flow results.

The contributions of zinc to lower Storys Creek from Storys Creek above Aberfoyle was 6.9 kg/day (86%), compared to 1.1 kg/day from Aberfoyle Creek (14%). These relative proportions are similar to the February 2005 results, and indicate that under low flow, groundwater dominated flow conditions, metal loads are dominated by Storys Creek. Sulphate contributions from Aberfoyle Creek are greater, about 60% of the total at the Storys below Aberfoyle site. This shows that although sulphate is being generated in the historic Aberfoyle workings, there is not a large associated metal load, even under groundwater dominated flow conditions.

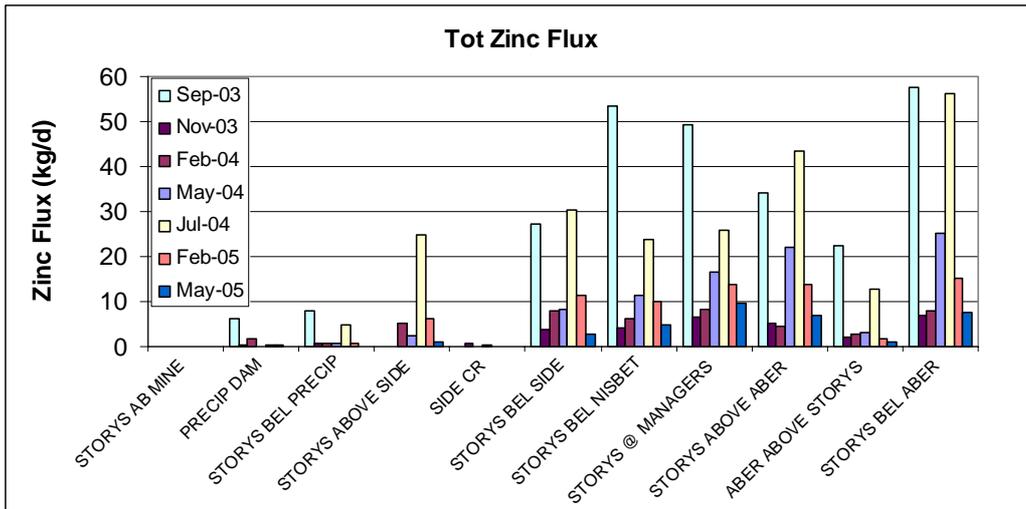


Figure 3.8. Total zinc fluxes for sites in Storys Creek for all sampling runs since September 2003. Note, Storys above Side Creek was not monitored in September 2003.

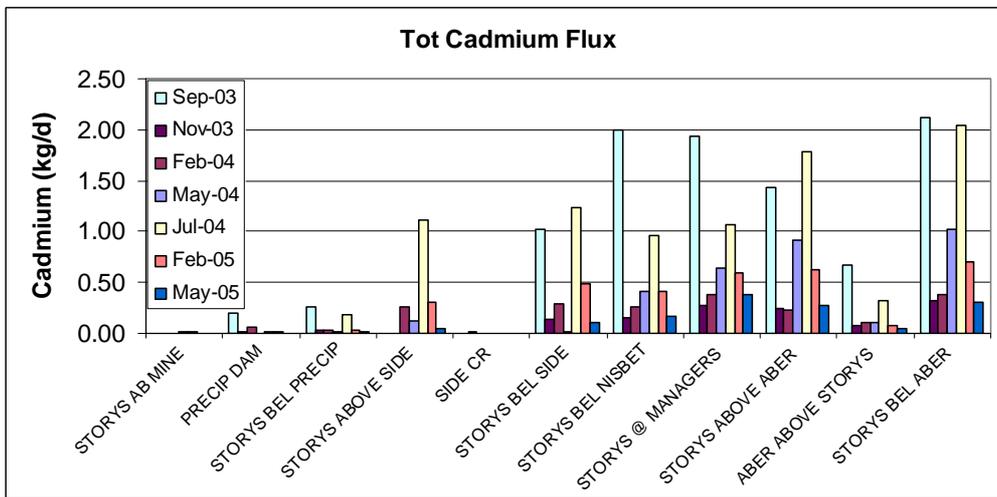


Figure 3.9. Total cadmium fluxes in Storys Creek since September 2003.

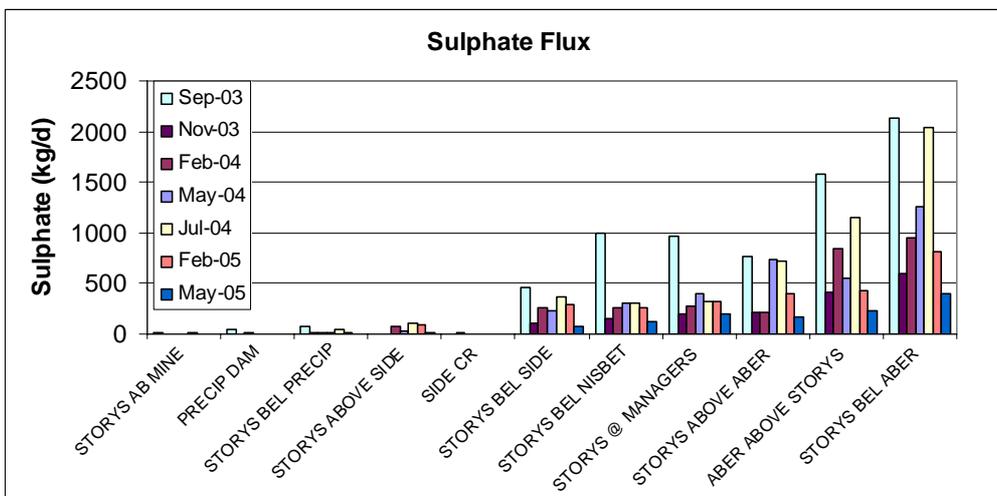


Figure 3.10. Sulphate fluxes in Storys Creek since September 2003. Storys above Side Cr was not monitored in September 2003.

Cadmium fluxes (Figure 3.9) continue to be similar to zinc fluxes, with increases above and below Side Creek and at the Managers Residence site. Storys Creek is the major contributor of cadmium to the South Esk, with only about 10% of the 0.3 kg/day entering the South Esk attributable to Aberfoyle Creek. The input from Storys Creek increases cadmium concentrations in the South Esk from below detection levels to 2 µg/L. Similar to zinc, the cadmium flux at the Managers Residence is within the range of monitoring results obtained since September 2003, but lower than previous results.

Within Storys Creek, sulphate results show similar trends to zinc and cadmium, with increases above and below Side Creek, and at the Managers Residence. Under these low flow conditions, the contribution from Aberfoyle Creek to lower Storys Creek (233) exceeded the input from Storys (173 kg/day). The total input from lower Storys Creek into the South Esk increase concentration in the larger river from 2 mg/L to ~6 mg/L. .

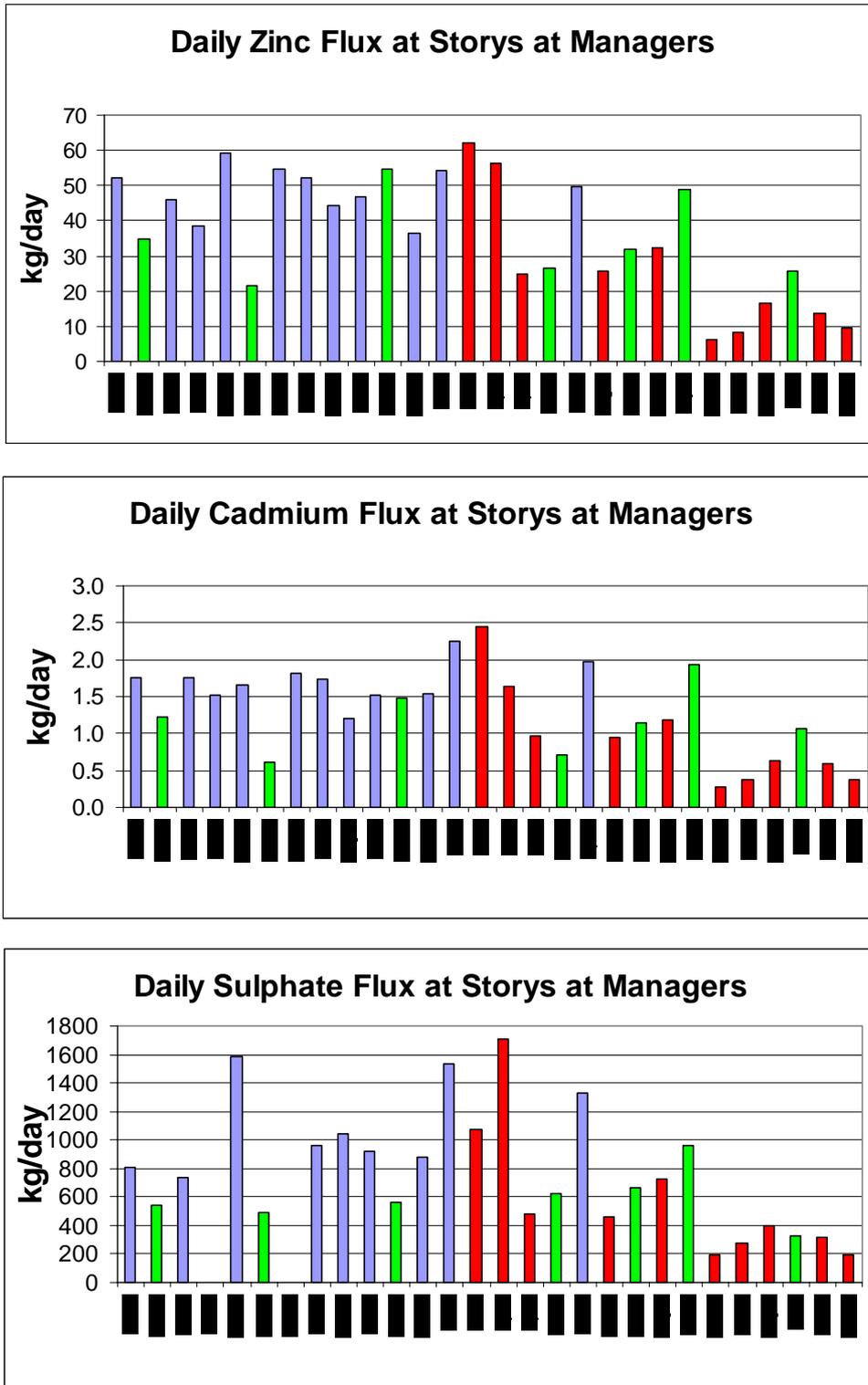


Figure 3.11. Daily total zinc, total cadmium and sulphate fluxes at Managers Site. Red denotes low flow (<250 l/s); blue denotes moderate flow (250 -350 l/s) and green denotes high flow (>350 l/s)

3.6 Present distribution of metal sources in Storys Creek

The May 2005 monitoring results provide useful insights into the present sources of contaminants in Storys Creek, as flow in the river was derived from groundwater through the historic mine site. There was no surface discharge from the Precipitate Dam, or Side Creek, and only a very small flow from Eastern Adit.

Between the Precipitate Dam and Side Creek, cadmium, copper and zinc appear to be entering from the historic tailings deposits on the steep valley wall. The inputs from these historic tailings do not substantially alter the pH of the creek, suggesting the seepage does not have a low pH. The low levels of iron and aluminium associated with the zinc, cadmium and copper is consistent with this hypothesis.

The largest source of contaminants entering Storys was due to groundwater seepage entering downstream of Side Creek. The banks were iron stained, and metal hydroxides were present on the bed of the river. It is unknown what portion of the contaminants in Side Creek might be derived from the historic tailings deposits, with drainage entering Side Creek via underground workings. The seepage in Side Creek catchment is characterized by low pH, high sulphate iron, aluminium, manganese, cadmium, copper and zinc levels, consistent with typical 'acid drainage'. The deposition of metal hydroxides on the bed of Storys Creek suggests that the seepage remains acidic until it enters the main stream.

The very low flow conditions resulted in elevated concentrations of metals and sulphate in Storys Creek, but overall low fluxes (10 kg/day zinc). Higher fluxes accompany higher flows, such as in September 2003 or July 04 when fluxes of 50 kg/day were measured (Figure 3.11). In July 04, under these higher flow conditions, a much larger proportion of contaminants entered Storys Creek upstream of Side Creek as compared to May 05, indicating that surface flow through the historic tailings is probably a major source to the river during wetter periods.

3.7 Impact of remediation works

Metal fluxes measured under low flow conditions in Storys Creek appear to have decreased since the remediation works were completed. This is evident in Figure 3.11 for zinc, cadmium and sulphate. Concentrations of the same parameters do not appear to have reduced as shown in Figure 3.6. Because flow rates were previously estimated, and are now measured with a flow meter, it is plausible that some of the observed flux reduction is due to differences in flow determination. A greater number of monitoring runs conducted at high flow rates is required to provide a better comparison of pre- and post-remediation water quality conditions.

3.8 Update on Red Mud trial

On the same day as water quality sampling was completed, the Red Mud remediation site was visited. Photos 8 through 11 show the extent of vegetation cover on both the zinc and copper contaminated trial plots. Vegetation was more common in protected areas such as hollows on both the copper and zinc trials. Brett Stewart examined the vegetation and observed signs of grazing.



Photos 8 and 9. Vegetation cover (left) and close up of vegetation on zinc contaminated material;



Photos 10 and 11. Vegetation cover (left) and close up of vegetation on copper contaminated material

3.9 Future monitoring

It is strongly recommended that the next 2 or 3 monitoring runs coincide with high flow events, as most of the monitoring over the past two years has coincided with low flows. When (if?) the winter rains begin, it would be useful to monitor as soon as practicable, to document pollutant transport following this extended dry period. Additional sampling should be completed later in the winter, when wet conditions have prevailed for a month or so.

4 Related References

ANZECC/ARMCANZ, 2000, Australian Water Quality Guidelines for Fresh and Marine Waters.

John Miedecke & Partners, 1998, Storys Creek / Rossarden Acid Drainage Remediation Study, Preliminary Report December 1997. Report to MRT.

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