Rehab2006_01

Storys Creek Water Quality Monitoring Results

11 January 2006

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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 tenth water quality-monitoring run completed on January 11, 2006 and compares results to previous findings. The monitoring was completed under conditions of low flow, even though the lower catchment received ~5 mm of rain in the 24 hours prior to sampling.

2 Sampling details

Water quality and flow monitoring was completed on 11 January 2004 by L. Koehnken of Technical Advice on Water and M. Reid of Mineral Resources Tasmania. All sites in Table 1 were visited and at each site pH, conductivity and temperature was measured *in situ* and a water sample was collected for subsequent analysis of metals, sulphate, fluoride and alkalinity. No samples were collected from Side Creek as there was no surface flow.

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 in January 2006 because most of the flow occurred around (rather than through) the pipe and was unable to be captured in the calibrated bucket. At this site, flow was visually estimated. A similar situation occurred at the Precipitate Dam, where flow is no longer confined to the pipe. Flow at this site was also visually estimated. 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 continues to affect the accuracy of the V-notch.

Conditions during sampling on January 11 were fine. In the 24 hours to 9 am on January 11, Fingal received 4.4 mm of rain, with only an additional 6 mm received in the previous 2-weeks. At Powranna, which is indicative of the upper catchment, only 1.8 mm of rain fell in the two days prior to monitoring, with an additional 14.4 mm falling over the previous two weeks. These rainfall patterns resulted in low flow at

the mine site. The sampling was attempting to monitor a rain event following a prolonged dry, but the forecast for rain throughout the catchment did not eventuate.

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 - Table 4, and discussed in the following sections.

3.1 Flows

Flows in January 2006 were low, with ~30 l/s recorded at the mine site, ~85 l/s recorded at the Managers Residence and ~105 l/s measured at Storys above Aberfoyle. Flow from the ALD was low, estimated at 0.2 l/s. Discharge was also very low (estimated at 0.5 l/s) from the Precipitate Dam, and Eastern Adit (<0.1 l/s). No surface flow was present in Side Creek, however subsurface flow was apparent entering Storys Creek downstream of Side Creek.

Photos 1-5 show flow conditions on the lease site, at the Manager's site, and at the confluence of Storys and Aberfoyle Creeks.

Photo 1. & Photo 2 Storys Creek at mine site. Photo 1 (left) View downstream from Storys below Precipitate Dam monitoring site; Phot 2 (right) View downstream from Storys below Nisbet monitoring site.

Photo 3 & Photo 4. Storys Creek at Managers Residence Photo 1 (left) view upstream, and Photo 2 (right) view downstream.

Flow in Storys Creek above Aberfoyle (~105 l/s) was about one and a half times the flow in Aberfoyle Creek (~70 L/s). These flows are consistent with the zinc and sulphate concentrations measured in Storys above Aberfoyle, Aberfoyle Creek and Storys below Aberfoyle, thus providing confidence in the flow estimates.

Photo 5. Confluence of Storys and Aberfoyle Creek. Storys Creek flowing from left to right and Aberfoyle Creek enters from top to bottom of photo.

3.2 Water quality results – concentrations

Water quality concentrations for January 2006 are presented in Table 2, Table 3 and Table 4. 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. Table 4 shows results for samples from the ALD, Eastern Adit, and samples collected from the lower Storys and Aberfoyle Creeks by a local resident during two high flow events in August 2005. One of the same events (10 August 2005) was captured by the Storys Creek monitoring, and summarized in a previous report.

3.3 Anoxic Limestone Drain (ALD)

Alkalinity concentrations in the ALD and upper Storys Creek for January are shown in Figure 3.1 along with previous results. The alkalinity concentrations in the ALD and in Storys Creek in January 2006 upstream of the mine site are similar to previous levels. The flux of alkalinity generated by the drain (Figure 3.2) is estimated to be ~5 kg/day, however this is based on a visual estimate of flow and must be considered to be a very rough estimate. It is probable that the flow estimate is high, and the alkalinity flux in January was similar to previous values when the drain was functioning. The flow from the ALD continues to be diverted towards the Side Creek catchment via a series of surface drains, with no apparent ingress of water to the underground workings. However, the lack of flow in Side Creek also indicates that the water is not remaining as a surface stream.

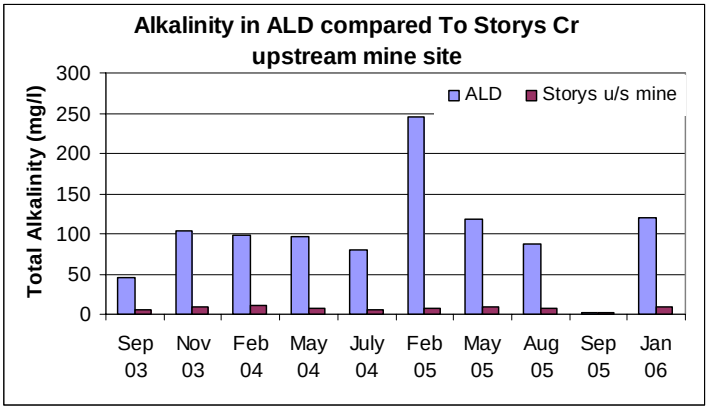

Figure 3.1. Alkalinity levels in water from the ALD compared to alkalinity levels in Storys Creek above the mine site. Laboratory error suspected in ALD result for September 05.

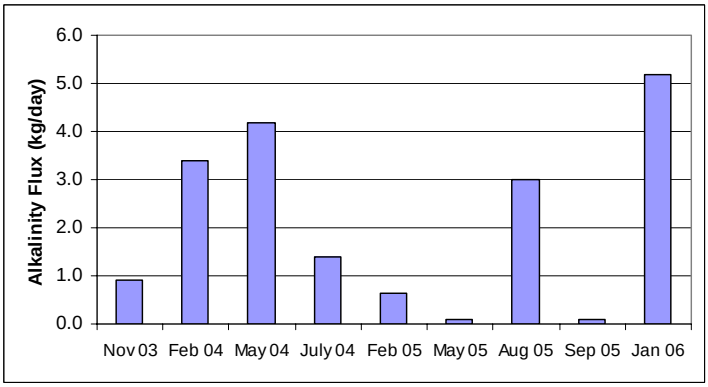

Figure 3.2 Alkalinity flux from ALD at Storys Creek. Note, January 2006 value based on visual flow estimate of 0.5 l/s which should be considered to be of low confidence.

Table 2. Water quality results and flow for Storys Creek monitoring, January 11, 2006. 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 Manager	Storys Ab Aber	Storys Bel Aber	Aber Ab Storys	S. Esk Ab Storys	S. Esk Bel Storys
Date		**11 Jan 06**	**11 Jan 06**	**11 Jan 06**	**11 Jan 06**	**11 Jan 06**	**11 Jan 06**	**11 Jan 06**	**11 Jan 06**	**11 Jan 06**	**11 Jan 06**	**11 Jan 06**	**11 Jan 06**
Alkalinity Total	mg/l CaCO3	9	<2	10	6	<2	6	4	3	14	32	15	16
Fluoride	mg/l	<0.01	1.48	0.11	0.33	0.79	0.39	0.28	0.28	0.62	1.15	0.02	0.05
Sulphate	mg/l	0.7	192	9.8	21.4	47.9	39.9	35.8	25.8	45.1	75.6	1.5	3.1
Al Dis	µg/l	<20	452	20	<20	459	<20	27	26	21	<20	<20	<20
Al Total	µg/l	22	924	37	589	1050	331	118	68	60	<20	70	69
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	636	25	83	102	55	55	31	24	8	<1	<1
Cd Total	µg/l	<1	620	25	78	108	53	54	33	26	9	<1	<1
Co Dis	µg/l	<1	71	2	2	5	3	1	<1	<1	<1	<1	<1
Co Total	µg/l	<1	68	2	2	5	3	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	5	34	2	188	222	27	40	20	11	6	<1	1
Cu Total	µg/l	4	25	3	281	255	80	58	19	83	9	<1	4
Fe Dis	µg/l	27	68	<20	<20	74	25	53	26	35	70	159	101
Fe Total	µg/l	58	115	21	224	1470	762	201	57	82	73	372	401
Mn Dis	µg/l	<5	5250	137	102	398	258	126	13	11	<5	<5	<5
Mn Total	µg/l	8	5070	136	103	389	254	123	14	12	6	17	20
Ni Dis	µg/l	<2	79	4	4	11	8	5	3	2	2	<2	<2
Ni Total	µg/l	<2	78	3	4	11	8	5	3	3	3	<2	<2
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	8	21800	856	1870	2870	1600	1520	769	564	260	<1	17
Zn Total	µg/l	12	21100	830	1910	2820	1600	1500	774	587	262	<1	26
Flow	l/s	30	0.5	30	30	35	72	83	104	173	69		

Table 3. Flow, pH conductivity and temperature results collected in situ, January 11, 2006 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	11 Jan 06	11 Jan 06	11 Jan 06	11 Jan 06	11 Jan 06	11 Jan 06	11 Jan 06	11 Jan 06	11 Jan 06	11 Jan 06	11 Jan 06	11 Jan 06
Flow	l/s	30	0.5	30	30	35	72	83	104	173	69		
pH (field)	pH units	7.25	6.12	6.76	6.62	5.95	6.26	6.52	6.76	7.25	7.37	6.95	7.43
EC	µS/cm	27.2	423	54.4	78.1	135	121.9	109.0	89.0	156.7	25.5	77.2	81.9
Temp	ºC	11.2	17.2	12.7	13.3	13.6	12.6	14.6	18.8	19.1	19.3	19.7	20.1
Zn tot flux	kg/d	0.03	0.91	2.15	4.95	8.53	9.95	10.76	6.95	8.77	1.56		
Cd tot flux	kg/d	<0.03	0.03	0.06	0.20	0.33	0.33	0.39	0.30	0.39	0.05		
Mn tot flux	kg/d	<0.01	0.22	0.35	0.27	1.18	1.58	0.88	0.13	0.18	0.04		
Fe tot flux	kg/d	0.15	0.00	0.05	0.58	4.45	4.74	1.44	0.51	1.23	0.44		
SO_4 flux	kg/d	1.81	8.29	25.40	55.47	144.85	248.21	256.73	231.83	674.12	450.70		

		ALD	Nisbet Cr	Eastern Adit
Date		11 Jan 06	11 Jan 06	11 Jan 06
Flow (l/s)		0.2		<0.1
pH (field)	pH units	7.3	6.11	6.61
Conductivity	µS/cm	262	38.1	152.7
Temperature	°C	15.2	10.3	10.3

Table 4. Water quality results from samples collected by Doug Loane during flood events in Storys Creek. Samples collected from Storys above Aberfoyle and Aberfoyle above Storys monitoring sites during high flow events on 10 August 2005 and 31 August 2005.

		Storys above Aberfoye	Aberfoyle above Storys	Storys Above Aberfoyle	Aber ab Storys
Date		10 Aug 05	10 Aug 05	31 Aug 05	31 Aug 05
Al Total	µg/l	810	691	4290	1450
As Total	µg/l	<5	8	<5	22
Cd Total	µg/l	19	12	25	18
Co Total	µg/l	<1	1	5	2
Cr Total	µg/l	1	1	4	2
Cu Total	µg/l	76	73	141	154
Fe Total	µg/l	551	1340	4950	2830
Mn Total	µg/l	44	247	185	312
Ni Total	µg/l	5	6	4	7
Pb Total	µg/l	<5	9	22	27
Zn Total	µg/l	544	498	516	622

3.4 Metal concentrations in Storys Creek

The water quality monitoring results from January 2006 show similar trends as previous runs:

- Arsenic, chromium and lead are present at or below the reporting limit of the laboratory at all the regular monitoring sites;
- The discharge from the Precipitate Dam had high concentrations of cadmium, manganese, nickel and zinc. The zinc concentration is the highest recorded from the Precipitate Dam since this phase of water quality monitoring began in September 2006. Why this concentration is so high is unknown.
- Zinc, cadmium and sulphate concentrations in Storys Creek are high, consistent with other low flow monitoring runs;
- There is a large increase in zinc and sulphate concentrations, and decrease in pH between the Storys below Precipitate Dam site, and Storys above Side Creek Site, and between the Storys above Side Creek and Storys below Side Creek sites (Figure 3.3 - Figure 3.5). As there was no surface flow in Side Creek, this again strongly indicates that groundwater inputs comprising water leaching through the tailings deposits, and through the workings in Side Creek are the major contributors to metals at the mine site.
- Copper levels show a large increase between the Storys below Precip Dam site, and Storys above Side Creek, with relatively little increase between the Above and Below Side Creek sites. This suggests that the majority of copper is derived from the old tailings deposits on the steep bank of the river upstream of Side Creek;
- The major sources of fluoride to Storys Creek are the Precipitate Dam, the area around Side Creek and Aberfoyle Creek;
- Downstream of the Storys below Side Creek, there is a gradual decrease in metal and sulphate levels;
- Compared to ANZECC trigger values for the protection of aquatic ecosystems, cadmium, copper and zinc are elevated throughout Storys Creek. Inputs from Aberfoyle Creek are lower than in Storys, but also exceed freshwater trigger values.

The zinc and cadmium concentrations measured in January 2006 are compared with previous zinc results for the Precipitate Dam, Storys below Side Creek and Storys at the Managers Residence in Figure 3.6. Levels of zinc and cadmium at all three sites are consistent with previous low flow monitoring periods.

The zinc load from Storys Creek increased zinc concentrations in the South Esk from <1 µg/L to 26 µg/L (Table 2). As shown in Figure 3.8, this increase is within the range of previous results, and increases zinc levels in the South Esk to above ANZECC (2000) freshwater trigger values.

The water samples collected by Doug Loane on 10 August 2005 and 31 August 2005 during high flow events show similar zinc levels, but greatly varying aluminium and

iron levels. This is because the samples were stored for a long time prior to analysis, and only total metals could be completed. The variations in concentrations are very likely attributable to variations in suspended solid concentrations between the samples. The similarity in zinc concentrations under high flow is interesting because under low flow conditions, the concentration in Aberfoyle Creek tends to be much less (half to one-third) of those in Storys Creek. The high flow event on 10 August 2005 is described in a previous report.

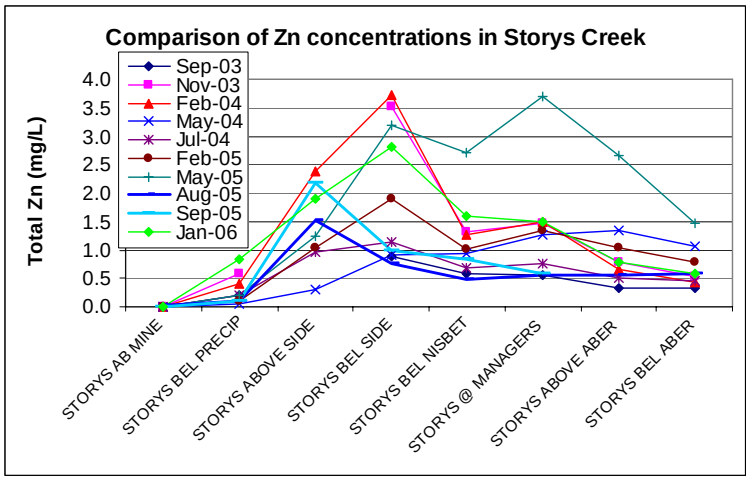

Figure 3.3. Total zinc concentrations at monitoring sites in Storys Creek by date.

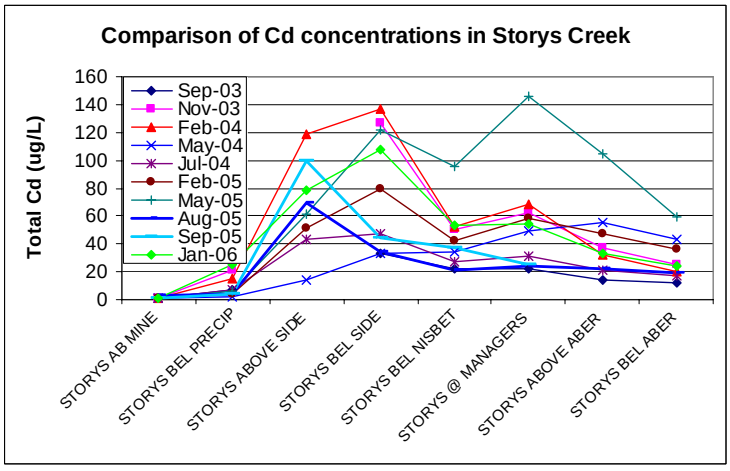

Figure 3.4. Total cadmium concentrations at monitoring sites in Storys Creek by date.

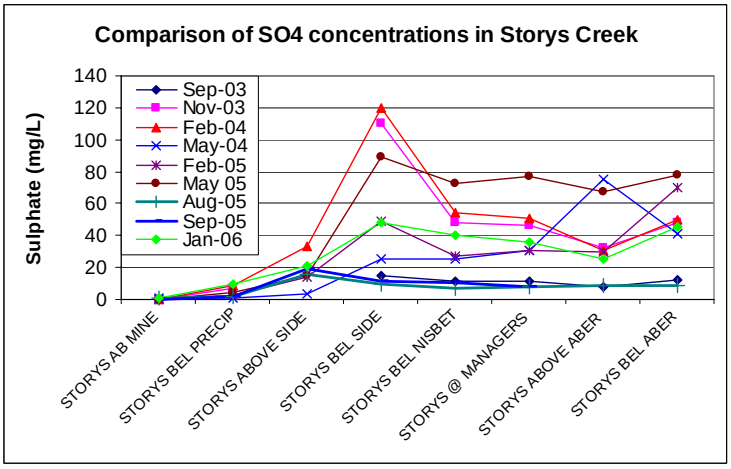

Figure 3.5. Sulphate concentrations at monitoring sites in Storys Creek by date

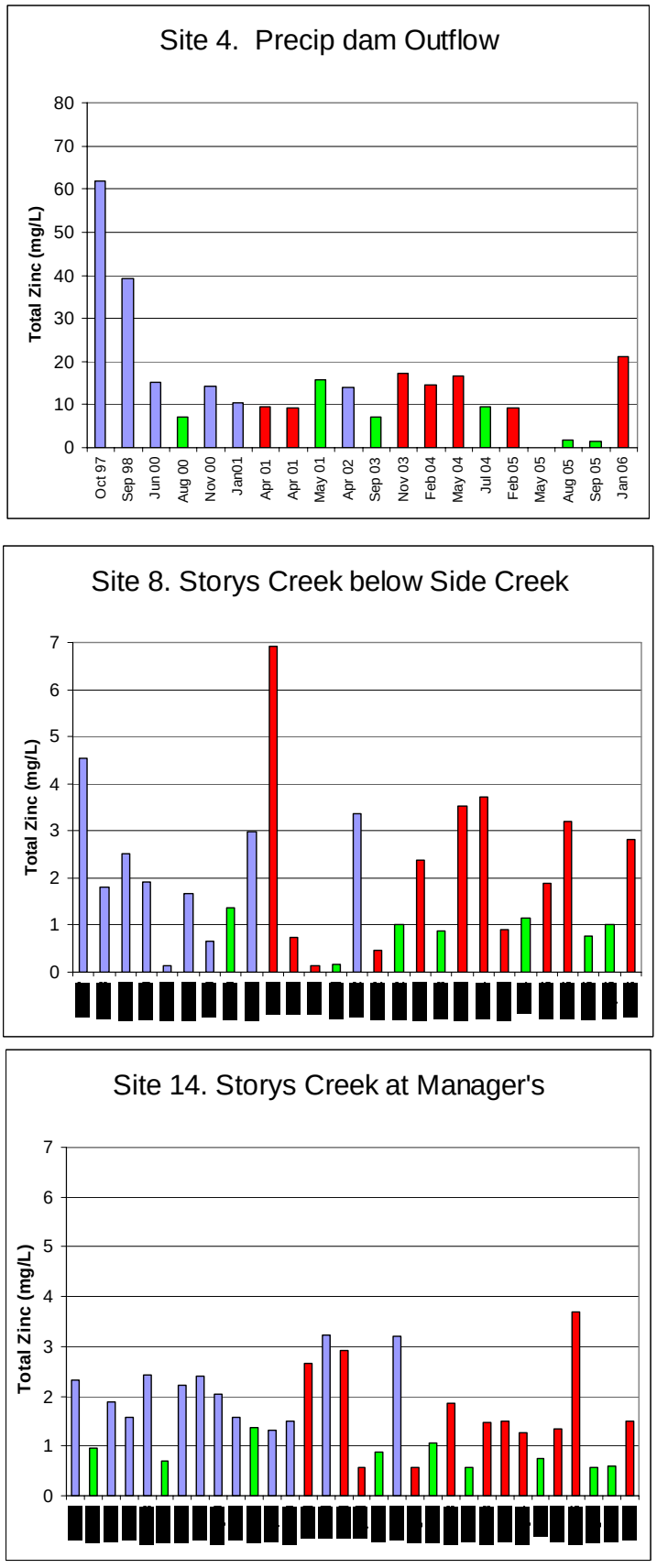

Figure 3.6 . Total zinc graphs comparing the Jan 2006 results with previous monitoring results. Red bars denote low flow (<250 L/s), blue bars denote medium flows (250 – 350 L/s), and green bars denote high flow (>350 L/s). Note different scale for the Precipitate dam results.

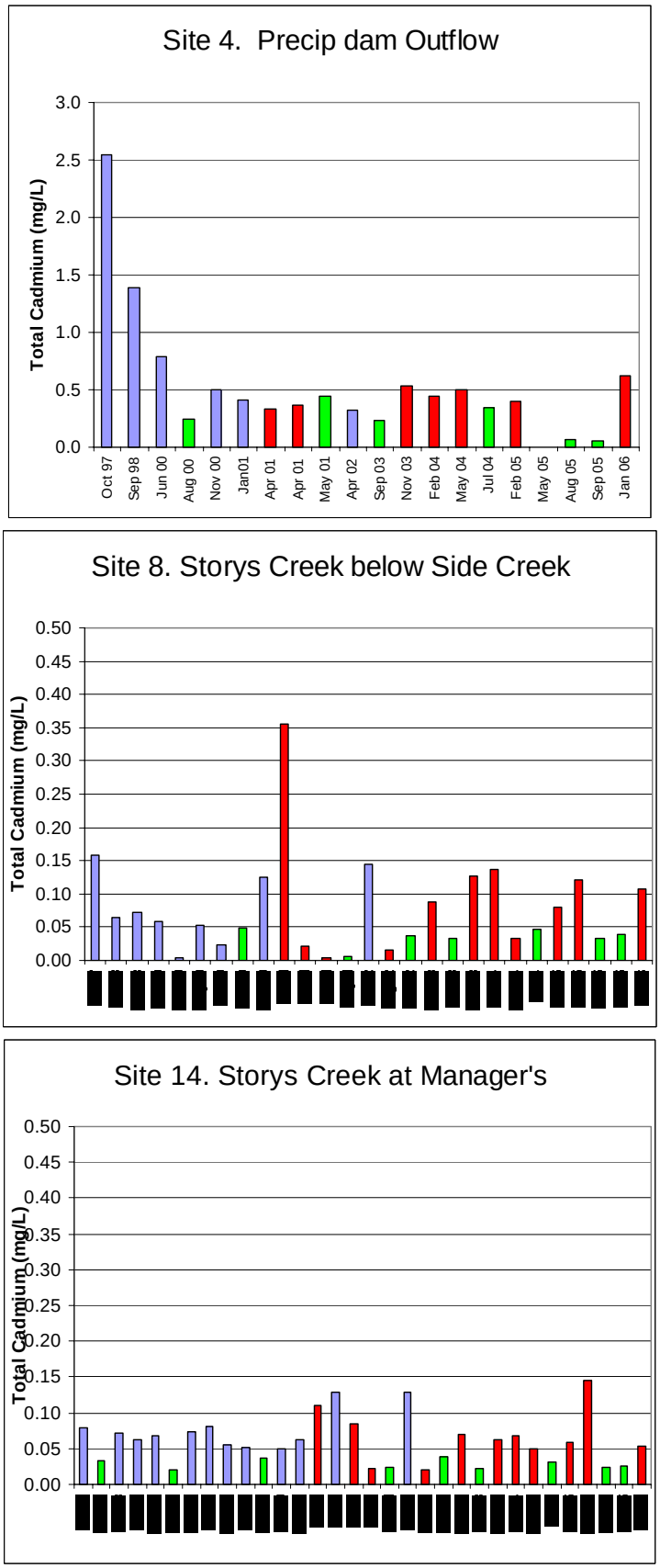

Figure 3.7. Total cadmium graphs comparing the Jan 2006 results with previous monitoring results. Red bars denote low flow in storys Creek (<250 L/s), blue bars denote medium flows (250 – 350 L/s), and green bars denote high flow (>350 L/s). Note different scale for the Precipitate dam results.

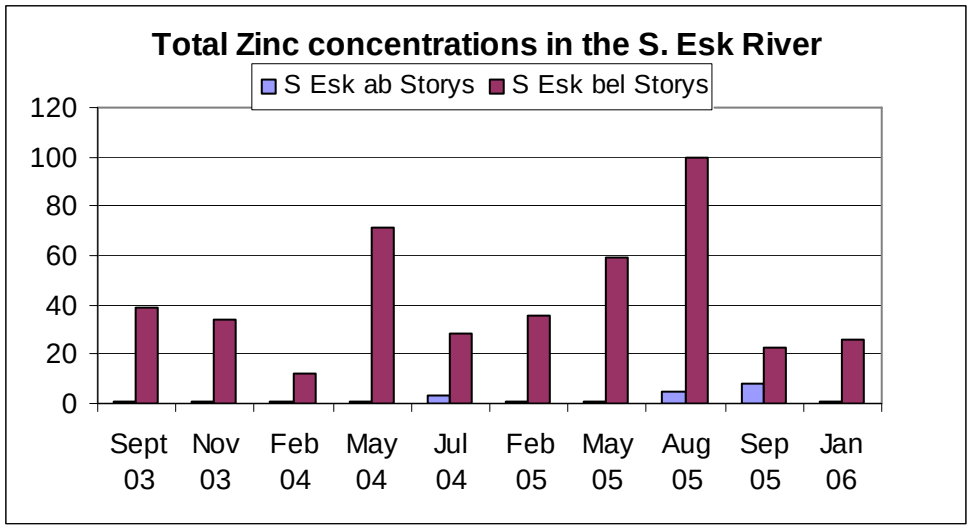

Figure 3.8. Comparison of total zinc concentrations in the South Esk River upstream and downstream of the confluence with Storys Creek.

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 3.9, Figure 3.10 and Figure 3.11 show zinc, cadmium and sulphate fluxes at each of the monitoring sites in Storys Creek compared to previous results since September 2003. Figure 3.12 compares all flux calculations between 1997 and the present.

Figure 3.9 and Table 3 show that zinc fluxes in January 2006 were low, consistent with previous low-flow monitoring results. The majority of the zinc flux entered between the Precipitate Dam and Storys above Side Creek, and between Storys above and below Side Creek. There was also a larger than usual contribution from the Precipitate Dam, due to elevated zinc concentrations.

Downstream of Side Creek, fluxes continued to increase through the Storys at Manager's monitoring site. These results are consistent with major metal sources located on the mine site between the Precipitate Dam and below Side Creek, but also show that zinc is continuing to enter below Side Creek, presumably due to the large volumes of tailings in the river. A similar pattern exists for the cadmium flux.

Iron, manganese and sulphate fluxes show the largest increases between the Above and Below Side Creek sites, consistent with the low pH, high metal water known to persist in this area.

In the lower river, Storys Creek contributed about 80% of the zinc load entering the South Esk, with Aberfoyle Creek contributing ~20%. Storys Creek also contributed the majority of the cadmium flux. Iron was contributed evenly between the two rivers, and Aberfoyle contributed the majority of the sulphate.

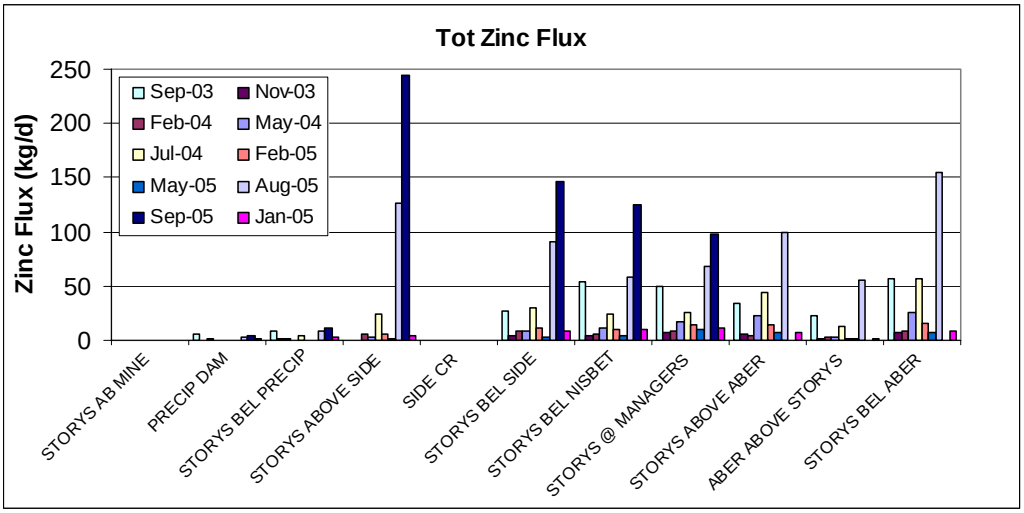

Figure 3.9. Total zinc fluxes for sites in Storys Creek for all sampling runs since September 2003. Note, Storys above Side Creek was not monitored in September 2003.

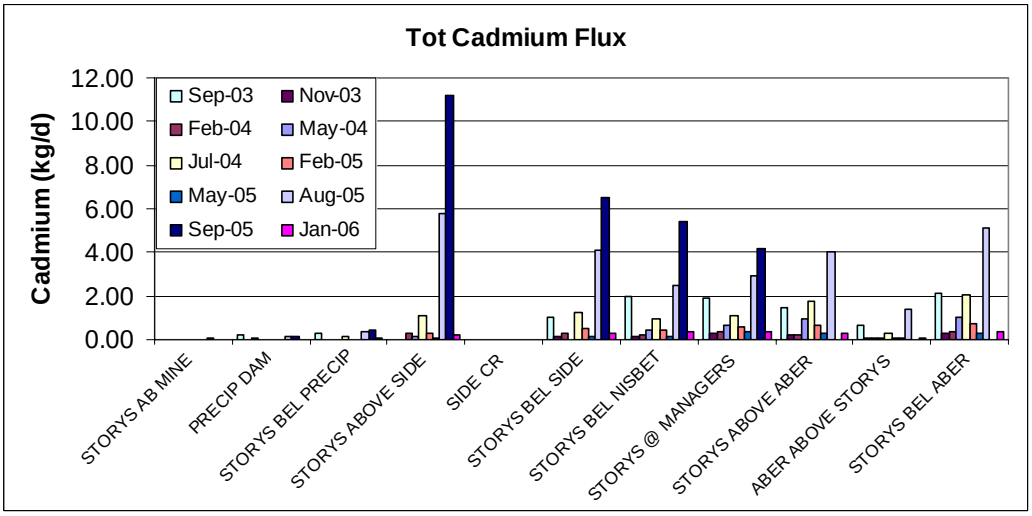

Figure 3.10. Total cadmium fluxes in Storys Creek since September 2003.

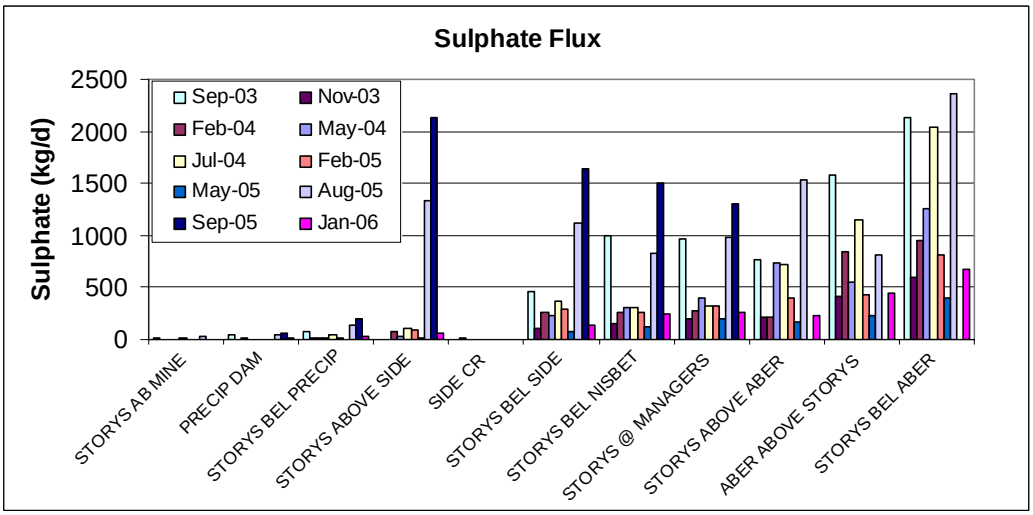

Figure 3.11. Sulphate fluxes in Storys Creek since September 2003. Storys above Side Cr was not monitored in September 2003.

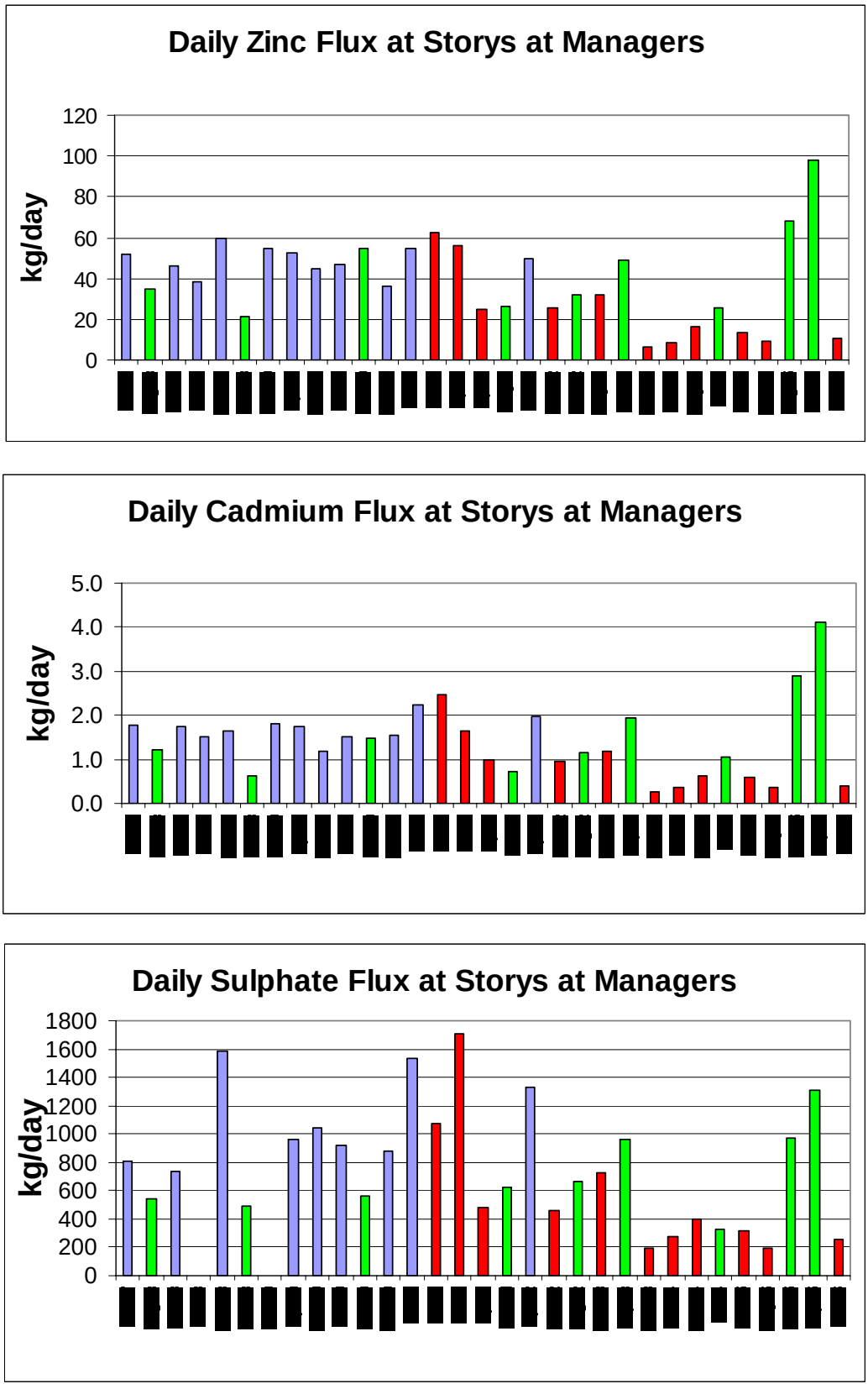

Figure 3.12. Daily total zinc, total cadmium and sulphate fluxes at Managers Site. Red denotes low flow (<250 l/s); blue denotes moderate flow (250 -350 l/s) and green denotes high flow (.350 l/s)

3.6 Impact of remediation works

The January 2006 results are consistent with previous low flow monitoring results, with the largest input of metals on the lease site continuing to be associated with inputs upstream and downstream of Side Creek, in the area of the remaining tailings deposit and the Side Creek adits. A smaller contribution is attributable to the tailings and sediment resident in the river bed. The zinc and cadmium concentrations in the discharge from the Precipitate Dam were the highest recorded since this phase of water quality began in September 2003. The outflow pipe from the dam is blocked, and discharge from the dam is flowing over the dam wall, which has resulted in some erosion of the wall. It is unknown if this is contributing to the higher metal concentrations.

3.7 Future monitoring

One more monitoring run is scheduled for Storys Creek. It is recommended that the final run target another high flow event, as this is when the highest metal fluxes are discharged from the site, and the tailings deposits have the greatest impact.

4 Related References

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

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