
Storys Creek Water Quality Monitoring Results

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A Report to Mineral Resources Tasmania

L. Koehnken
Technical Advice on Water



1 Introduction

Mineral Resources Tasmania (MRT) has completed large-scale remediation works at the historic Storys Creek mine site in eastern central Tasmania. 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 third quarterly water quality-monitoring run completed on February 26, 2004 and compares the findings to previous results.

2 Sampling details

Water quality and flow monitoring was completed on 26 February 2004 by L. Koehnken of Technical Advice on Water and W. Grunn from MRT. Similar to the previous monitoring trips, water samples were collected from the Storys Creek catchment, lower Aberfoyle Creek, and from the South Esk River upstream and downstream of the confluence with Storys Creek as shown in Table 1.

In addition to the sites listed in Table 1, two additional sites were monitored in February, Storys Creek upstream of Side Creek, and Nisbet Creek, which is a tributary of Storys Creek downstream of Side Creek. The upstream of Side Creek site was monitored to refine estimates of the pollutant load entering from the large jig tailings deposits located upstream of this site, and the pollutant load entering from the Side Creek valley. Nisbet Creek was monitored to confirm that this tributary was not a significant contributor to the pollutant load in Storys Creek.

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, fluoride and alkalinity. Unlike previous monitoring runs, the ALD sample was analysed for metals, sulphate and fluoride as well as alkalinity. This was to confirm that the water directed into the underground workings was not contributing to the metal loads in Storys Creek,

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
8	Storys Cr below Side Creek	Significant pollutant load enters via Side Creek-should reduce due to remediation works
13	Storys below Nisbet	Indicates inputs from diffuse sources downstream of Side Creek
14	Storys at Managers/Storys below Pumphouse*	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	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
Extra Site	Storys above Side Creek	Indicate pollutant load from upstream tailings vs downstream Side Creek
Extra Site	Nisbet Creek	Confirm low metal load from creek

***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.**

At each river site in Storys Creek, flow was measured at one to three points in the channel at a depth of 0.6 of the water depth (from the surface). Flow from the ALD was measured using a calibrated bucket and stopwatch. Flow from the Precipitation Dam was not able to be measured due to the flow from the dam being unchannelised. 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.

Conditions during sampling were fine, and followed several weeks of very low rainfall. Between the November 2003 sampling run and the February run, a large flood event occurred during the last few days of January.

3 Results and discussion

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

3.1 Flows

On February 26, flow in Storys Creek was very low, similar to conditions during the previous monitoring trip on November 28, 2003, with flow <100 L/s at all sites within Storys Creek upstream of Aberfoyle Creek (Table 2). Photos 1 - 4 compare flow during November and February at the Storys Creek at Managers site, demonstrating the similarity between these sampling runs.

As stated in the November 2003 water quality monitoring report, these extreme low flow conditions are the lowest recorded since monitoring began at Storys Creek in October 1997. However, it must be stressed that previous monitoring relied solely on gauge boards at the Manager Residence Site for flow estimates. Because of the nature of the channel in this reach of the river (as shown in Photos 1 – 4), the accuracy of gauge boards at very low flows is limited. For example, in November 2003, based on gauge board height, flow in Storys Creek was in excess of 100 L/s where as using the flow meter it was estimated at ~50 L/s. It is possible that some of the historic low flow data over estimate flows (and therefore fluxes). A comparison between the gauge boards and flow meter estimate can not be made for the February 2004 flow data, as the gauge boards were removed by the flood event in late January.

In spite of the high rainfall in late January, there was very little discharge from the Precipitate Dam (estimated at 1 –2 L/s), no flow entering Storys Creek from Side Creek, and only ~0.1 L/s entering from Eastern Adit. These low inputs suggest that the January flood event did not increase ground water levels in the area for an extended time period.

Flow at Storys Creek above Side Creek was difficult to measure due to subsurface flow and the braided nature of the channel. The flow value presented in Table 3, 25 l/s based on the similarity of flow between Storys Creek below the Precipitate Dam and Storys Creek below Side Cr (25 l/s) and assumes flow was consistent through this reach.



Photo 1. & Photo 2 Storys Creek at Managers Residence, looking upstream Nov 2003 (left) and in Feb 2004 (right).



Photo 3. & Photo 4 Storys Creek at Managers Residence, looking downstream Nov 2003 (left) and in Feb 2004 (right).

3.2 Flood in early January 2004

Although flow was very low during sampling in November 2003 and February 2004, there was a large flood event in late January which transported large amounts of sediment through Storys Creek. Samples of sand and silt deposited on bars in Storys Creek at the Managers site and above the confluence with Aberfoyle Creek were collected and forwarded to MRT for metal analysis. The results will be reported in a subsequent report and provide an indication of whether metal-rich tailings material

comprises a significant portion of the suspended sediments moving through the system.

The flood waters also altered the channel at the foot of the historic tailings deposits where the channel had been straightened (Photo 5), and scoured a new flood channel downstream of Nisbet Creek. Between Nisbet Creek and the Managers Residence there was extensive erosion of banks and deposition of flood debris (Photo 6).



Photo 5. Storys Creek at mine site. Channel has been reworked during January 2004 flood event.



Photo 6. Storys Cr between Nisbet Cr and Managers Residence, showing extensive erosion of de-vegetated banks

As previously noted, local scour during the flood event resulted in the removal of the gauge board at the Storys Creek at the Manager's Residence site, but as shown in Photos 1 - 4, there were no large scale changes to the channel.

3.3 Water quality results – concentrations

Water quality results for February 2004 are presented in Table 2 and Table 3. Three of the water samples were obtained from ‘clean’ water ways in the catchment: the ALD (which is clean water modified by the addition of alkalinity), Storys Creek above the Precipitate Dam and Nisbet Creek. All three of these samples demonstrate that background concentrations of metals in unmined areas are very low, generally at or below the level of detection. The higher levels of total iron and total manganese in the ALD sample is due to the presence of particulates or colloids, which were removed during filtration resulting in low dissolved levels. Comparing the alkalinity levels in the ALD sample (98 mg/l) with the other two ‘clean’ samples (11 mg/l and 13 mg/l) shows that the ALD is continuing to impart substantial alkalinity to the water. Unfortunately, the conduit leading into the underground workings was blocked, and the alkalinity-rich water was not directly entering the mine. Major earth works completed by W. Grunn on 26 February resulted in the redirection of the ALD outflow into an alternative drain reporting to the old mine.

Similar to previous results, metal levels downstream of the mine workings are elevated, with the exception of chromium, arsenic and lead which are at or below detection levels. The concentrations of sulphate, cadmium, manganese, nickel and zinc in the Precipitation Dam continue to be very elevated, with levels of iron and aluminium low, presumably due to the high relatively pH of the water (~7).

The results show that most of the pollutant load is entering Storys Creek between the Below the Precipitate Dam site and the Storys Creek below Side Creek site. In particular, copper, cadmium and zinc appear to be entering from the tailings deposits above Side Creek, with iron, aluminium, manganese and additional zinc entering via Side Creek. The low pH of Side Creek seep is consistent with the transport of iron and aluminium. For the remainder of the catchment downstream of Nisbet Creek, pollutant concentrations decrease as flows increase, indicating the tailings and Side Creek are presently the major sources of metals to the catchment.

Fluoride values are elevated compared to the clean rivers, but with the exception of Storys Creek below Side Cr, generally within the agricultural guideline values of 1 mg/l for long-term irrigation use or 2 mg/l guideline value for short-term irrigation use or livestock drinking water.

Figure 1 compares total zinc and total cadmium values obtained in February 2004 with previous monitoring results. Total metal values are shown, but for these parameters total and dissolved values are very similar for all sites. The recent results are very similar to the November 2003 results, with both zinc and cadmium levels continuing to be well above recommended guideline levels for the protection of aquatic ecosystem (Zn = 0.015 mg/l; Cd = 0.0004 mg/l for 90th percentile protection level). Zinc and cadmium values at Storys below Side Creek are relatively high, close to 90th percentile values, while results at the other two sites are close to the historic median values, as shown in Table 4.

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 Manage r	Storys Ab Aber	Storys Bel Aber	Aber Ab Storys	S. Esk Ab Storys	S. Esk Bel Storys
Date		26/02/04 10:20	26/02/04 10:40	26/02/04 10:50	26/02/04 11:15	26/02/04 11:30	26/02/04 12:20	26/02/04 13:20	26/02/04 15:00	26/02/04 15:20	26/02/04 15:10	26/02/04 14:20	26/02/04 15:40
Alkalinity Total	mg/l CaCO ₃	11	9	12	6	<1	8	2	2	13	26	16	16
Fluoride	mg/l	<0.02	1.1	0.14	0.58	1.8	0.31	0.2	0.25	0.64	1	0.03	0.04
Sulphate	mg/l	0.41	140	8.4	33	120	54	51	31	50	70	1.7	2.9
Al Dis	µg/l	<20	<20	<20	<20	989	<20	29	25	<20	<20	<20	<20
Al Total	µg/l	<20	106	<20	547	1040	86	33	69	33	<20	25	43
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	436	14	117	136	50	68	31	20	9	<1	<1
Cd Total	µg/l	<1	446	15	119	137	52	68	32	20	9	<1	<1
Co Dis	µg/l	<1	39	<1	2	12	<1	<1	<1	<1	<1	<1	<1
Co Total	µg/l	<1	40	<1	3	12	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	3	2	186	88	13	45	15	10	6	<1	<1
Cu Total	µg/l	<1	5	3	269	93	25	45	17	11	7	<1	1
Fe Dis	µg/l	<20	<20	<20	<20	20	<20	<20	<20	<20	<20	184	188
Fe Total	µg/l	<20	101	<20	213	3080	156	<20	33	20	<20	223	285
Mn Dis	µg/l	<5	3070	24	125	1260	121	48	16	11	9	<5	<5
Mn Total	µg/l	<5	3130	25	128	1270	123	48	17	11	10	<5	7
Ni Dis	µg/l	<1	43	2	6	22	6	5	2	2	1	<1	<1
Ni Total	µg/l	<1	43	1	8	27	6	5	2	2	2	<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	5	14200	384	2290	3720	1240	1510	650	428	226	<1	11
Zn Total	µg/l	5	14600	395	2370	3720	1270	1500	670	424	229	1	12
Flow	l/s	18	1.5	25	25	25	57	64	80	220	140		

Table 2 (continued)

		ALD	Nisbet Cr
Date		26/02/04 9:15	26/02/04 12:00
Alkalinity Total	mg/l CaCO ₃	98	13
Fluoride	mg/l	0.03	0.02
Sulphate	mg/l	0.69	0.84
Al Dis	µg/l	<20	<20
Al Total	µg/l	62	22
As Dis	µg/l	<5	<5
As Total	µg/l	8	<5
Cd Dis	µg/l	<1	<1
Cd Total	µg/l	<1	<1
Co Dis	µg/l	<1	<1
Co Total	µg/l	3	<1
Cr Dis	µg/l	<1	<1
Cr Total	µg/l	<1	<1
Cu Dis	µg/l	<1	<1
Cu Total	µg/l	2	<1
Fe Dis	µg/l	44	<20
Fe Total	µg/l	1520	32
Mn Dis	µg/l	<5	<5
Mn Total	µg/l	306	<5
Ni Dis	µg/l	2	<1
Ni Total	µg/l	2	<1
Pb Dis	µg/l	<5	<5
Pb Total	µg/l	6	<5
Zn Dis	µg/l	2	9
Zn Total	µg/l	6	1

Table 3. Flow, pH conductivity and temperature results collected in situ, 26 February 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	26/02/04 10:20	26/02/04 10:40	26/02/04 10:50	26/02/04 11:15	26/02/04 11:30	26/02/04 12:20	26/02/04 13:20	26/02/04 15:00	26/02/04 15:20	26/02/04 15:10	26/02/04 14:20	26/02/04 15:40
Flow	l/s	18	1.5	25	25	25	57	64	80	140	220		
pH (field)	pH units	7.23	7.11	7.18	6.56	5.84	6.76	6.38	6.60	7.30	7.60	7.70	7.70
Conductivity	µS/cm	32.3	356	54.8	110.5	293	158.1	143.5	104.6	170	239	89.6	96.0
Temp	°C	10.0	16.0	10.4	12.7	12.9	12.5	16.5	17.6	18.1	18.6	17.4	17.9
Zn tot flux	kg/d	0.01	1.89	0.85	5.12	8.04	6.25	8.29	4.63	8.06	2.77		
Cd tot flux	kg/d	0.00	0.06	0.03	0.26	0.30	0.26	0.38	0.22	0.38	0.11		
Mn tot flux	kg/d	0.01	0.41	0.05	0.28	2.74	0.61	0.27	0.12	0.21	0.12		
Fe tot flux	kg/d	<0.01	0.01	<0.04	0.46	6.65	0.77	<0.11	0.23	0.38	<0.24		
SO ₄ flux	kg/d	0.6	18.1	18.1	71.3	259.2	265.9	282.0	214.3	950.4	846.7		

		ALD	Nisbet Cr	Side Creek	Eastern Adit
Date		26/02/04 9:15	26/02/04 12:00	26/02/04 11:30	26/02/04 11:50
pH (field)	pH units	7.48	6.92	3.59	6.44
Conductivity	µS/cm	219	37.6	540	225
Temperature	°C	14.3	8.2	13.5	9.6

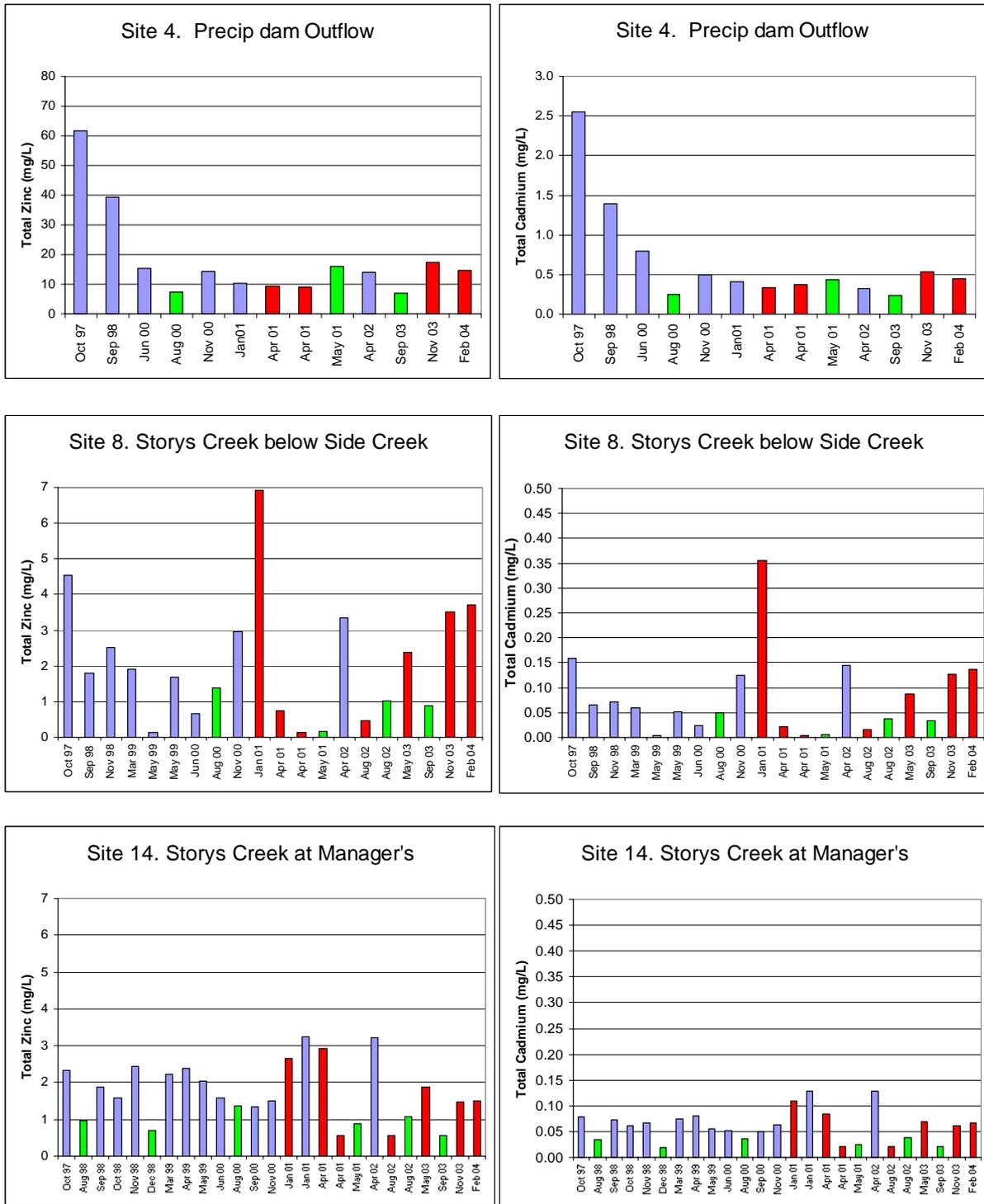


Figure 1 . Total zinc (left) and total cadmium (right) graphs comparing the February 2004 results with previous monitoring results. Red bars denote low flow (250 L/s), blue bars denote medium flows (250 – 350 L/s), and green bars denote high flow (>350 L/s). Note different scale for the Precipitate dam results.

Table 4. Comparison of February 2004 total zinc and cadmium results to historic median and 90th percentile levels.

Site	Feb 04 Tot Zn Results	Feb 04 Tot Cd Results	Historic results	Total Zinc	Total Cadmium
Precip outflow	14.6 mg/l	0.446 mg/l	Median 90 th %tile	14.3 34.8	0.44 1.27
Storys bel Side	3.72 mg/l	0.137 mg/l	Median 90 th %tile	1.75 3.80	0.056 0.146
Storys at Managers	1.50 mg/l	0.068 mg/l	Median 90 th %tile	1.57 2.82	0.062 0.1

Sulphate results for the monitoring sites are presented graphically in Figure 2. Sulphate is a good indicator of pollutant input, as it is naturally very low in undisturbed catchments, and is not affected by pH changes in the water column. Figure 2 shows that sulphate concentrations increase substantially between the Storys below the Precipitate Dam and Storys below Side Creek sites. Concentrations decrease downstream, reflecting dilution by clean tributaries.

Sulphate concentrations in Aberfoyle Creek were considerably higher than in lower Storys Creek, but zinc concentrations were lower (Table 2). This may be due to the higher pH in Aberfoyle Creek (pH = 7.6) promoting the precipitation of zinc from the water column, or it may reflect different inputs between the two catchments. The difference in sulphate to zinc ratios between the two rivers is striking, with Storys Cr having a ratio of 1:21 (Sulphate:Zinc), and Aberfoyle only 1:3.

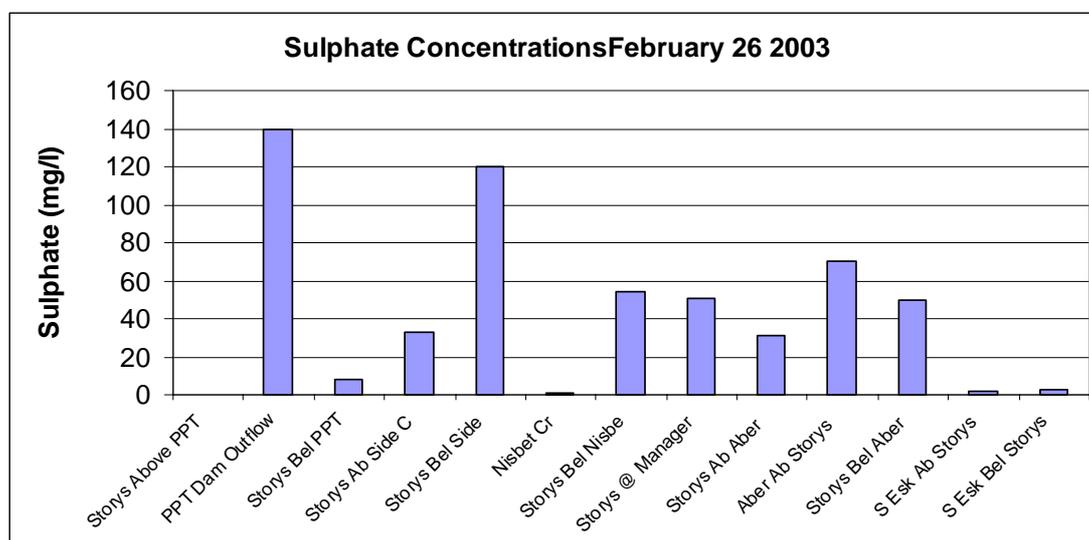


Figure 2. Sulphate concentrations at all monitoring sites on Feb 26, 2004.

3.4 Water quality - fluxes

Using the flow estimates obtained with the flow meter and the analytical results, fluxes for total zinc, total cadmium, total iron, total manganese and sulphate were

calculated and presented in Table 3. The February 2004 zinc fluxes at all sites are presented graphically in Figure 3, and zinc, cadmium and sulphate results are compared with historical results at the Managers site in Figure 4.

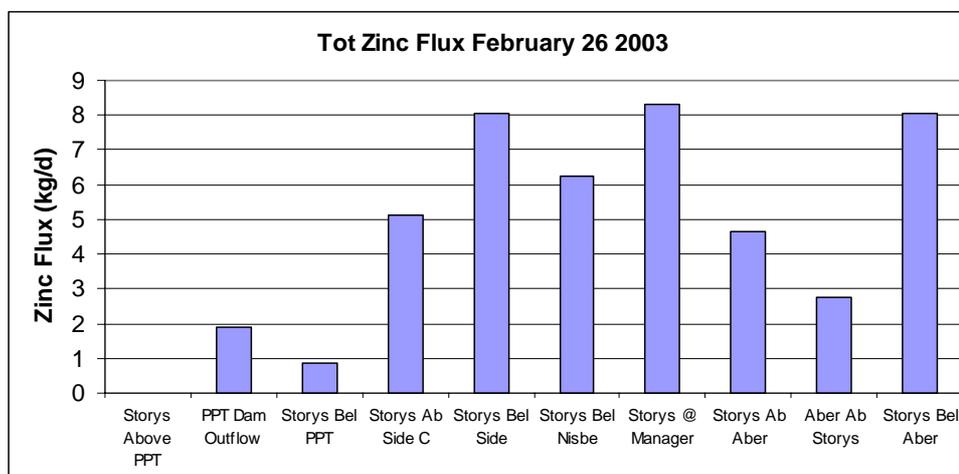


Figure 3. Total zinc fluxes for sites in Storys Creek, February 2004.

The zinc fluxes show that the major input of zinc occurs between Storys below the Precipitate Dam and Storys above Side Creek, and between Storys above Side Creek and Storys below Side Creek. The results differ somewhat from previous balances which showed an increase in zinc fluxes between Side Creek and the Managers Residence, although these differences are probably within the errors of the flow estimates. The lack of flow from Side Creek combined with the increased zinc flux in this area suggests that ground water inputs are the dominant pollutant pathway in this section of the river. Due to the proximity of the jig tailings deposits to Side Creek, it is also possible that the increase in zinc is due to groundwater inputs from the jig tailings, rather than (or in addition to) Side Creek.

The fluxes show that there is a reduction in zinc loads between the Managers Residence and the confluence of Storys and Aberfoyle Creek. Aberfoyle Creek contributes about 35% of the total zinc load entering the South Esk, consistent with previous monitoring results. This input of zinc increased zinc concentrations in the South Esk from <1 µg/l to 12 µg/l. This is less of an impact than previously found in September 2003 or November 2003 when zinc concentrations increased from 1 µg/l to ~35 µg/l.

Compared with historical monitoring data (Figure 4), the zinc, cadmium and sulphate fluxes are close to the lowest recorded, similar to the November 2003 results. The high concentrations and low fluxes underscore the very low flows in the river during sampling.

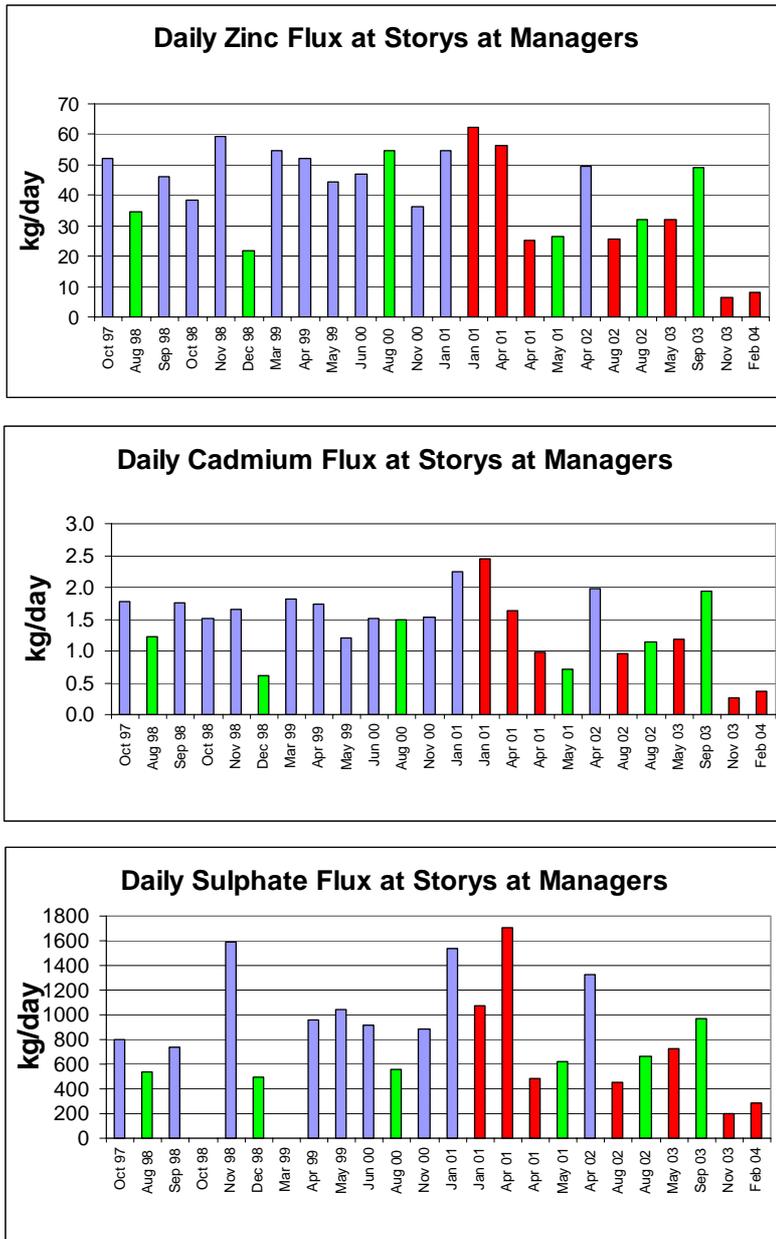


Figure 4. Daily total zinc, total cadmium and sulphate fluxes at Managers Site. Red denotes low flow (<250 l/s); blue denotes moderate flow (250 -350 l/s) and green denotes high flow (>350 l/s)

4 Impact of remediation works

The February water quality monitoring has provided important information as to the state of the site under very low flow conditions. The similarities between the November 2003 and February 2004 flows and water quality results is especially interesting given the large flood event that occurred between the two sampling periods. The fact that metal concentrations and fluxes are almost identical between the two monitoring periods strongly suggests that there is a constant input of pollutants to groundwater entering the river. If the majority of pollutants were associated with a build up within the tailings and sediments, the February fluxes should have been much lower than the November results, as the pollutants would have been flushed out during the flood, and unlikely to be replaced during the short period between the flood and monitoring in February. The water quality data supports a scenario where there is at least one source of pollutants which is releasing metals and sulphate to groundwater at a constant rate (~5 kg/day). The additional pollutant loads associated with higher flows (up to 50 kg/day) are likely due to additional inputs associated with the accumulation and flushing of metals from the tailings and sediments.

Based on a comparison of fluxes with previous low flow events (red bars in Figure 4) it appears that the low flow input of zinc to the river may be decreasing. However, all of the previous low flows were at least twice the flow rate measured in November 2003 or February 2004, which hampers interpretation. In addition, the ratio of zinc loads between Storys and Aberfoyle Creeks has not changed with time, as would be expected if there was a decrease in Storys Creek (and no change in Aberfoyle Cr). Future monitoring of flow events similar in magnitude to the historic data set will provide a better comparison for evaluating the impact of the remediation works.