Storys Creek Remediation Program

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ABSTRACT

A metalliferous mine has operated at Storys Creek from the 1890s to 1979. Storys Creek drains from a pristine catchment and National Park and remains as the most degraded stream from historic mining in north-eastern Tasmania. It has been the subject of public concern since the closure, particularly at times of high rainfall such as existed in 1985 and 1986.

The mine is located on the banks of the creek, which flows into a major river, the South Esk River, which is one of Tasmania's largest rivers and important for recreational fishing and water supplies. For much of the life of the of the operations tailings were directly discharged into the creek, and in latter years stockpiled or very close to it. Little rehabilitation was carried out at mine closure. The result was erosion and subsequent deposition on the banks of the creek downstream. Direct emissions of adit water and the consequential emission of contaminated ground water to the creek continue to affect water quality.

Contaminant loads discharging from the mine and tailings comprise 70% of the metal load in the catchment and are by far the largest single source. Acidity data suggested that the introduction of systems to introduce alkalinity could be effective in ameliorating the residual acid drainage impacts in the Storys Creek catchment.

After a period of investigations and trials which proved their effectiveness, treatments adopted have included the following:

- relocation of tailings to a constructed and clay capped disposal area and rehabilitation of tailings area;
- crushed limestone addition to stream flows;
- crushed limestone addition to creek banks and exposed tailings;
- sealing of a drainage Adit; and
- construction of an anoxic drain to generate alkalinity to surface waters draining to old mine workings

These innovative treatments have resulted in a marked improvement in water quality draining from the area. The anoxic drain is believed to be one of the few, if any, which has been constructed to have generated high levels of alkalinity from clean waters and offers a solution to the clogging problems experienced in such drains in the past. Similarly, the use of crushed limestone in an active stream has proved effective in buffering acid drainage and removing metals from solution.

INTRODUCTION

Tin and tungsten mines have operated on the southern slopes of the Ben Lomond range in north east Tasmania since the 1890s. The principal operations were Storys Creek and Aberfoyle, named after their adjacent creeks (see Figure 1). They developed into meaningful operations the 1920s and 1930s respectively and continued to provide employment throughout the 1930s depression. The plateau is composed of an exposed Jurassic dolerite sheet. The orebody is a vein deposit in Silurian siltstones and slates associated with the underlying Devonian granite.

Although they were not major producers, wolfram production was particularly important in the war years. In 1957 for example, Storys Creek produced 280 tons of wolfram and 28 tons of cassiterite from 17 395 tons of ore, while Aberfoyle produced 595 tons of cassiterite and 269 tons of wolfram from 66 571 tons of ore (Blissett, 1959). By the 1970s milling at Storys was reduced to pre-concentration for final treatment at Aberfoyle. At this mine principally, tailings and waste materials were discharged in streams and transported down the river systems. Little rehabilitation was done when mines finally closed in 1981.

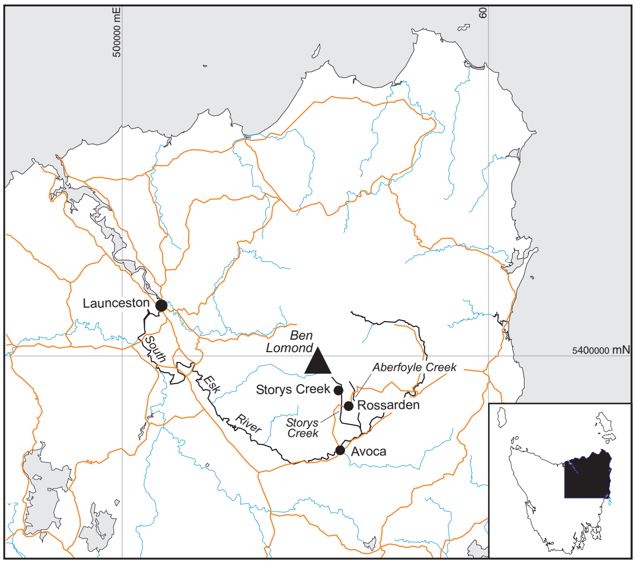

FIG 1 - North-east Tasmania showing Storys and Aberfoyle Creeks and the South Esk River.

There has been continuing public concern over the abandoned nature of the mines and their effects on water quality (Bobbi, 1996). Both Storys and Aberfoyle Creeks are degraded and there had been complaints of contamination in the South Esk River which is downstream. In 1985 for example the precipitate dam at Storys Creek, which contained tailings and residue, was damaged by flooding and discharged material as far as the South Esk.

Rehabilitation work, which consisted of capping tailings at both mines, had been carried out for the State by Mineral Resources Tasmania (Brett, 1997). A portion of mining royalties is collected to fund the Rehabilitation of Mining Lands Trust for such work. Insufficient resources were available for a full investigation until 1997, when the Commonwealth Government provided funds for a review into remediation options for the area through the RiverWorks Tasmania program. Subsequently the Trust and RiverWorks have funded rehabilitation projects. The program has been a collaboration between the Supervising Scientist Division of Environment Australia, The Department of Primary Industries, Water and Environment and Mineral Resources Tasmania Division of the Department of Infrastructure, Energy and Resources.

Storys Creek rises on the Ben Lomond Plateau at an elevation of 1340 metres. The creek falls rapidly to 680 metres just below the mine. It continues a further 18 km past the former mine township of Rossarden to join Aberfoyle creek 1.5 km above the South Esk River. This is an important river with a range of beneficial uses, water consumption and drains into the Tamar Estuary at Launceston.

The subject of this paper is the investigation into the remediation of the Storys Creek and Aberfoyle mine sites and the selection of rehabilitation projects at Storys Creek.

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WATER QUALITY INVESTIGATIONS AND CONTAMINATION SOURCES

Investigations

Water quality and flow data has been collected from numerous locations since the early-1980s (Locher, 1993). However, flow measurements were lacking and acidity had not been directly measured in many cases and could not be calculated because of the lack of data.

Therefore, a single event sampling was conducted in October 1997. Figure 2 shows a schematic of the creek catchments and sampling stations. The sampling incorporated rigorous stream flow and water quality sample collection to provide data on pollutant loads. Mean flows for the catchments were established and sampling results were used to calculate load estimates for zinc, cadmium, copper, iron, sulfate, acidity and alkalinity. Although the load values were a single event, comparison with previous data gives some confidence in the calculations. These provided the data to evaluate the pollutant sources and their significance.

Water quality

Table 1 shows a summary of the exceedances of water quality guidelines (ANZECC, 1992) for Storys Creek, Aberfoyle Creek and the South Esk River above and below the confluence.

Based on the water quality sampling, zinc, cadmium and copper exceed guidelines for aquatic life for these metals in Aberfoyle Creek and Storys Creek.

In the South Esk, only copper and aluminium slightly exceeds the guidelines, cadmium detection limits are not low enough for comparison. Copper is also elevated above the confluence and exceeds the guidelines. Therefore, the contribution from Storys Creek is not significant. Aluminium also exceeds aquatic life and drinking water quidelines above and below Storys Creek, with minimum contribution from the creek.

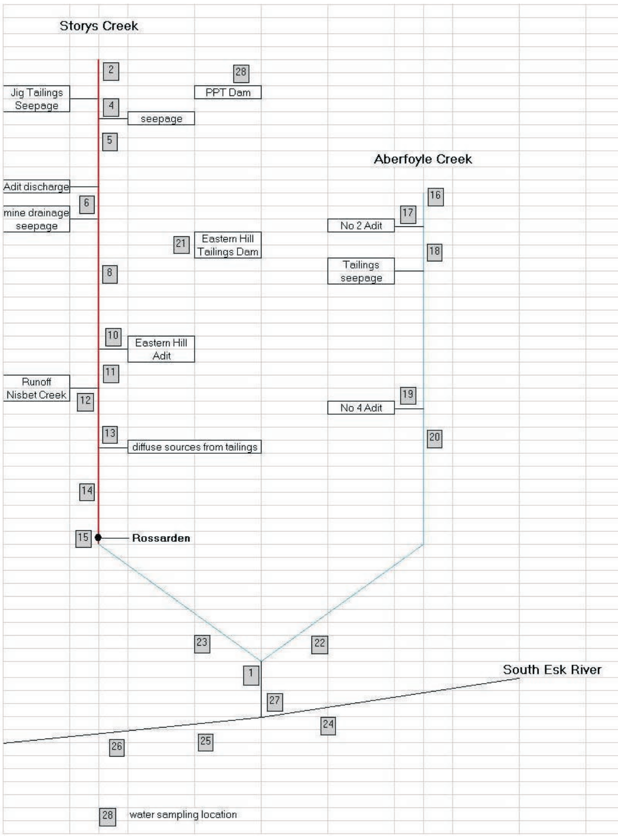

FIG 2 - A schematic of the Storys and Aberfoyle Creek catchments and sampling stations.

TABLE 1

Summary of October 1997 water quality and ANZECC 1992 guidelines.

		Conc (ppm)	South Esk above	Storys Creek	Aberfoyle Creek	South Esk below
Aquatic life	Al	0.1	x	x		x
	Cd	0.0002		x	x	x?
	Cu	0.005	x	x	x	x
	Zn	0.05		x	x	
Drinking water	Al	0.2	x	x		x
	Cd	0.005		x	x	
	Cu	0.005				
	Fe	1		x	x	
	Mn	0.2		x	x	
	Zn	5				
Irrigation	Al	5				
	Cd	0.01		x		
	Cu	0.2				
	Zn	2				
Livestock	Al	5				
	Cd	0.01		x		
	Cu	0.5				
	Zn	0.05				

Notes:
x = exceeds ANZECC guidelines

Zinc, copper and cadmium in Storys Creek waters near the South Esk exceed aquatic life standards. Cadmium and aluminium also exceed drinking water, livestock and irrigation guidelines.

In Aberfoyle Creek only cadmium, copper and zinc exceed aquatic life guidelines and cadmium, iron and manganese exceed drinking water standards. The waters are suitable for other uses.

Loads

The main contaminants are acidity, sulfate and the metals, cadmium, copper, iron, manganese and zinc. The metals which exceeded water quality guidelines are indicated in Table 1. The natural waters have very low concentrations of sulfates, cations and anions and are essentially devoid of any neutralising capacity (Miedecke, 1998). Metals are at detection levels. This means that even small acid drainage loads affect water quality and beneficial uses.

Loads were calculated by using the flow data developed in the snap shot sampling and correlated with flows measured at a gauging station in Storys Creek. The data confirmed that Storys Creek is the major pollutant source and contributes over 70 per cent of the total Zn, Cd and Cu loads and most of the acidity. Aberfoyle Creek contributes lower loads of metals, but is a significant source of alkalinity, which buffers the Storys Creek acid drainage. Pollutant loads are relatively low (Zn 40 kg/day, Cd 1.3 kg/day), when compared to other areas of historical acid drainage – such as Mount Lyell (copper 2500 kg/day). Sulfate and acidity loads are low. The figures provided some confidence that the acid drainage sources were amenable to passive treatment and *in situ* neutralisation to remove metals from solution (see below).

The Storys Creek catchment comprises the main acid drainage sources. Figure 3 summarises the acidity, alkalinity, sulfate, iron, zinc, cadmium and copper load data expressed as the per cent of the loads in Storys Creek at the Rossarden gauging station for the 1997 sampling. Loads are calculated from measured flows. The main loads were identified as the diffuse sources from tailings on the banks and within the creek itself, together with discharges from the main workings via Side Creek Adits. Point sources were leachates from an old tailings dam (Precipitate Dam), and the Eastern Hill exploration adit. The creek has a long history of disturbance and transport of discharged mine waste, from past alluvial mining and massive flooding. In 1929 a 1:10 000 year flood event occurred causing major flows of alluvial debris downstream. From aerial photography and site inspections, it is observed that the majority of waste materials are deposited in the stream bed between the mine and Rossarden township. After the township, the stream gradient increases, and it would appear that most of the waste materials have been distributed down the catchment. The water quality data also supports this, as the major metal inputs occur above Rossarden.

Water quality in Storys Creek at Rossarden township downstream of the mine workings shows an improvement over historic levels using the data collected in the 1980s. (Locher, 1993; Miedecke, 1998). Virtually all water quality parameters are indicating a reduction in concentrations, many improving by up to 50 per cent. This is partly attributed to a reduction in the overall oxidation rate as physically stable oxidation profiles develop over time in the creek-bank deposited tailings. Underlying poorly oxidised tailings could re-acidify if they are exposed in the future. There is a similar pattern for the Storys Creek above Aberfoyle Creek, where there is also an observed trend of improved water quality. Cd, Zn, Cu have reduced by greater than 50 per cent since the 1980s (using mean data).

Acid drainage point sources

Although point sources such the Precipitate Dam and the drainage from the Storys Creek mine workings and Eastern Hill Adit do not contribute major contaminant loads, they are significant and provided an opportunity for removal or sealing.

The Precipitate Dam was composed principally of spigotted tailings materials. These were highly permeable coarse tailings, grading into tailings sludges in the centre and along the old creek bed. They were covered with a shallow 200 - 300 mm cap of precipitate materials resulting from the treatment of acid mine waters from the mine. Water quality was poor, but with only moderate acidity and sulfate loads. The lower pH in the waters leaching from the embankment was attributed to the oxidation processes in the coarser wall materials. The dam contributed approximately 20 per cent of the pollutant load including the highest source of cadmium and became an immediate target for removal.

The Eastern Hill adit was in competent geological conditions and suitable for plugging. There was no obvious drainage path for the Side Creek mine workings.

Diffuse sources

Jig tailing stockpiles above the creek, creek bank tailings deposits and tailings within the creek bed make up the major diffuse sources of contamination. Discharges from the Side Creek Adit have generally been low and were expressing themselves as subsurface discharges to the creek bed, rather than obvious surface flows. It is therefore not possible to quantify the loads, but these were still expected to be significant.

The tailings have only a low sulfur content (less than 0.1 per cent S). The NAG pH values are greater than 4 which indicates that the samples are non-acid forming. However, since the tailings are essentially devoid of ANC, the pH of material represented by these samples would be expected decrease to about 4 to 5.5 as it oxidises (as indicated by the oxidised sample). At such low pH conditions, metal solubility can be relatively high and is the major ongoing potential source of soluble metals in the stream. The results suggested that improving the buffering capacity of the tailings by the additional of crushed limestone, would significantly reduce the metal release rate from the tailings.

STORYS CREEK WATERS, CONTROL OF METAL RELEASE AND SOLUBILITY

Figure 4 shows a graph of pH versus Cu, Cd and Zn concentrations for the available Storys Creek monitoring data (1984 - 1997). This plot shows that a pH greater than 7 is adequate to precipitate Cu and Cd, but the pH needs to be at least 7.5 to effectively remove Zn, although even at pH 7, the Zn concentrations will be significantly less than at pH 5 to 5.5.

Water samples were collected at various locations and buffering curves generated in the laboratory. Figure 5 shows the buffering curves resulting from the titration of acidity from the natural acid pH of these samples to pH 8.5.

Alkalinity can be provided by direct lime dosing and by increasing the alkalinity inputs into the catchment. For example, at Side Creek approximately 220 mg $CaCO_3$/L is required to raise the pH to 7.5. The total alkalinity required is only about 9.5 kg $CaCO_3$/day. This alkalinity addition is well within the design capability of limestone drains and SAPS. Assuming a flow of about 40 L/s in Storys Creek below Side Creek, the alkalinity requirement is about 120 kg $CaCO_3$/day to raise the pH to 7.5. This is only about 45 tonnes per year.

It was concluded that limestone addition was feasible to raise the pH of the waters, precipitate metals from solution and thereby reduce toxicity.

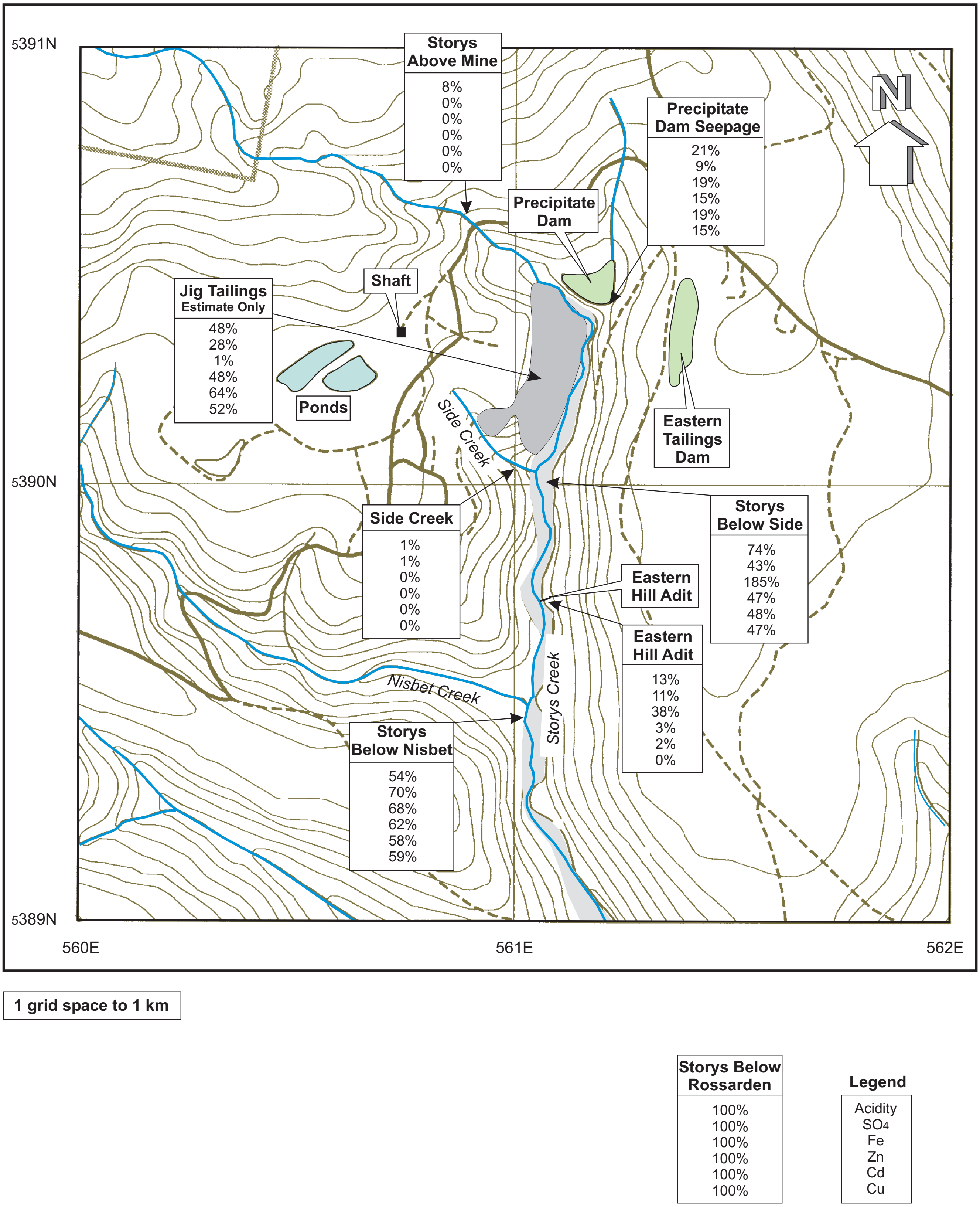

FIG 3 - Acidity, alkalinity, sulfate, iron, zinc, cadmium and copper load data expressed as the per cent of the loads at Rossarden.

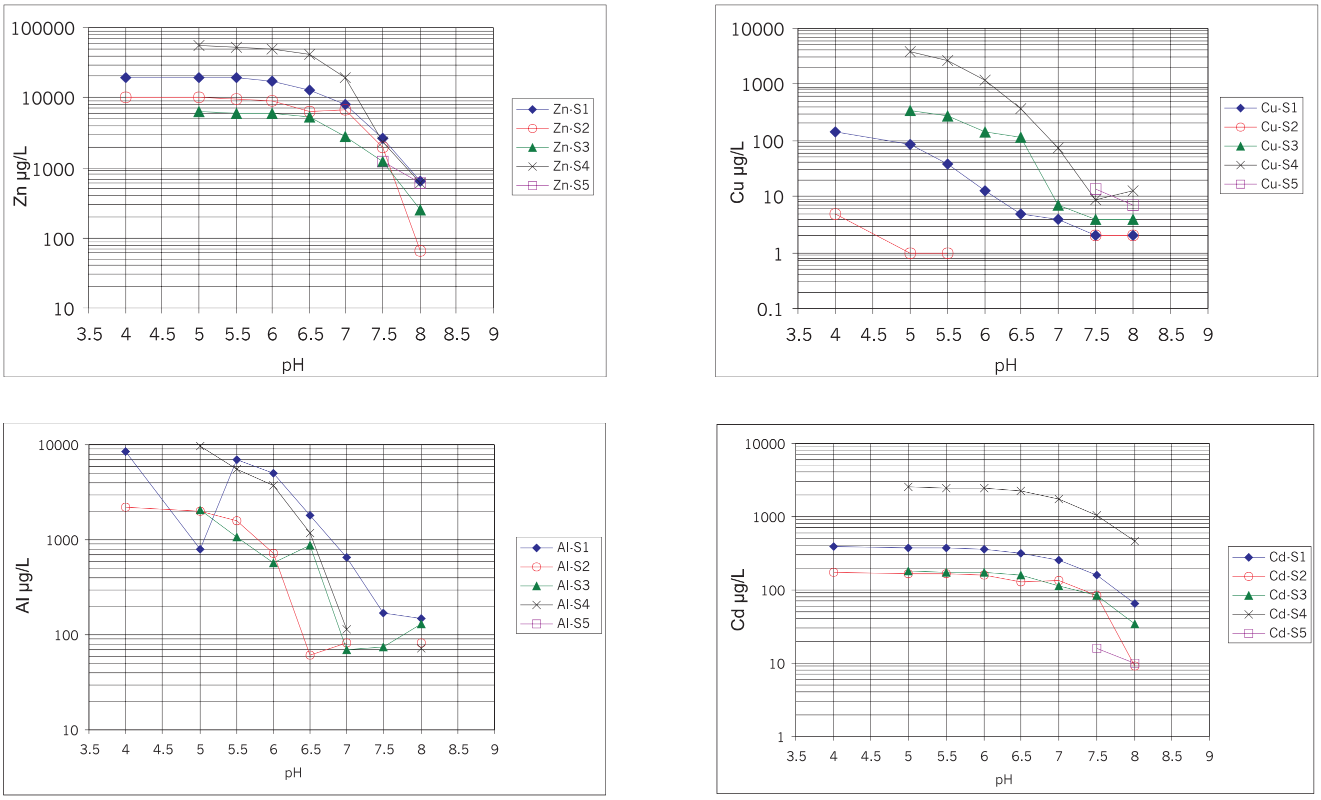

FIG 4 - pH dependent solubility of Zn, Cu, Al and Cd respectively for filtered water samples from the Storys Creek catchment.

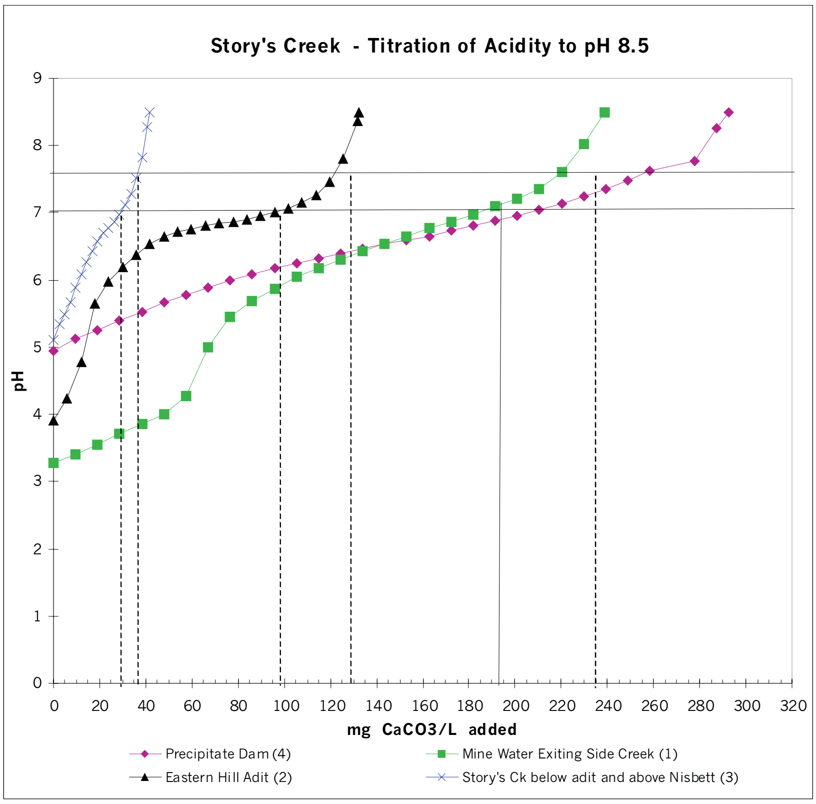

FIG 5 - Buffering curves resulting from the titration of acidity from the natural acid pH of these samples to pH 8.5.

ALKALINITY ADDITION TRIALS

Alkalinity using crushed limestone

Laboratory investigations were followed by field trials to evaluate the potential benefits of alkalinity buffering. Crushed limestone (agricultural grade) at a rate of ten tonnes per hectare was added to both coarse (jig) and fine tailings in laboratory lysimeter trials. Laboratory buffering tests with limestone were very successful for the jig tailings, but only moderately successful for the fine tailing materials. There were problems with maintaining water flows through the fine tailings samples. It is believed that due to the low acidity, the limestone reacted only very slowly and therefore did not provide sufficient alkalinity to affect a reduction in the dissolved metals.

Infiltration tests for jig tailings showed a permeability of 10^{-4} cm/sec, which would permit three times the annual rainfall of 960 mm to potentially flow through them and transport contaminants. Two large-scale lysimeters were constructed in the jig tailings stockpile, one treated with limestone and the other left untreated. The leachates from the lysimeters were collected periodically from the containers and analysed for acitity, metals and common cations over a 12-month period. Volumes collected frequently exceeded greater than 200 L which indicated that the infiltration rate was very high, as expected. It is estimated that almost 100 per cent of rainfall reported to the sample containers. The water quality data shows that the leachates from the untreated jig tailings are of very poor quality, with low pH, and very high metal concentrations. The treated tailings showed an improvement with reductions in acidity and metal concentrations in the order of 50 per cent (Miedecke, 2000). However, the pH in the treated tailings was slightly less than expected, with significant residual acidity, indicating that the alkalinity provided was insufficient to raise the pH and buffer the acidity. The results gave confidence into the benefits of a limestone buffering program.

The very poor water quality collected from the untreated lysimiter (the most contaminated in the study) exceeding the historic information and resulted in a revision in the expected contaminant load from the tailings. The contaminant loads from the jig tailings was revised and estimated to be 48 per cent of the acidity loads in the creek above Rossarden. It was concluded that the jig tailings posed a serious risk to water quality in the creek and to further metal dissolution. Treatment and/or removal of the tailings therefore became a priority.

Limestone sand addition trial to Storys Creek

A large-scale trial was used to confirm laboratory results. Approximately 240 tonnes of limestone sands (screened and generally 6 mm) were added to Storys Creek at the bridge above the mine site in August to September 1998. The limestone sands were observed to progressively move approximately 1.5 km downstream to near the Nisbett Creek – Storys Creek junction after high flow events. The main deposits were in the vicinity of the jig tailings adjoining the creek and the sands were well distributed over the creek bottom and banks. There was no sign of armouring of the limestone materials. Water samples were collected at downstream stations on an opportunistic basis.

The results showed an increase in pH to approximately 7 in the Precipitate Dam area and a general increase downstream. There was a marked reduction in metals in solution and significantly reduced acidity and sulfate loads (Miedecke, 2000). There was a progressive reduction in effect down to the Nisbett Creek Junction. This correlates well with the observation of sand distribution. There are no obvious improvements in water quality at the Storys Creek below the managers residence, near Rossarden.

There was an excellent correlation of metal concentrations with sulfates, which indicates the metal source is from acid seepages (Miedecke, 2000). There also appeared to be an approximate 25 per cent to 75 per cent reduction in metal, acidity and sulfate loads in the area of the creek which has been treated. It was concluded that the addition of limestone sands has been effective, but limited to the actual area where the sands have been distributed.

Anoxic limestone drain (ALD)

The construction of anoxic limestone drains adjacent to the hill slopes and recharging groundwater draining to mine workings with alkalinity was a possible remediation method. As it had not been previously demonstrated that an ALD would be effective in generating significant alkalinity in ‘clean’ water, a trial was constructed.

The trial ALD was constructed up-slope from the main shaft and in an area which is saturated from leakage from the ponds constructed in the area for mine use. The drain was excavated and filled with approximately 20 tonnes of limestone (size approximately 75 - 100 mm), then a layer of hay and horse manure (stable waste), a polythene sheet, then covered with topsoil. The retention time was estimated at 16 hours (based on a ten per cent void area). The horse stable manure with the polythene cap provides the seal so that inputs of atmospheric oxygen are minimised and the accumulation of CO_2 within the ALD is maximised and therefore assists in alkalinity generation.

Water was directed to one end of the drain by a pipe, and samples collected at the outflow. Flow rates were controlled at approximately four litres per minute. Alkalinity generation rates have ranged from approximately 50 to 300 mg/L. The variation is attributed to inflows of other waters in winter and rain events.

The drain has proven very effective at generating alkalinity in clean waters and has application for alkalinity recharge. It is believed to be the first application of such a design, which traditionally have only been believed to be effective in buffering acid drainage sources. It is believed that the organic cap on the ALD may be an important source of CO_2 and high alkalinity and it is suspected that the organic matter is playing more of a role than just acting as an oxygen barrier. The alkalinity generation rates indicate that the life of the drain would be approximately 20 years. The life of the anoxic layer which is the organic substrate is not readily calculated. If data from the SAPS systems is indicative, the organic layer might be exhausted in five to ten years (Hedin, 2000).

REMEDIATION WORKS

Following the success of both the crushed limestone trial application to tailings and the limestone sand addition to Storys Creek, full-scale remediation works were carried out in 2000, 2001 and 2002 (Miedecke).

These consisted of:

- Excavation and relocation of 64 000 cubic metres of precipitate tailings dam to a secure repository at the former eastern tailings dam. The material was neutralised with 50 tonnes of agricultural limestone and sealed under 450 mm of compacted clay.
- Construction of a two-metre long concrete plug in the Eastern Adit.
- 80 tonnes of agricultural limestone was spread over the jig tailings stockpiles, and 170 tonnes of limestone was spread over the creek bank tailings deposits from Storys Creek to Rossarden.
- An anoxic limestone drain was constructed up hill from the mine at Storys Creek. It was 2.5 metres deep, containing 1100 tones of limestone and covered with 300 mm of hay and manure.

- 400 tonnes of limestone has been added to Storys Creek at five locations.
- At the time of writing 60 000 cubic metres of jig tailings are being relocated to the eastern tailings dam repository. The material is being neutralised with 800 tonnes of limestone, sealed under 500 mm of compacted precipitated dam tailings and 500 mm of compacted clay.

The cost of remediation investigations and the resulting program of works has totalled approximately $A 1.04 million. A summary is set out in Table 2.

RESULTS AND CONCLUSIONS

It was noted that the addition of alkalinity to Storys Creek itself by the addition of limestone sand, resulted in the creation of an obvious white precipitate in the creek bed during dry periods. This is believed to be an aluminium (and iron) hydroxide floc. This precipitate changes in nature and becomes more dense further down the creek and was removed in high flow periods, presumably being carried further downstream and ultimately to the South Esk River system.

TABLE 2

Remediation works cost summary.

Year	Project	Trust ($)	RiverWorks ($)	Total ($)
1997 - 1998	Investigation and trials		108 500	
	Precipitate Dam drilling		10 500	119 000
1999 - 2000	Precipitate Dam	156 000	192 000	348 000
	Limestone banks	30 100		
	Tracks for limestone addition	15 000		
	Plans	14 800		59 900
2000 - 2001	Anoxic drain	77 500		77 500
2001 - 2002	Limestone additions	30 900		30 900
2002 - 2003	Jig tailings (budget)	150 000	255 000	405 000
				1 040 300
	Total	474 300	566 000	1 040 300

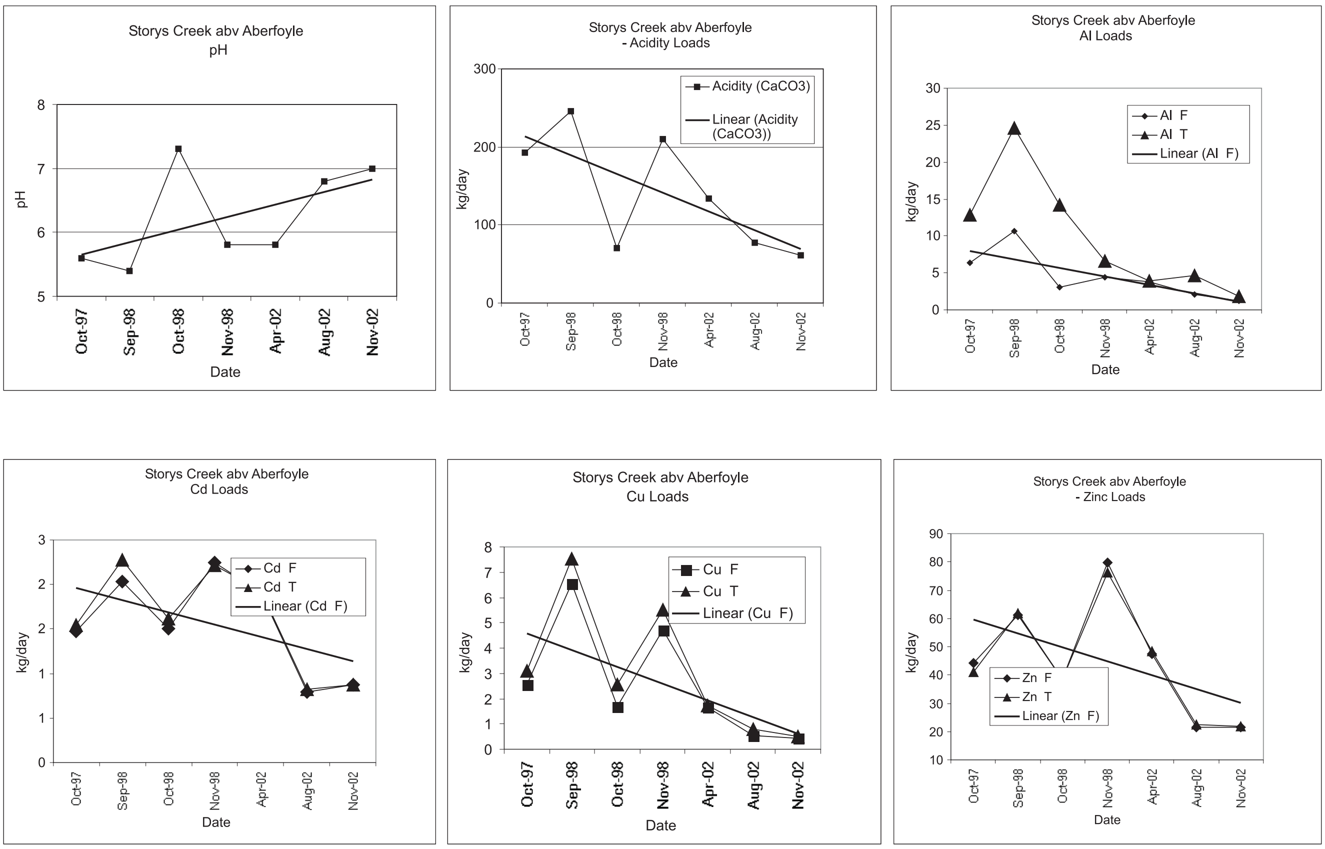

FIG 6 - Improvement in contaminant loads for Storys Creek above the South Esk River.

TABLE 3

Improvement in contamination for Storys Creek above the South Esk River.

	Date from	Date to	pH	TDS	SO_4	Cd	Cu	Fe	Mn	Zn
				(mg/L)						
Storys Creek below Rossarden bridge										
Mean	Apr 1982	May 1990	5.7	100	51	0.109	0.700		0.6	3.105
	Apr 1995	Oct 1997	Before							
Mean			5.7	61	26	0.08	0.23	0.88	0.4	2.38
Max						0.14	0.4	1.5	0.72	4.30
Min						0.03	0.1	0.4	0.15	1.00
	Oct 1998	Nov 2002	After							
Mean			5.94	75	31	0.06	0.13	0.48	0.4	1.57
Max			6.9	170	68	0.13	0.25	0.91	0.58	3.11
Min			5.2	13	10	0.02	0.04	0.06	0.07	0.57
Storys Creek above Aberfoyle Creek										
	Apr 1982	Sep 1998	Before							
Mean			5.5	59	22	0.06	0.16	0.2	0.22	1.52
Max			5.6	71	24	0.07	0.22	0.31	0.24	1.76
Min			5.4	47	19	0.05	0.1	0.10	0.20	1.26
	Oct 1998	Nov 2002	After							
Mean			6.54	100	33	0.02	0.04	0.23	0.21	0.67
Max			7.3	145	51	0.04	0.07	0.41	0.34	1.04
Min			5.8	70	17	0.01	0.01	0.04	0.03	0.31
Storys Creek below Aberfoyle Creek										
	Nov 1996	Sep 1998	Before							
Mean			6.4	127	31	0.05	0.1	0.37	0.32	1.44
Max			6.8	147	35	0.08	0.22	0.65	0.43	2.69
Min			6.4	107	27	0.02	0.06	0.14	0.13	0.74
	Oct 1998	Nov 2002	After							
Mean			7.6	185	69	0.02	0.04	0.24	0.19	0.67
Max			7.8	240	88	0.03	0.07	0.41	0.34	1.04
Min			7.5	115	50	0.01	0.01	0.04	0.03	0.31

Subjectively, the appearance of Storys Creek has improved markedly following limestone addition, with little of the previous iron staining and discolouration.

Opportunistic water quality sampling may miss isolated events which may have influenced water quality (such as an intense storm after an extended dry period – such as the jig tailings leaching). However, there have been demonstrable improvements in water quality immediately in the vicinity of the mine and where remediation works were concentrated. For example the removal of the Precipitate Dam tailings has markedly reduced this source of contamination (Miedecke, 2000).

There has been an increase in pH and a reduction in metals in solution and significantly reduced acidity and sulfate loads.

Figure 6 shows the increase in pH and the reduction in contaminant loads for Storys Creek above the South Esk River and Table 3 the change in parameter concentrations. In general terms contaminant load have reduced by 50 per cent.

Monitoring also shows there is an increase in metal concentrations following rainfall events. However, the best water quality coincides with high flows, due to the contribution of clean water further up the catchment, which is steep and flows vary rapidly following rainfall events.

The increase in metal contribution following these events is attributed to seepage from contamination sources such as jig tailings and creek bank materials. The removal of the jig tailings was not completed in the sampling period and further improvements are expected.

The addition of crushed limestone to the creek banks also appears to have raised pH, decreased acidity and metal concentrations and pollutant loads, but may not have decreased pollutant concentrations in low flow conditions (as was anticipated). This is because the base flow is made up of groundwater infiltration but as expected water quality was improved by limestone sand addition to the creek bed.

The construction of the anoxic alkaline drain coincided with a period immediately following the observations of mine outflows from the area near Side Creek (and probably other locations). This dramatically effected water quality and there was a marked improvement after the ALD was constructed.

Table 4 summarises the water quality in Storys Creek above the South Esk river after the works (but not jig tailings removal).

There have been demonstrable improvements in water quality and Storys Creek waters are now suitable for agriculture and livestock uses, except for a marginal exceedance of Cd. Further improvements are expected after jig tailings removal is completed.

TABLE 4
Summary of 2002 water quality and ANZECC (1992) guidelines.

		Conc (ppm)	South Esk above	Storys Creek	Aberfoyle Creek	South Esk below
Aquatic life	Al	0.1				
	Cd	0.0002		x	x	
	Cu	0.005		x	x	
	Zn	0.05		x	x	
Drinking water	Al	0.2				
	Cd	0.005		x	x	
	Cu	0.005				
	Fe	1			x	
	Mn	0.2			x	
	Zn	5				
Irrigation	Al	5				
	Cd	0.01		x		
	Cu	0.2				
	Zn	2				
Livestock	Al	5				
	Cd	0.01		x		
	Cu	0.5				
	Zn	0.05				

Notes:
x = exceeds ANZECC guidelines

REFERENCES

ANZECC, 1992. Australian water quality guidelines for fresh and marine waters (ANZECC: Canberra).

Blissett, A H, 1959. The Geology of the Rossarden – Storeys Creek District, Geological Survey Bulletin No 46, Department of Mines, Tasmania.

Bobbi, C, Fuller, D and Oldmeadow, D, 1996. South Esk Basin: State of Rivers Report. Technical Report, DPIF/National Landcare Program, Hobart.

Brett, D M, 1997. Rossarden Storys Creek Mine Site, Report on Rehabilitation Works, November.

Hedin, 2000. Personal communication.

Locher, H, 1993. Rossarden/Storeys Creek Overview of Environmental Monitoring Data. Department of Environment and Land Management.

Miedecke, J, 1998. Storys Creek/Rossarden Acid Drainage Remediation Study – Preliminary Report. John Miedecke and Partners, March.

Miedecke, J, 1999a. Storys Creek/Rossarden Acid Drainage Remediation Study – Precipitate Dam Relocation Design Report. John Miedecke and Partners, 1997 March.

Miedecke, J, 2000. Storys Creek/Rossarden Acid Drainage Remediation Study – Final Report, John Miedecke and Partners, September.

Miedecke, J, 2000a. Storys Creek Remediation, Report on Remediation Works Autumn 2000, John Miedecke and Partners.

Miedecke, J, 2000b. Storys Creek Remediation, Precipitate Dam Relocation Construction Report, John Miedecke and Partners.

Miedecke, J, 2000c. Storys Creek Remediation, Jig Tailings Relocation Design Report, John Miedecke and Partners.

Miedecke, J, 2000d. Storys Creek Remediation, Anoxic Limestone Drain Design Report, John Miedecke and Partners.

Miedecke, J, 2000e. Storys Creek Remediation Study. Final Report, John Miedecke and Partners.

Miedecke, J, 2002. Storys Creek Water Quality Monitoring, John Miedecke and Partners.

Zurbruch, 1996. *Proceedings 17th Annual West Virginia Surface Mine Drainage Task Force Symposium*.