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Viewpoint

Environmental protection and management: A water pollution case study within the Greater Blue Mountains World Heritage Area, Australia

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ABSTRACT

The Grose River is contained almost entirely within a World Heritage Area. While sewage pollution in the area has been addressed, pollution at damaging levels continues from a disused coal mine, closed in 1997. Despite some surface rehabilitation, no action has occurred to remediate zinc polluted waters emanating from the mine. We examine the historical regulation and management of the Australian Commonwealth and New South Wales governments and highlight gaps in both regulatory systems. We conclude that there is an urgent need to improve regulation of water pollution, mining and management of the environment in highly valued world heritage areas.

Introduction

The encroachment of human activities has modified most ecosystems of the globe (e.g., Botkin and Keller, 2009). Due to human activities it is becoming increasingly difficult to identify any natural environment that has not been altered to some extent. One approach to limiting the adverse impacts generated by humans has been to identify particularly 'valuable' or 'unique' environments and to manage them as protected areas. This approach regulates threats of human disturbance for selected 'protected areas' (Pimm et al., 2001). The form of protection varies internationally and there are a wide range of reserve classifications, including nature reserves, national parks, national monuments, and wilderness areas. Protected areas may be terrestrial, marine and/or freshwater (WDPA, 2009). Protection of large terrestrial reserves also often offers some protection for waterways within their boundaries (Fitzsimons and Robertson, 2005), although reserve boundaries rarely enclose the entire catchment watershed (Linke et al., 2008). This is one of the issues in the ongoing debate over the most appropriate approach to protecting aquatic ecosystems compared with terrestrial reserves (Moulton, 2009).

The Blue Mountains region is environmentally one of the most highly valued and comprehensively protected areas in Australia. The region has unique geology and biodiversity, and was considered of sufficient international significance to be declared a United Nations Educational, Scientific and Cultural Organisation (UNESCO) World Heritage Estate because of the area's natural values (UNESCO, 2009; Commonwealth Government, 2009a). In the 50 years since the initial creation of the Blue Mountains National Park, the area has continued to expand (NPWS, 2001). Several adjoining National Parks are now collectively regarded as part of the Greater Blue Mountains area. The majority, but not all areas are naturally vegetated and most of the area is considered to be in good ecological condition (Commonwealth Government, 1998).

The Blue Mountains region has historically witnessed considerable conflict between development and conservation (Mosely, 1999). Issues such as increased urban development, tourism, forestry, infrastructure development, and mining have frequently created strongly divergent views. The source of the environmental conflict has often originated from a 50 km string of settlements, stretching from Penrith in the east to Mt Victoria and Lithgow in the west. This ridge-top development bisects the National Park and houses a population of more than 80,000 residents (BMCC, 2002). It also caters for a large number of tourism visitors (Commonwealth Government, 1998; BMCC, 2002). Water pollution is one of many threats to the National Park that generates environmental conflict in the management of the area (Berman et al., 1987).

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Historically, a major source of water pollution in the Blue Mountains area has been sewage effluent. In July 1980 there were 12 sewage treatment plants (STPs) servicing a population of 46,000 in the Blue Mountains (MWS&DB, 1987). In the 1980s and early 1990s six STPs disposed of their wastewater into streams that flowed into the National Park estate lands (Berman et al., 1987).

Another source of water pollution throughout Australia, and in the Blue Mountains, has been water contamination from mining. The Blue Mountains region has had coal and other mining activity for more than a century (Macqueen, 2007). Although many of the mines have been closed, there are several active coal mines in the Western Blue Mountains, particularly in the Lithgow and upper Coxs Valley area (Lithgow Tourism, 2009).

One part of the Blue Mountains National Park that has been adversely affected by pollution by a combination of sewage effluent and mining pollution is the upper reaches of the Grose River, an otherwise pristine environment that is protected as a declared Wilderness Area within the National Park lands, and is also part of the Greater Blue Mountains World Heritage Area. The upper Grose River catchment (Fig. 1) is used as a case study for this paper. Regulation and management of water pollution in this area reflects a number of the strengths and weakness of regulation of coal mining, water pollution, and management of waterways within Australia's protected areas. Recommendations are made for future management to minimise the chance of similar environmental contamination issues arising in other protected areas.

Environmental protection of the Blue Mountains

The Blue Mountains became a popular holiday destination for Sydney residents, particularly since the construction of the first railway link between Sydney and mountains in the late 1800s. Over time, the impressive scenery of the area has become increasingly widely appreciated. The bushland has also become a popular destination for bush walking and camping along walking trails (Macqueen, 2007).

Over the 20th century there was a gradual increase in the recognition of the environmental values of the Blue Mountains. Conservation of large tracts of the area was advocated by the Sydney Bushwalking and Mountains Trails Club from early in the 20th

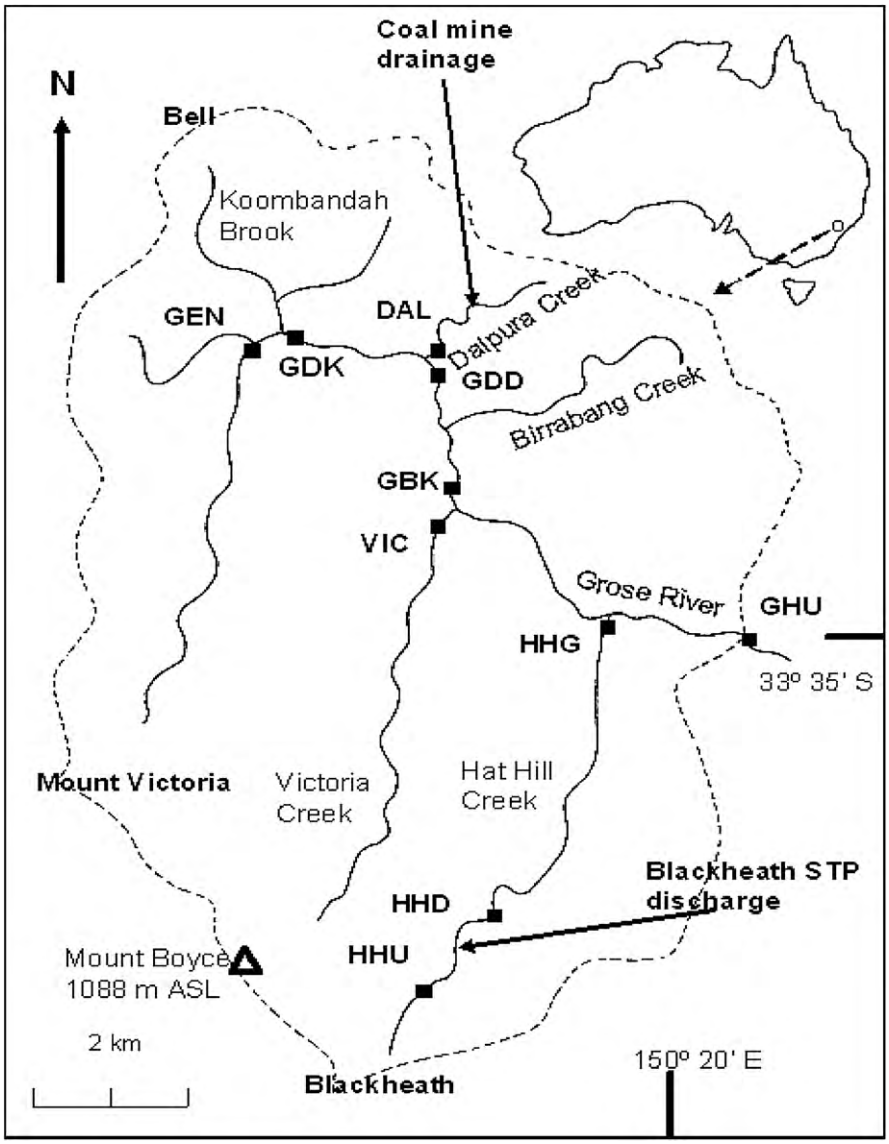

Fig. 1. Map of survey sites (square symbols), waterways and waste discharge points in the upper Grose River study area (sampled by Wright and Burgin, 2009a). Approximate catchment boundary of study area is indicated by dashed line. Inset shows location of study area in south-eastern Australia.

century (Macqueen, 2007). In the 1930s they were a small, but vocal and articulate group led by the pioneer Australian conservationist Myles Dunphy. In 1932 he presented a far-sighted and ambitious plan for a Blue Mountains National Park with 'primitive-areas'. However government action to formally protect the area was slow, although a watershed decision for the area was the 1959 gazettal of the initial segments of the Blue Mountains National Park (Mosely, 1999). Its boundary has since expanded, and in 1974 management responsibility for the national park estate was entrusted to the newly instigated New South Wales National Park and Wildlife Service (NPWS), now a division of the Department of Environment and Climate Change and Water (DECCW). The Australian Commonwealth Government also gained environmental management responsibilities in the Blue Mountains with the listing of the Greater Blue Mountains Area as a World Heritage Area in 2000 (DECC, 2009).

Sewage effluent disposal

The Blue Mountains encountered widespread water pollution from 12 sewage treatment plants that serviced the wastewater needs generated by townships of the Blue Mountains (Berman et al., 1987). Six of the STPs used to discharge directly to National Park streams. In 1980 the management of the area's sewerage (and water supply) system was transferred from the Blue Mountains City Council to the Sydney Water Board (now Sydney Water Corporation). The condition of the STPs at transfer was regarded as being 'antiquated' (Commonwealth Government, 1998). The Water Board admitted that water pollution from the Blue Mountains STPs caused unacceptable water pollution to Blue Mountains streams, particularly to waterways within the National Park boundary (MWS&DB, 1987). A 20-year improvement strategy has led to major modifications to the Blue Mountains sewerage system and treated effluent is now released to waterways away from the National Park. This has been achieved by transferring the effluent flows to a large treatment plant at Winmalee, in the lower Blue Mountains, that now releases its wastewater effluent to a small tributary of the Nepean River (Sydney Water, 2009).

Coal mining pollution

Coal seams exist under much of the Blue Mountains and coal mining was identified as a potential source of environmental conflict in the Blue Mountains World Heritage nomination (Commonwealth Government, 1998). Across New South Wales coal mining is licensed under the *Mining Act* (1992) and administered by the New South Wales (NSW) Department of Mineral Resources, now part of the NSW Department of Industry and Investment (I&I). Previously, coal mining in NSW was regulated by the *Mining Act* (1906) and more recently the *Coal Mining Act* (1973). However, under the *National Parks and Wildlife Service Act* (1974) coal mining was not a permitted activity in NSW national parks.

The New South Wales Government has regulated water pollution from point-source waste discharges since the early 1970s, initially under the *Clean Water Act* (1971) by the State Pollution Control Commission, and more recently under the *Protection of the Environment Operations Act* (1997) by the Environment Protection Authority (EPA, now a division of DCCEW). This approach to regulation and control of water pollution has relied on a 'command and control' approach, with licences being issued for discharges into waterways. These 'Environment Protection Licences' under the *Protection of the Environment Operations Act* (1997) specify concentration limits for various pollutants that are permitted to be discharged. This is an equivalent 'permit' approach to that pioneered in the United States (US) under the US *Federal Water Pollution Control Act* (1948), now the US *Clean Water Act* (1972). As with NPWS, the EPA has also been incorporated into the larger NSW environmental agency DECCW.

The Grose River

The Grose River catchment is nestled in the approximate centre of the Greater Blue Mountains area, to the immediate north of the urban corridor that runs between Penrith and Mount Victoria. The Grose River forms part of the headwaters of the Hawkesbury—Nepean River, one of the largest coastal draining river systems in south-eastern Australia. It rises at nearly 1000 m, near Mount Victoria and flows without barrier to its confluence with the Hawkesbury—Nepean River. At its closest point, the Grose River catchment is approximately 60 km west of Sydney (Fig. 1). The area is rugged, with deeply incised sandstone and shale canyons, valleys and gorges. Much of the area is not serviced by vehicular or walking trail access (NPWS, 1999).

The majority (approximately 95%) of the upper Grose River Catchment is natural bushland in undisturbed condition due, in part, to its rugged nature and lack of formal access (NPWS, 1999). The margins of the catchment are subject to human disturbance including the two small townships of Blackheath and Mount Victoria, local and main roads, and a passenger and goods railway line. Despite the protection of a large proportion of the Grose River catchment as a protected area (National Park, Wilderness Area, World Heritage Area), the Grose River has suffered two different forms of water pollution. The first was organic pollution from treated sewage effluent from Blackheath sewage treatment plant (STP) (Wright and Burgin, 2009a). The second was contaminated drainage from a derelict coal mine, the Canyon Coal Mine.

Blackheath sewage treatment plant

Blackheath STP was built in 1938. It was one of the six Blue Mountains treatment plants that discharged wastewater into National Park streams. Ownership and management of Blackheath and all other Blue Mountains STPs were transferred from Blue Mountains City Council to the Sydney Water Board in 1980 (MWS&DB, 1987). It was the last of the STPs that discharged to waterways flowing into Blue Mountains National Park. Blackheath STP was closed and demolished in mid-2008 (Sydney Water, 2009). For 70 years it had discharged effluent into Hat Hill Creek, a tributary of the Grose River in the headwaters of the Hawkesbury—Nepean River catchment (Fig. 1). The Blackheath plant was situated a short distance upstream of this National Park boundary, and provided secondary treatment of wastewater from approximately 5000 residents (EPA, 2008). Since its closure, sewage from Blackheath is transferred to Winmalee STP in the lower Blue Mountains for treatment and disposal to a tributary of the Nepean River (Sydney Water, 2009).

The Blackheath STP was licensed to discharge wastewater under conditions detailed in Environment Protection Licence (EPL) 1712, under the *Protection of the Environment Operations* (POEO) *Act* (1997). The licence specified a set of conditions which included limits on the concentration of pollutants allowed in waste discharges for 16 pollutants, mostly heavy metals and nutrients, with average and 90th percentile limits specified for each of the pollutants (see Table 1; EPA, 2008). The effluent outflow ceased in mid-2008 with the STP being fully decommissioned.

While in operation, effluent discharges from Blackheath treatment plant caused organic pollution of Hat Hill Creek and the

Table 1
Pollutant discharge limits in the Blackheath STP and Canyon Coal Mine Environment Protection Licences. All units in micrograms per litre unless otherwise specified.

Attribute	Blackheath STP EPL #1712		Canyon Coal Mine EPL #558
	Average	90th percentile	100th percentile
Aluminium	870	6100	–
Cadmium	0.2	0.7	–
Copper	35	96	–
Cyanide	57	500	–
Iron	610	8100	1000
Lead	4.4	7.6	–
Mercury	0.8	1.3	–
Total nitrogen (mg/L)	–	45	–
Total phosphorus (mg/L)	–	10	–
Zinc	90	240	5000
Hydrogen sulphide	340	2300	–
Chlorine (mg/L)	–	6.1	–
Nitrogen (ammonia) (mg/L)	–	35	–
BOD (mg/L)	10 (1)	20	–
TSS (mg/L)	10 (1)	20	–
Faecal coliforms (colonies per 100 mL)	–	200 (2)	–
Oil and grease (mg/L)	Annual load limit 1570 kg	10	

Grose River. While still in operation in 2003, total nitrogen (N) and total phosphorus (P) levels in Hat Hill Creek were elevated approximately 130 times above background levels (Wright, 2006). Nitrogen rose from 102 μg/L above the sewage effluent outfall to 14,316 μg/L downstream. Phosphorus rose from 3.8 μg/L above the STP to 507 μg/L below (Wright and Burgin, 2009a). Although pollution levels dropped with distance downstream, nutrient levels remained substantially above background levels and lifted nutrient levels in the Grose River. Based on a 2003 survey of macroinvertebrates, waste discharges from Blackheath STP also had an adverse impact on aquatic ecosystems (Wright and Burgin, 2009a,b).

The Canyon Colliery

For more than 50 years the Canyon Coal Mine conducted underground coal mining in the upper north-west corner of the Grose River catchment. The mine lease was granted before the area was declared National Park (Macqueen, 2007). Two drainage shafts from Canyon Colliery were constructed in the late 1970s to dewater the mine, directing the majority of the flow into Dalpura Creek, a tributary of the Grose River (Catalyst, 2008). A second drainage shaft was also constructed, directing a lesser volume of mine drainage into Jinki Creek, another small tributary of the Grose River (Fig. 1). The mine was closed in 1997 because it had exhausted its coal lease (Macqueen, 2007). Consequently, the mine was permanently closed in 1997 and the lease was surrendered in 2005. Effluent from the mine continues to flow into Dalpura and Jinki Creeks (I. Wright, pers. obs., November 2009).

The mine drainage from the derelict Canyon Coal Mine is contaminated with ecologically damaging levels of zinc (Wright and Burgin, 2009a,b) due to 'acid mine drainage', a common environmental problem in coal and metal mines (Johnson, 2003). Zinc can be highly toxic at trace levels to aquatic biota (ANZECC and ARMCANZ, 2000). In 2003, about 6 years after the mine ceased operation, a analysis of water and river invertebrates concluded that the Grose River was impaired due to the mine drainage (Ian Wright, Ph.D. Thesis, 2006). Zinc levels in the upper reaches of the Grose River rose from less than 10 μg/L zinc to 388 μg/L due to the inflow from the mine (Wright and Burgin, 2009a). While zinc levels dissipated with distance downstream, they were all higher than the ANZECC and ARMCANZ (2000) guidelines for aquatic ecosystem protection (trigger value for protection of 95% of species of 8 μg/L). Macroinvertebrate survey results confirmed that the mine waste was having an adverse toxic impact on the stream-dwelling macroinvertebrates of the upper Grose River (Wright and Burgin, 2009a,b).

Canyon Coal Mine was operated according to conditions detailed in Consolidated Coal Lease (CCL) 742 approved in February 1990 by the then New South Wales Minister for Mineral Resources. This Lease provided the government's expectations for environmental management, and other matters, for the operation of Canyon Coal Mine. The Lease contained a clause (No. 27) that addressed the issue of water pollution:

> The registered holder shall provide and maintain to the satisfaction of the Minister efficient means to prevent contamination, pollution, erosion or siltation of any stream or watercourse or catchment area or any undue interference to fish or their environment and shall observe any instruction which may be given by the Minister with a view to preventing or minimising the contamination, pollution or siltation of any stream, watercourse or catchment area, or undue interference to fish or their environment.

As with the Blackheath STP, the discharge of wastewater from the coal mine was also regulated under the *Protection of the Environment Operations Act* (1997) with a licence for point source discharge of wastewater, 'Licence EPL 558' (EPA, 2001). The Colliery Licence only specified three pollutants, including zinc concentrations, to a maximum of 5000 mg/L of effluent (Table 1). Following cessation of the mine's commercial production of coal in 1997, the pollution discharge licence for the coal mine was surrendered in 2001.

The *Mining Act* (1992) provides that conditions may be imposed on mine leases that require environmental rehabilitation of a mine site after mining activity has ceased. The lease for Canyon Colliery (CCL 742) included clauses explaining the required rehabilitation that would be expected after the mine activity ceased. Repair to disturbance to the natural environment is carried out by the former lease holder, according to a mine closure plan that must be approved by Department of Primary Industries (DPI). Advice from DPI discussed the rehabilitation of surface works at the mine—this included the demolition of buildings and revegetating of the disturbed area at the surface workings of the Mine (I. Wright, pers. comm. from DPI, 16 October 2008). The zinc polluting discharge flowing from the Mine was not part of the rehabilitation plan (Letter from DECC Director-General to I. Wright, 22 January 2008). We believe that this was an oversight by DPI.

Since the commercial operation at Canyon Colliery ceased in 1997, and the coal lease was surrendered in October 2005, the DPI has been responsible for overseeing the environmental rehabilitation of the natural environment previously disturbed by the coal mining activity.

Critique of New South Wales regulatory system for coal mining and STP effluent pollution

There are shortcomings in the NSW regulatory system controlling coal mining and water pollution, which emerge from this case study. A major shortcoming is that the water pollution licensing system focusses on procedural requirements as opposed to achieving environmental outcomes. For example, the receiving waterways below both waste discharges are tributaries that flow directly into a highly valued conservation area (National Park, Wilderness Area and World Heritage Area). We consider that the licence would have been more likely to succeed in protecting the condition of the upper Grose River if it had specified ongoing monitoring of the health of the stream environment, rather than only specifying end-of-pipe discharge limits from both the coal mine and the STP. As was identified by the ecological research conducted by Wright and Burgin (2009a,b) both waste discharges were causing significant degradation of the health of the river ecosystem below each point source discharge.

Other shortcomings include the lack of opportunity for public input to the pollution licensing system, and the lack of implementation of the legislation to realise the bold objectives of the POEO Act. One of the main objectives of the Act is 'to protect, restore and enhance the quality of the environment in New South Wales, having regard to the need to maintain ecologically sustainable development'. Under the licensing conditions of both water pollution discharges in this case study, it appears unlikely that either waste discharge could have satisfied the objectives of the POEO Act. In particular, both pollution sources failed to: '*protect, restore and enhance the quality of the environment*' (POEO Act, Section 3 Objective a).

This is, at least in part, because despite the extensive regulatory regime for pollution in NSW, the current system focusses on process as opposed to environmental outcomes. This approach is a common criticism of the 'command and control' regulatory approach to pollution (e.g., Bates, 2002). If environmental outcomes had been stated in the pollution licensing process, we find it inconceivable for a licensed zinc discharge of 5000 μg/L in a World Heritage Area where background levels are below 10 μg/L. The permitted level of zinc from the Canyon Coal Mine was more than 600 times the Australian water quality guideline for zinc of 8 μg/L. The only scenario under which such an outcome could be acceptable for environmental protection would be where the waste discharge was strongly diluted by river flows. Based on data collected in 2003 in the Grose River (Wright and Burgin, 2009a), it was estimated that the Canyon Colliery contributed approximately 40% of the Grose River flow immediately below Dalpura Creek. Given such a low degree of dilution, 5000 mg/L of zinc is substantially above recognised safe levels for aquatic ecosystems (ANZECC and ARMCANZ, 2000). Under such conditions, even maintaining strict adherence to the licensing conditions would not have provided environmental benefits to the Grose River.

This lack of protection would have been less likely to occur if the community had the opportunity to have input into the pollution licensing system. However, there is no public submission process for input into granting or setting licence limits of waste discharge agreements, 'Environment Protection Licences', under the POEO Act. The licence limits are set at the discretion of DECCW. Once planning approval has been provided by the NSW Planning Minister, under the *Environment Protection and Assessment Act* (EP&A) (1979, amended 2008), an Environment Protection Licence may not be refused and must be substantially consistent with any approval given by the Minister (s 75V EP&A Act). In the future, all applications for planning approval of coal mines will be dealt with under Part 3A *Environmental Planning and Assessment Act 1979*, as directed by Schedule 1, *State Environmental Planning Policy (Major Projects), 2005*. This means that there is no direct avenue for public participation in the licensing process, or in setting licence limits and, in addition, there are no third party rights of appeal once a licence is issued.

The review of Environment Protection Licences is required within 5 years of their issue, and public notification is required, however public submissions are not required to be sought or considered in any changes to the licence. When the *Protection of the Environment Operations Bill* 1997 was debated by the New South Wales Parliament there were concerns raised about the lack of public participation in the licensing system, with greater opportunities for input and appeal in similar pollution licences in Queensland, South Australia and Victoria (Smith, 1997).

The difficulty in ensuring that strict environmental outcomes are maintained is that the licensing process must balance the need to protect the environment with the benefits to the community from undertaking activities such as mining (Farrier and Stein, 2006). Establishment of discharge limits perhaps requires continuous modification of licence conditions based on regular monitoring that is focussed on environmental protection. However, it is unclear who is currently responsible for the coal mine drainage, given that it continues to flow and pollute, despite its environmental protection licence being surrendered. This has occurred despite many worldwide examples where pollution continues after commercial production ceases, often associated with mining or industrial sites, such as the closure of coal mines in the United Kingdom (Younger, 1993).

Although the senior author sought the rationale from senior officers in DPI as to why the mine rehabilitation plan did not address the continued discharge of pollution, an answer was not forthcoming. It is our view that the process for surrendering a licence should have involved checking to ensure that the waste discharge has ceased, which it clearly has not, we suggest that the POEO Act needs modification to ensure that licences are not surrendered if they still generate pollution.

Now that the licence has been surrendered, potentially the most logical approach to rehabilitation from the NSW Government is to obtain funds from the *Derelict Mines Program*, administered by a joint steering committee that comprises DECCW and I&I. Based on the priorities of the program (risks to public safety, pollution impacts, contamination, erosion or land degradation, and public concerns), realistically the only criteria that would meet the guidelines is 'pollution impacts'. Even if public concern for pollution of a seldom visited wilderness area was substantial, the type of rehabilitation offered (detailed site assessment, reduction of safety hazard by fencing and fillinGaps ig shafts, management of water and sediment movement, acid mine drainage management, monitoring and revegetation of sites; I&I, 2009) are also not a good match with the restoration requirements of the site.

Commonwealth involvement in the Grose River

The role of the Commonwealth Government in regulating environmental matters is constrained by its powers established under the Constitution (s 51) with regulation focussing on matters of national significance, including nationally threatened species,

Ramsar wetlands, World Heritage Areas and migratory species, which are covered by the Commonwealth *Environment Protection and Biodiversity Conservation Act* (EPBC) (1999). The EPBC Act establishes an assessment and approvals process for actions that may significantly impact a matter of national environmental significance, of which world heritage areas are one (EPBC Act, Part 3). This means that any new activity which is proposed that may significantly impact a World Heritage Area, or values that have been identified as having national significance, requires approval from the Commonwealth Government under the EPBC Act. The two waste discharges that caused pollution to the Grose River began before the Blue Mountains World Heritage Area was nominated, and indeed before the EPBC Act was enacted. The EPBC Act lacks provisions to deal with existing impacts that degrade World Heritage Areas. Under the current Act, if the Canyon Colliery was to lodge a development application, the Federal Minister for the Environment would have the power to refuse approval based on the impact of the mine on the World Heritage Area. However, there is no power under the EPBC Act to order remediation or clean up of existing pollution, or to assess the impacts of existing actions. The limited scope of the Act and its resulting inability to deal with often serious threats to the values of areas of national environmental significance has been highlighted in the recent independent review of the EPBC Act (see EDO submission on the EPBC Act online at http://www.edo.org.au/edonsw/site/policy.php).

There are two important precedents where the Commonwealth Government has taken direct action to rehabilitate or prevent freshwater pollution from mine activity. Firstly, the Commonwealth Government created the Supervising Scientist to be an environmental watchdog for uranium mining at the Ranger Uranium Mine, in the Kakadu area, Northern Territory (Commonwealth Government, 2009b). This was created following the Ranger Uranium Environmental Inquiry, conducted from 1975 to 1977, which found that the proposed mine could result in unacceptable environmental damage. The Commonwealth Government accepted the findings of the enquiry and created the Office of the Supervising Scientist in 1978, under the Commonwealth *Environment Protection (Alligator Rivers Region) Act* (1978) to ensure that all aspects of the mine were carried out in a manner that would protect the environment. The Office of the Supervising Scientist is probably a unique body of its kind in Australia that provides independent assessment with a clear central objective of ensuring that the mining does not damage the local and regional environment. It also funds a substantial research program that allows it to generate scientific knowledge to help it fill information gaps that may impede the Office making a decision based on relevant scientific knowledge (Commonwealth Government, 2009b).

A second precedent was the Captains Flat mining area in NSW, which had been generating severe heavy-metal pollution of the Molonglo River for many decades (Nicholas and Thomas, 1978; Norris, 1986). In 1976, the Commonwealth Government funded extensive environmental rehabilitation of the former contaminated mine site to mitigate and reduce water pollution. The reason for the action was perhaps not to protect a river in a National Park or World Heritage Estate, but may have been prompted because of its strategic importance to the landscape of Australia's capital city as Lake Burley Griffin, Canberra, is an artificial impoundment of the Molonglo River.

The Grose River case study is a reminder that the Commonwealth and New South Wales environmental relationship remains young and has potential for improvement. Understandably, from time to time, problems occur that are not adequately managed by one of the two levels of Government best suited to deal with the issue. Perhaps such limitations relate to the 'Constitutional uncertainty' that was discussed in the 1999 Senate review of the Commonwealth Environmental powers (Parliament of Australia Senate, 1999). Although there appears to have been continued reluctance to intervene, the review did suggest that the Commonwealth Government should take a stronger role in environmental matters, with the Senate Committee's recommendations:

> The Commonwealth should exercise a leadership role in the protection and improvement of the Australian environment. This role should be supported by the unsparing use of all Constitutional power available to the Commonwealth to act in the field of the environment.

Outlook for water pollution in the upper Grose River

As previously indicated, Blackheath STP was closed in mid-2008 and the disposal of treated sewage to Hat Hill Creek was terminated. Sampling in the area by the senior author (unpubl. data) in Hat Hill Creek, 18 months after the treatment plant closure has indicated that the improvement of water quality was considerable. Water quality below the outflow had improved to a level effectively equivalent to background water quality. However, the outlook for the water pollution in the upper Grose River remains bleak due to the continued heavy-metal contamination from the Canyon Coal Mine. Overseas examples of derelict coal mines suggest that the pollution may continue for centuries (e.g., Herlihy et al., 1990; Younger, 1993).

Lessons to be learnt from past errors

There are three broad issues behind the previous and current water pollution in the upper Grose River that could be better managed in the future: (1) setting of waste licence limits for specific pollutants and protection of receiving waterway values; (2) regulation of continuing pollution after closure of a mine; and (3) collective action between all regulatory authorities and both levels of Government.

In terms of setting licence limits for pollution licences, our biggest criticism of the current system is that licences should be set in a manner that ensures discharges do not threaten identified environmental values in the receiving environment. The ANZECC and ARMCANZ (1992, 2000) water quality guidelines provide a recommended approach (for all Governments in Australia and New Zealand) for developing locally relevant guidelines to meet certain waterway outcomes. In the case of the Grose River the uses and values of the receiving waterway would probably have been 'Protection of the aquatic ecosystem' given the sensitivity of the area and the aims of the *National Parks and Wildlife Act* (1974).

The environmental impact of sewage pollution in the upper Grose River was recognised as being unacceptable, and was solved, but coal mine drainage was ignored. The closure of Blackheath STP and 11 other STPs in the Blue Mountains was largely due to Sydney Water Board's bold decision in the late 1980s to remove sewage pollution from high conservation value waterways in the Blue Mountains. This was identified by the Water Board in a landmark 'environmental value approach' to sewage management (Berman et al., 1987), as reported in the Water Board's 1988–1989 Annual Report:

> Consideration is being given to a scheme to transport effluent out of the National Park area for treatment at Winmalee. This scheme would avoid completely the addition of any (treated) effluent to streams within the Blue Mountains National Park.

The ongoing problem of mine drainage from the Canyon Coal Mine has never received similar attention and action to sewage pollution. After the mine's closure, all government agencies appear

to have failed to address the water pollution that continues to be emitted from the coal mine. It is unclear why the mine owners were not required to decontaminate the mine drainage. We suggest that, no matter how remote the area, all applications for surrender of waste discharge licences/coal mine leases should include a thorough physical assessment to ensure that the contamination has ceased. There appears to have been limited dialogue between the two (NSW) regulatory agencies that managed the coal mine (DMR) and the water pollution (EPA), particularly during the months before and after the coal mine closed in 1997. DMR regulated the mining activity, and also has responsibilities for the formal 'mine closure' process that operates when a coal mine's operations permanently cease. At the time of writing, the mine has been closed for 12 years, and although terrestrial rehabilitation of the mine is still underway and appears to have been focussed on areas disturbed by surface operations at the mine, there has been no activity to remediate the mine drainage pollution.

Conclusions

There has been considerable debate on the topic of conservation of freshwater aquatic reserves in Australia (e.g., Fitzsimmons and Robertson, 2005) and internationally (e.g., Moulton, 2009). The Grose River situation is perhaps of some relevance for this debate. The Grose River flows within a catchment that is broadly protected by the Blue Mountains National Park, but this has not prevented the river itself from being polluted. This case study reinforces the importance of integrated natural resource management for waterways and their catchments. All major sources of disturbance and pollution of a river within its watershed need to be considered. The two pollution sources in the Grose River came from relatively minor land uses, but collectively had a disproportionately negative influence on the water quality and ecological health of the Grose River.

Perhaps all point sources of water pollution should be subject to 5-year licence reviews to ensure that any adverse environmental impacts they create are not beyond reasonable limits. If problems were identified, actions could be directed to reduce the impacts. This could also include reassessment of security bonds retained by government to ensure that they remain commensurate with the passing of time and/or increase in line with inflation. We note that the security bond on the Canyon Coal Mine, as approved in 1990, was the comparatively trivial amount of AUD$133,500.

In relation to the continuing pollution, the ecologically toxic coal mine drainage (Wright, 2006) may have 'fallen through the cracks' in regulations between the responsible agencies, with the Department of Primary Industries' mine closure plan having only had regard for the surface works, and the Department of Environment and Climate Change accepting the surrender of the Environment Protection Licence. In both cases, it appears that regulatory authorities failed to hold the owners of the coal mine responsible for long-term remediation of the drainage beyond the commercial life of the coal mine. As a consequence of inaction it appears that the Grose River will join a growing international list of derelict mines that continue to contaminate rivers and lakes (e.g., Johnson, 2003).

Perhaps an unusual feature of the Grose River contamination is that it has occurred in such an environmentally valued river, flowing in the centre of such highly protected lands (National Park, Wilderness Area and World Heritage area) that are also thoroughly regulated by NSW and Commonwealth Government agencies. It begs the question: if this continued drainage from a coal mine is allowed to continue to pollute a river in such an environmentally significant and protected area, what are the chances of similar pollution at less protected areas?

Recommendations

In summary, we suggest that the Grose River pollution may be regarded as an Australian case study from which lessons may be learnt for improved management of coal mining, water pollution and protection of high-conservation catchments and rivers. We recommend that permissive discharges of waste material to waterways (termed Environmental Protection Licences in NSW) clearly detail the values of the aquatic environment that they intend to protect. This should be consistent with community-derived aims and values for the receiving environment. Scientifically credible and comprehensive environmental indicators that are consistent with Australian Water Quality Guidelines (ANZECC and ARMCANZ, 2000) need to be regularly monitored in the receiving environment, as well as the waste discharge, to ensure that the impact is within specified limits. Environmentally robust discharge licences are needed to protect waters from pollution impacts and enable timely corrective actions to be taken to reduce, or remove, unacceptable waste releases. An improvement in regulation and protection of rivers from pollution would reflect an increasing public demand for protection of the environment (e.g., DECC, 2006).

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