This online textbook provides free access to a comprehensive education and training package that brings together the knowledge of how countries, specifically Australia, can adapt to climate change. This resource has been developed formally as part of the Federal Government’s Department of Climate Change’s Climate Change Adaptation Professional Skills program.

Chapter 3: Identifying & Implementing Water Efficiency & Recycling Opportunities by Industry Sector

Lecture 3.3: The Mining Sector
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Peer Review

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Review for this program was received from: Alex Fearsside, Leader of the Sustainability Team, Melbourne City Council; Alison Scotland, Sydney Water Corporation; Anna MacKenzie, ACT representative, Australian Association of Environmental Education and Deputy Principal Campbell Primary School; Anntontette Joseph, Director – Urban Water Efficiency Initiatives, Commonwealth Department of Environment, Water, Heritage and The Arts; Barry Coker and Jeffrey Briggs, St Andrews Hospital, Brisbane; Dr Barry Newell, ANU Fenner School of Environment and Society, Facilitator of ANU Fenner School of Environment and Society’s Climate and Water Integration Group; Caleb Furner, Sydney Water Corporation; Carl Binns, Sydney Water Corporation; Claire Hammond, Sydney Water Corporation; Cheryl Davis, International Water Association; David Dumaresq, ANU Fenner School for Environment and Society, Senior Lecturer Human Ecology, Agro-ecology, and Sustainable Systems; Dennis Lee, Sydney Water Corporation; Glenn MacMillan, Genesis Now Pty Ltd; Jill Grant, Director Sustainable Development, Commonwealth Department of Resources, Energy and Tourism; Karen Jacobson, Commonwealth Department of Resources, Energy and Tourism; Kevin Moon, Institute of Hospital Engineering Australia; Kieran Coupe, Manager, MeterMate, Water and Energy Managers; Nick Edgerton, AMP Capital Sustainable Share Fund (formerly the Institute for Sustainable Futures, University of Technology Sydney, Australia); Para K Parameshwaran, Sydney Water Corporation; Adj. Prof Paul Perkins, Australian National University, Chair, Environment Industry Action Agenda and Barton Group; Dr Marguerite Renouf, Director UNEP Working Group for Cleaner Production, University of Queensland; Phil Smith, President of the Australian Association of Environmental Education; Rob McKenna, Energy Saving Specialist, Water & Energy Programs, NSW Department of Environment and Climate Change; Sally Armstrong, Sydney Water Corporation; Stan Scahill, The Institution of Engineers Australia (Biomedical Engineering College); Stephen Fahey, Environment Officer (Energy & Water), ANU Green; Victoria Hart, Facilitator and Program Director, Sustainability Victoria; and Vivian Filling, Australia Industry Group.

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Adapting to Changes in Water Availability - Industrial & Commercial Sectors

Lecture 3.3: The Mining Sector

Educational Aim:
The aim of this lecture is to provide an overview of the opportunities to save water in mining operations.

Learning Points
1. Water is essential for a mining operation, and as it is involved in all stages of the process there are a range of opportunities to reduce its consumption, while protecting the supply and receiving natural systems.

2. There are clear economic, environmental and social reasons for adopting best practice in water management in mining operations, considering that, as the Minerals Council of Australia points out:¹
   i. Water is essential and vital for all aspects of the mining process, and in many countries, such as Australia, the economic value of water is rising due to growing demand and increasing scarcity,
   ii. There are direct financial consequences of poor operational water management, such as not matching water requirements with supply and running out of water, compromising the process and the quality of the product,
   iii. Water management can affect the connection and special interests of indigenous people to Australia’s lands and waters, particularly native title rights and interests,² and
   iv. Poor water management that leads to failures in pollution control, such as the performance of tailings dams, can lead to catastrophic consequences for receiving river or groundwater systems.

3. Failure to plan for such considerations can result in loss of licence to operate and not only affect a company locally but, in the internet age, can rapidly become an international issue affecting shareholder value.³ The value of clean water is now seen as an important social and environmental good, therefore mining operations with poor water management are likely to experience a flow-on of negative social and economic consequences. These can include, losses of key staff and difficulties in recruitment, a drop in investor attractiveness, obstacles to accessing other key resources such as ore bodies, land or water, and difficulties with operational licences - all leading to a decrease in shareholder value, especially if better performing companies take over contracts.

4. The experience of leading researchers in this field, for instance at the ‘Centre for Water in Mining’ at the University of Queensland, shows that ad hoc approaches to water management in mining rarely capture a significant potential of the freshwater savings available. Also ad hoc approaches, by definition provide little chance of the most cost effective water saving investments to be identified. Their research has found that, to realise the potential for water savings in this sector, the first step is to effectively measure, monitor and account for water use. This can involve forming a water management committee involving key representatives from relevant parts of the company and ensuring that relevant responsibilities are built into job descriptions.

5. When developing a water management plan and starting to measure, monitor and account for waste usage, all current and potential sources of water need to be taken into account. From an operational perspective, water is classed as either raw (not previously used for a task) and worked (used for a task at least once). Raw primary water sources refers to not just water from rivers, lakes or groundwater but also refers to rainwater, reuse of treated effluent, and from mine dewatering. Worked, or used/recycled, water, can be sourced directly from tailings thickener overflow, filtration plant filtrate or site stormwater runoff. Worked water can also be sourced from tailings dams, washdown bay discharge, acid mine drainage, runoff and seepage. Examining the various potential water sources provides the opportunity to develop strategies to achieve significant reductions in the use of surface freshwater resources and groundwater while maximising water reuse.4

6. The benefits of taking the time to undertake an assessment of the various water sources is shown by the studies on mine sites water usage by the ‘Centre for Water in Mining’ at the University of Queensland. For instance, Dr Claire Cote and Professor Chris Moran have undertaken a whole of system analysis of water usage in coal mining in the Bowen Basin of Queensland.5 Their analysis, which examined a range of possible ways to reduce freshwater use and maximise water reuse, suggests that it should be possible to maintain current levels of coal mining whilst reducing freshwater usage by 70 per cent, and total net overall water usage by 40 per cent across the entire Bowen Basin of coal mines.6

7. Another practical example of the benefits of undertaking a whole system analysis of potential water savings is of Newcrest’s Cadia Valley Operations, located 25 kilometres south of Orange in the New South Wales Central Tablelands. As the Minerals Council of Australia states, ‘The operation consists of the Cadia Hill open pit and Ridgeway underground mines. Combined they produce 23 million tonnes per annum of ore, which is treated through a shared ore treatment facility producing 690,000 ounces of gold and 72,000 tonnes of copper a year. On average, 80 per cent of water used at the operation is internally recycled. Water makeup is sourced, in order of priority, from site runoff, treated effluent town water from Orange and Blayney, licensed water from the Belubula River, and the purpose-built Cadiangullong Dam.7 This example, and others like it, demonstrate how mining operations can significantly reduce freshwater usage by sourcing their water needs from a local town’s effluent.8

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8. Although some mines are achieving significant water savings there is yet to be a uniform framework for water accounting to allow constant reporting, benchmarking and transference of programs across sites. To address this, the Mineral Council of Australia (MCA) began a ‘Water Accounting Framework’ initiative in 2005. The MCA engaged the Sustainable Minerals Institute (SMI), UQ led by Professor Chris Moran and Dr Claire Cote, to ‘develop a suite of metrics’ to enable consistent accounting within industry, with the preliminary draft of a ‘National Standard for Water Use Accounting in Mining’ proposed in 2009. A summary of how this framework is designed is outlined below in the brief background reading.

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Brief Background Reading

**Potential for Fresh Water Savings in the Mining Sector**

A number of mines around the world recycle water for reuse onsite, with some having water recycling rates as high as 80 per cent.\(^{10}\) The Alcoa World Alumina ‘Water Management Strategy’ for the McCoy Crusher Site is a leading example of this, and includes a focus on maximising the harvesting and recycling of water onsite. Since being fully commissioned in January 2005, over 400ML of water has been harvested and recycled onsite. Furthermore through efforts to reduce water consumption and increase the use of lower quality water instead of potable water, Alcoa’s Western Australian mining operations reduced its potable water consumption by 42 per cent in 2005. Argyle Diamond Mine in the Kimberley Region of Western Australia obtains more than 40 per cent of its process water from tailings facility water recovery.\(^{11}\)

There are a range of options to use water more efficiently across mining operations (see Table 3.3.1) that can reduce the amount of water required on-site, and thus ensure that re-used and recycled water makes up a higher percentage of total water used on mining sites. For instance, dust suppression accounts for roughly 19 per cent of the total water yearly input in mines.\(^{12}\) According to research commissioned by the Commonwealth of Australia, strategies include ‘... route planning (with sensitivity to ambient environmental conditions, for example, less watering is required in wetter conditions), optimising truck speeds and wetting rates, application of dust suppressants, increased attention to haul road maintenance and developments of efficient spray technologies’.\(^{13}\) Also, lower quality recycled water can be used directly for dust suppression. The Australian government has published a series of sustainable development best practice reports for the mining sector that includes two reports which discuss dust suppression.\(^{14}\)

Environmental compliance in the area of water management is gradually becoming more stringent. Mine-site water management across Australia is typically governed at the state government level by a number of statutory requirements, which include the need for licences to obtain a surface water or groundwater supply and to discharge water off-site, approval to construct particularly water storage options, and a requirement to develop an ‘Environmental Management Plan’ for the mine-site. Water management past these requirements has mostly been undertaken through self-regulation on a company by company basis as required by company boards or senior management. This form of self-regulation typically includes the use of overarching principles, operational strategies and quantifiable targets. Companies increasingly are using voluntary sustainable development frameworks to guide these efforts, such as the ‘International Council on Mining & Metal’s Sustainable Development Framework and Principles’,\(^{15}\) the ‘Australian Minerals Industry Framework for Sustainable Development - Enduring Value’,\(^{16}\) the ‘Strategic Framework for Water Management in the Minerals Industry’,\(^{17}\) and the ‘Global Reporting Initiative - Mining & Metals Sector Supplement’.\(^{18}\)

\(^{14}\) Environment Australia (1988) Dust Control, Best Practice Environmental Management in Mining Series, Commonwealth of Australia
Such efforts are allowing leading mining operations to operate beyond compliance levels for water management, delivering strong economic results along with positive effects on social licence.

**Water Management Plans – Responsibility and Incentives**

As outlined in Chapter 2, effective water management involves a range of systems and strategies, informed by accurate measurements and monitoring. Implementation of programs is both a technical and a social challenge with a range of new skills required by staff, calling for effective capacity building of personnel involved in water management. Furthermore, relevant responsibilities for water management across different areas of the operation should be clear, such as being included into job descriptions and staff incentives. For instance,

- at the corporate level, staff should be responsible for developing and implementing the water management plan, including contingencies for flooding and drought conditions, and integral to the broader company-wide environmental management system.

- at the mining operations level, staff should be responsible for developing and implementing site specific water management plans - also planning for potential risks of flooding or drought conditions - and integrating in to the company wide water management plan.

- at the mineral handling and processing level, staff need to be formally responsible for water use in mineral separation, dust suppression, tailings, and water recycling.

- at an appropriate level staff should also be involved in managing broader water issues, such as water flow and quality monitoring, ensuring environmental flows to the receiving environment and in playing a constructive role in local and regional water planning.

Once responsibility for water management is clear, staff bonuses and incentives can be used to encourage improved water management and motivate staff to implement new water management activities.

There is a growing amount of supporting material to inform mine site water management plans, including a DEWHA 1998 report that examines in detail a range of strategies to better manage and reduce water use across each stage of the mining process. The report provides clear step by step best practice notes for water management for each of the important stages of the mining process, as summarised in Table 3.3.1.

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Table 3.3.1 Activities at various stages of a mine’s life cycle

<table>
<thead>
<tr>
<th>Exploration</th>
<th>Shipping of Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temporary Water Supply</td>
<td></td>
</tr>
<tr>
<td>− Water resources/users</td>
<td>− Spillage</td>
</tr>
<tr>
<td>− Potable water treatment</td>
<td>− Dust control</td>
</tr>
<tr>
<td>− Discharge of excess drilling water</td>
<td></td>
</tr>
<tr>
<td>− Waste water disposal</td>
<td></td>
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<tr>
<td>− Site stormwater management</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Resource Development and Design</th>
<th>Rehabilitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>− Water supply – identification and quantification</td>
<td>− Post-mining landform drainage design</td>
</tr>
<tr>
<td>− Impacts of water abstraction/diversion on local</td>
<td>− Contaminated site remediation</td>
</tr>
<tr>
<td>− Water resources/users</td>
<td>− Borefield and water supply scheme decommissioning</td>
</tr>
<tr>
<td>− Government approvals</td>
<td>− Decommissioning of mineral processing and transport facilities</td>
</tr>
<tr>
<td>− Water supply, storage and treatment (design and construction)</td>
<td>− Mine pit lake modelling and formulation of closure strategies</td>
</tr>
<tr>
<td>− Dust suppression and dewatering discharge</td>
<td>− Stakeholder approval and development of catchment management plans</td>
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<tr>
<td>− Waste water disposal</td>
<td></td>
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<tr>
<td>− Site stormwater management</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Mining, Minerals Processing and Refining</th>
<th>Post-Mining and Closure</th>
</tr>
</thead>
<tbody>
<tr>
<td>− Water supply management</td>
<td>− Rehabilitation performance monitoring</td>
</tr>
<tr>
<td>− Water treatment (worked water and potable)</td>
<td>− Erosion control and drainage maintenance</td>
</tr>
<tr>
<td>− Mine dewatering</td>
<td>− Contaminated site remediation verification</td>
</tr>
<tr>
<td>− Worked water recovery, storage and reuse</td>
<td>− Stakeholder and regulatory sign-off</td>
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<tr>
<td>− Worked water disposal (discharge management)</td>
<td></td>
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<tr>
<td>− Dust control and contamination management</td>
<td></td>
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<tr>
<td>− Catchment management (including AMD)</td>
<td></td>
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<tr>
<td>− Performance monitoring and reporting</td>
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</tbody>
</table>


**Water Management Plans – Water Accounting Systems**

Accurately accounting for the volume and quality of water flows into and out of the mine site is essential to enable an effective water management plan that can ensure legislated standards and company benchmarks are met. In Australia, one of the aims of the ‘National Water Initiative’ is to improve water resource accounting, ‘to underpin sustainable water resource management’.²² Water accounting, based on a series of measurement, monitoring and reporting protocols, can provide accurate data on the amount of water being used, re-used on site, and released into receiving environments. Water accounting in mining operations can be complex, however currently, there is no agreed national standard for water use accounting in mining. To address this, the Mineral Council of Australia began work on a ‘Water Accounting Framework’ in 2005, engaging the Sustainable Minerals Institute at the University of Queensland, led by Professor Chris Moran and Dr Claire Cote.


The research team was tasked to develop the fundamental framework and metrics for an accounting program that could be used across the mining sector to enable consistency within industry. In 2008, a draft was released for extensive consultation with a wide range of stakeholders. The proposed framework focuses on two key areas:

1. **The Input-Output Model**: Firstly the framework considers water management issues of water coming into and leaving the mine site, and considering the potential impacts on the local region including the environment, local communities, and other stakeholders.

   **Water inputs**: The framework defines water sources as including rainfall and runoff, along with water supplies including dams, lakes, rivers, seas, oceans, aquifers, entrainment (water held in process materials), municipal supply, and third-party entities.

   **Water quality**: In the framework, the general terminology for measuring water quality is ‘high quality’ and ‘low quality’, which is defined by the organisation based factors such as the water’s economic value or useful value to the local region. For example, economic value may reflect the cost of purchasing potable water (high quality) or cheaper non-potable water (low quality). Useful value may reflect the potential for using the water for irrigation or livestock drinking (high quality) or by industry only (low quality). As an example defining water quality, the definitions used in testing the water accounting framework were:

   - **High quality**: water that (1) has a total salt concentration less than 2000 mg/L and (2) does not contain any constituent that could prevent its use in site operations.
   - **Low quality**: water that (1) has a total salt concentration greater than 2000 mg/L or (2) contains a constituent that could prevent its use in site operations.

   **Outputs**: Outputs may be a mixture of water from a range of sources, including seepage, evaporation, discharge, environmental flows, entrainment and flows to other organisations or water users.

2. **The Operational Model**: Secondly the framework focuses on the use of water onsite, including processes that have an impact on water quality and quantities, classified as either;

   **Use-Treat-Store** - referring to the management of water in site operations, such that: ‘Use’ refers to processes that involve water, such as dust suppression, drinking, showering, equipment wash down, mineral concentrating/cleaning, cooling, dewatering ore bodies and processing ore; ‘Treat’ refers to processes that aim to improve the quality of water, such as cyanide destruction and physical settling, and ‘Store’ refers to the capture and holding of water.

   **Diversions** - referring to water that is moved around the site but does not serve any consumptive purpose. It is important to note that this definition is different from the definition of a diversion in the Commonwealth Water Act (2007) but similar to the definition of a ‘return flow’, with the exception that a return flow includes cooling water.

   **Status of water** - referring to whether water is ‘raw’, ‘worked’ or ‘treated’. This terminology replaces ‘reused’ and ‘recycled’, which can be confusing due to overlap and circular definitions, with raw water being classified as is all site inputs, including rainfall and runoff that is collected and stored.

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Apart from providing a uniform language and set of metrics for managing water issues the framework provides a means to ensure that information related to the minerals industry water use can be reported to the National Water Initiative and other stakeholders, such as the Global Reporting Initiative, in a consistent manner. Such efforts are further informed by the International Council on Mining & Metals Sustainable Development Framework.\textsuperscript{24} The ICMM framework is based on a set of ten principles and calls for independent assurance and public reporting. The ICMM reporting system has three indicators specifically related to water.

**Water Management Plans – Monitoring, Auditing, and Review**

Guidance on developing and implementing a system to monitor water management is provided for Australia in the ‘Australian Guidelines for Water Quality Monitoring and Reporting’, developed by the ‘Australian and New Zealand Environment and Conservation Council’ and the ‘Agriculture and Resource Management Council of Australia and New Zealand’. According to this work key aspects of a monitoring plan include the location and frequency of water sampling, choice of measurements appropriate to the local situation, and sample timing and measurement sensitivity. An appropriately designed and implemented monitoring system will allow early detection of significant deviations or breaches of predetermined thresholds to signal the need for a specific response. Priorities areas to monitor water quality and flow are locations on the mine site where:

1. there are substantial movements of water,
2. water quality could change significantly,
3. operational procedures are dependent on certain water quality parameters, and
4. where a potential hazard could occur and then impact on occupational health and safety or ecosystem integrity.

The guiding principle for water management is to ensure adequate water for mine operations, while reducing the likelihood of excess water abstraction and/or excessive discharge. Hence it is intended that an analysis of the site and proposed operations that considers the above items should identify the priorities for water monitoring, along with the specific parameters to be monitored, the sampling frequency and location of monitoring sites. When considering the release of water into receiving environments, the strictest requirements relate to the protection of aquatic ecosystems and vary between waters of high conservation value, slightly/moderately disturbed, or highly disturbed. The Commonwealth Government\textsuperscript{25} has published guidelines for receiving waters and these are enforced by the state regulatory agencies. A further minerals industry guide to applying the Commonwealth guidelines was prepared by the Australian Centre for Mining Environmental Research.\textsuperscript{26}

Key References

Corporate Sustainability and Mining


Governance and Water


Water Hydrology and Mining


Water Quality


Water Management Plans


Water Accounting


Case Studies of Best Practice


Conference Proceedings


International Organisation and Journal

