



Dr. Cherie D. McCullough

DIRECTOR, PRINCIPAL
ENVIRONMENTAL SCIENTIST

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Education

PhD Aquatic Ecotoxicology Charles Darwin University, Darwin, 2006
MSc (hons) Freshwater Ecology, Waikato University of Auckland, Hamilton, 1998
BSc Zoology, James Cook University of North Queensland, Townsville, 1994

Affiliations

Australasian Institute of Metals and Metallurgy (AusIMM) CP(Env)
Member Closure Planning Practitioners Association (CPPA)
International Mine Water Association (IMWA)
Australian Society for Limnology (ASL)

Relevant Experience

Mine Pit Lakes
Mine Closure Planning
Mine Water Impacts
Mining Rehabilitation
Environmental Monitoring and Risk Assessment
Acid and Metalliferous Drainage (AMD)
Aquatic Ecology
Aquatic Ecotoxicology



www.minelakes.consulting

SUMMARY

Cherie is Director of Mine Lakes Consulting and Principal Environmental Scientist. She has over 20 years' experience in consulting and research, focused on environmental management issues. Her career interests and experience focus particularly on the mining industry and with water resources. Cherie's primary skills are in environmental management, ecotoxicology, ecology, geochemistry and hydrogeology. Cherie is a recognised leading international expert on pit lake sustainability, closure planning and rehabilitation, with project experience across Australasia, Asia, and North and South America.

She has published over 100 peer-reviewed scientific journal and conference proceeding papers, book chapters, Commonwealth and state leading practice and industry guidelines, a book and extensive international industry articles and conference presentations on pit lakes, mine closure, aquatic ecology and ecotoxicology. Cherie has helped develop guidance for mine closure, pit lakes and mine water impacts for Western Australia, South Australia, the Commonwealth of Australia, Papua New Guinea, Canada and the Asia-Pacific Economic Cooperation (APEC).

EMPLOYMENT HISTORY

MINE LAKES CONSULTING

Director and Principal Environmental Scientist | 2017–Current
Company direction, business development and project management. Providing clients solutions for environmental and operational issues resulting from mine pit lakes, mine waters, mine closure planning.

GOLDER ASSOCIATES

Associate and Principal Environmental Scientist, Mine Closure Lead (Asia-Pacific) | 2010–2017

Mine closure lead for Asia-Pacific, project management, direction and technical lead of environmental projects, particularly major international mine closure and mine rehabilitation projects.

EDITH COWAN UNIVERSITY

Senior Research Fellow, School of Natural Sciences | 2010–2014

University and industry funded part-time role. Developer and co-Principal of Mine Water and Environment Research Centre (MiWER), collaboratively developing and managing mine restoration and sustainability research programmes from grant application to data collection and project management through to final publication.

Research Fellow–Senior Lecturer, School of Natural Sciences | 2004–2010

Developing and delivering undergraduate units across a range of scientific disciplines. Supervised four Post-Doctoral Research Fellows, two Graduate Research Assistants and three M.Sc. research



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students (all as primary supervisor). Delivering undergraduate courses in Environmental Pollution and Environmental Monitoring and Investigation. Also supervising two B.Sc. (hons) and four M.Sc. research students (three as primary supervisor). Part of the multi-institutional and multi-disciplinary Centre of Excellence for Sustainable Mine Lakes researching environmental solutions to acid and metalliferous drainage (AMD) and mine closure issues. Supported by industry and government competitive grants.

ENVIRONMENTAL RESEARCH INSTITUTE OF THE SUPERVISING SCIENTIST (ERISS)

Doctoral Researcher | 2000–2004

Doctoral researcher with the Department of Environment and Heritage. Managing multiple- lines-of-evidence environmental toxicity evaluation research project for risk assessment of mine water discharge from Ranger Uranium Mine into Kakadu National Park. Formal derivation of an ANZECC/ARMCANZ water quality guideline trigger value for magnesium through biological and chemical assessments at scales from laboratory bioassays, to natural and artificial mesocosms and at full field scale.

MCCULLOUGH FRESHWATER ENVIRONMENTAL CONSULTANCY

Director/Environmental Scientist | 1996–1999

Managing (project management, costing, tenders, grant applications, reporting, etc.) for this environmental consultancy begun during my M.Sc. degree. Provided expert advice to government and private bodies, occasionally sub-contracted to other environmental consultancies.

AUCKLAND INSTITUTE AND MUSEUM

Field Botanist | 1995–1996

Collecting, identifying and archiving 880 floral specimens for museum herbarium collections and contract pharmacological research (<http://www.aucklandmuseum.com/collections-research/collections/search/?entcl=http%3a%2f%2f.rdf.aucklandmuseum.com%2fperson%2f16482>). During this time I also developed an interest and expertise in aquatic plants.

KEY PROJECT EXPERIENCE

COPPER (PILBARA)

Mine closure planning for copper ore mine with pit lakes. Strategies for in-pit waste disposal and backfill of acid-generating wastes was made against an original strategy no back fill and pit lakes. The environmental-outcome based assessment incorporated above ground waste landforms including waste rock dumps, heap leach pads and a tailings dam. Best practice was found to be partial backfill of the pit void with a permanent water cover by the pit lake.

GOLD/SILVER & COPPER/GOLD (LAOS)

Closure standard and mine closure plan to meet international industry and stakeholder good expectations. Conceptual mine closure plan gap analysis, closure plan development and closure costing for both gold/silver and gold silver mines to meet good international environmental and social standards. A risk assessment was made by an expert panel to identify and then manage all key social, environmental and economic risks. The MCP used international and the newly developed corporate closure standards to provide a mine planning framework to direct closure activities as part of operation and closure phases.

GOLD/SILVER (PERU)

In-country development of a conceptual closure plan for a high altitude mine in the Peruvian Andes. We then developed a conceptual design and formal closure plan in both English and Spanish as part of mining application approvals. A previous operator's mine closure plan had been rejected by nearby communities, primarily because it presented risk of surge waves. The closure design was developed through consultation with the mining company and other contractors designing the operational site layout to ensure compatibility and minimize movements for closure works. The closure plan's objectives also aimed to meet both Peruvian mine closure and water quality regulatory requirements as well as the expectations of key stakeholders including concerned villagers downstream.



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LEAD (KIMBERLEY)

Risk assessment of AMD from underground mine workings on wildlife and pastoral values of a remote tropical Australian lead mine. Gap Analysis and Development of Site Management Plans (SMP) to meet Contaminated Sites regulations for mine closure planning and lease relinquishment. Following a contaminant-transport-receptor model, studies demonstrated both low existing receptor values and contaminant attenuation such that no significant environmental risk was presented by the discharge with management by simple stock and wildlife exclusion at the point source.

COAL (HUNTER VALLEY)

Coal mines of the Upper Hunter Valley District are expected to be many years away from closure. Nevertheless, ahead of regulatory requirements, regional operators have collectively begun closure planning for voids as pit lakes under the auspices of the New South Wales Minerals Council Pit lakes of this region feature a range of areas, depth and shapes. Currently, most pits are still operational and pit lake planning is only at a very high conceptual stage that has not extended to planning of individual operations. Consequently, efforts have not yet been made by operators to reshape pit walls, cover exposed coal measures, revegetate surrounding landforms, etc.

A review of national and international grey (e.g. reports) and peer-reviewed (e.g. conference proceedings, books and industry and academic journal papers) literature was undertaken to provide examples of leading industry practice mine pit void beneficial end uses examples suitable for both dry and wet pits (lakes) of the Upper Hunter Valley coal mining region. These final pit lakes will take a variety of forms, depending upon the context and final end use. Some will be completely backfilled, some partially and some not backfilled at all. Final mine closure landforms for representative mining projects were summarised across the regional landscape to provide a snap-shot of current regional closure planning. Pit lake water quality for representative pit voids of the region were also summarised and extrapolated for future water quality expectations and issues. Recommendations of potential end use options for the region were then made based upon their suitability in this mining industry and socio-environmental context. Study presentation, media and engagement with

industry members, regulators and community stakeholders was undertaken. An open workshop undertook a Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis to broadly define regional possible sustainable end uses with key stakeholders from regulators, industry and community.

ZINC/COPPER (QUEENSLAND)

Closure objectives and criteria development and conceptual closure risk assessment for different closure scenarios for an open pit void below groundwater. Scenarios assessed for further investigation included in-pit tailings disposal or no backfill, with and without either rapid-fill or permanent seasonal river diversion to maintain a water cover.

COAL (SOUTH WEST AUSTRALIA)

Development of a flow-through closure strategy following riverine breach of an acid coal mine pit lake that had been partially backfilled. We began with a literature review considering key risk and opportunities from existing, and proposed case studies for pit lakes with flow-through as a mine closure strategy. We then determined what effect unplanned river flow-through had had on water quality and environmental values lake biological, chemical and physical indicators through field studies. This work included studies of effects of AMD contaminated pit lake discharge on receiving regional river water quality and risk to loss of end use values.

A Water Management Plan (WMP) to trial a novel river flow-through closure strategy which aimed to improve pit lake water quality and meet stakeholder expectations of end uses, was developed. The WMP derived site-specific water quality trigger values and demonstrated that river water was naturally elevated in iron and manganese concentrations, and raised salt levels from deforestation; showed that water quality guidelines were not relevant for these parameters. The WMP used an Adaptive Management approach to advance the strategy within a flexible framework and monitoring program that protected values of downstream receiving systems. Regular community communication of findings and stakeholder consultation (from initial scoping studies to monitoring results and study conclusions) enabled a



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closure trial to go ahead with an aim of being a final closure. This project was shortlisted in 2015 for a Western Australian government Golden Gecko environmental sustainability award.

GOLD/COPPER (LAOS)

Data review and risk assessment of proposed closure strategy using PAF waste to backfill into a mine void pit lake in southern Laos creating a buttress against a highwall. Geochemistry, surface and groundwater quality and hydrogeology reviewed and summarised in this proposed backfill context. Formal Lao PDR risk assessment then undertaken to identify key risks. Risks included weathering of PAF to form geotechnically-competent backfill construction material, creation of (more) AMD contamination of lake water quality, discharge of contaminated lake water to ground and surface water social/environmental receptors. Risk controls included developing a better understanding of backfill geochemistry and geotechnics and for a good pit lake water balance to determine risk and mitigations required, of discharge of contaminated lake waters.

ALL COMMODITIES (WESTERN AUSTRALIA)

Development of a holistic environmental monitoring strategy for pit lakes of the Collie Coal Basin to be used by regulators, industry and consultants for both these and other pit lakes in the state. Advice was given to leading international industry standards on all elements of sampling including: sampling objectives, health and safety issues, key physical, chemical and biotic instrumentation, sample QA/QC and data analysis and reporting.

COAL (LATROBE VALLEY)

Expert mine closure planning advice to company and representative expert for the Hazelwood Mine Fire Inquiry.

Literature review of science and case-studies for considering erosion caused by wave action at mine lake closure

Hydrodynamic transport process modelling to determine shoreline erosion under different batter rehabilitation designs. MLC collaborated with a European research organisation to develop the first entire pit lake shoreline erosion model. We then

applied this to proposed pit lake batter designs under scenarios of storms, batter angles and cover types to inform rehabilitation earthworks.

Numerous closure studies including an earthworks and drainage schedule for batter rehabilitation, third party review of pit lake modelling, pit lake riparian planting literature review and recommendations, and environmental studies of an historic pit lake as a regional analogue.

IRON ORE (MID-WEST)

Risk assessment of increasingly acidic and saline pit lake water to stock watering. ANZECC/ARMCANZ (2000) primary industries guidelines for livestock drinking water and a literature review of the health effects of saline waters were used as guidelines to evaluate exceedances for metals, metalloids and other solutes include TDS. Salinity modelling demonstrated that increasing salinity soon exceeded sheep and beef cattle drinking water acceptability such that the pit lake was unlikely to be used as a watering source. Nevertheless, drinking water risk remained for goats which preferred saline to fresh water which then required further risk management.

ALL (ASIA PACIFIC)

Development of Mine Closure Checklist for Governments guidelines as part of a multi-national team. The checklist provides governments in the APEC region with a simple, practical and accessible tool to support the development of comprehensive mine closure policy and frameworks. The development of this tool account for leading international standards and practices, as well as input from numerous stakeholders.

NICKEL (GOLDFIELDS)

Part of the expert closure planning team as a pit lake specialist for internal IPS (Identification Phase Study) studies closure planning the Nickel West Facility in the northern Goldfields of Western Australia. As part of this extensive project, studies required knowledge review and gap assessment, site inspection and sampling of the flooded voids, risk assessment closure and option analysis for all landforms, recommending further studies for later phases. Operations considered included Mt Keith and Leinster.



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IRON ORE (MID-WEST)

Risk assessment of increasingly acidic and saline pit lake water to regional birdlife to meet state government mining approval requirements. Expected pit lake water quality models indicate acute toxicity to aquatic life and the risk of bioconcentration leading to trophic bioaccumulation to waterfowl feeding there. A literature review of the ecology of the expected bird species against the likely poor-quality foraging habitat (steep sides, deep water) and food resources (low primary productivity rates) afforded by the pit lake demonstrated that negligible risk was likely to exist due to little bird dietary intake occurring from the lake.

COAL (QUEENSLAND)

Expert advice for closure of multiple pit voids in a river valley as flow-through systems to avoid ongoing levee maintenance. Services provided included; guided tour of Collie Pit Lakes District, organised tour of German pit lakes districts in Central and Lusatian regions, SWOT and closure options analysis, literature review of leading practice for end use and flow-through closure design, further studies recommendations.

OIL SANDS (CANADA)

Global expert technical reviewer of the Alberta Provincial Government and oil sand industry's CEMA technical guidance documents (2008 and 2012 versions) for the closure planning "End Pit Lakes Technical Guidance Document" for rehabilitation oil sands mine pits as pit lakes. These multi-author Guidelines provide state-of-the-art international leading practice guidance to mine closure of this internationally significant mining region.

Global expert technical reviewer of the Alberta Provincial Government and oil sand industry's CEMA technical guidance documents (2008 and 2012 versions) for the closure planning "End Pit Lakes Technical Guidance Document" for rehabilitation oil sands mine pits as pit lakes. These multi-author Guidelines provide state-of-the-art international leading practice guidance to mine closure of this internationally significant mining region.

ALL COMMODITIES (AUSTRALIAN COMMONWEALTH)

Writing the Preventing Acid and Metalliferous Drainage guidelines sections on pit lakes and AMD risk assessment for the revised Australian Commonwealth series Leading Practice Sustainable Development Program for the Mining Industry (Department of Foreign Affairs and Trade (DFAT)). In addition to compiling leading practice approaches to mine closure together into one document for these topics, the guidelines also featured case studies of successfully rehabilitated Australian mine closure landforms.

DIAMONDS (NORTHERN TERRITORY)

Human health and environmental (HHERA) Risk assessment of a proposed increasingly saline and metalliferous pit lake as per leading guidance. A conceptual source-pathway-receptor (SPR) model was developed. Our assessment then considered predictively modelled water quality data (contaminant and concentration) in the Consequence model component using a combination of client and MLC risk models.

ZINC (NORTHERN TERRITORY)

Expert advice for closure of a large zinc, lead and silver mine where a previous river diversion is proposed for seasonal flow-through in a wet-tropical monsoonal environment. Advise included best practice and development of a framework to address regulator concerns regarding closure planning.

Analysis of historical water quality from reference points and those receiving mine waters to determine key contaminants of potential concern for meeting compliance that might require further investigation e.g., through field or laboratory toxicological testing. Previous degradation and values of receiving waterways were determined from stakeholder discussion and compliance reporting documentation.