

**CAPABILITY STATEMENT**

# Acid and Metalliferous Drainage Characterisation and Management

Earth Systems provides specialist expertise in acid and metalliferous drainage/acid rock drainage (AMD/ARD) management associated with developing, operating and decommissioned mining operations globally. From identification and characterisation through to prediction, prevention, control and treatment, Earth Systems has been providing site-specific solutions to AMD-related issues to meet the needs of both our clients and the environment for over 20 years.

Earth Systems is an industry leader in AMD characterisation and the development of innovative and cost-effective AMD management and treatment strategies.

## WHAT IS AMD?

Acid and metalliferous drainage, also known as acid mine drainage or acid rock drainage, is both an environmental and economic issue impacting metal, coal, diamond, mineral sand and uranium mining operations as well as other industrial and quarrying operations and sites affected by acid sulfate soils.

AMD is produced when sulfide minerals (predominantly pyrite) are exposed to air, which allows them to oxidise and break down. This reaction produces sulfuric acid and dissolved metals ('acidity') including iron, aluminium, manganese, copper, lead and zinc. The acid produced can also mobilise other metals such as arsenic, cadmium, chromium, cobalt, manganese and nickel. Sulfides are geochemically stable when immersed in water, and generally only begin to oxidise once the host rock is excavated or exposed to the air.

AMD the single most important environmental issue faced by mine sites around the world. It can also cause major acid damage to site infrastructure with immediate economic consequences.

In some cases, the acidity produced by sulfide oxidation can be neutralised in the presence of carbonate minerals. The result is neutral metalliferous drainage (NMD) or neutral mine drainage, which has a near-neutral pH but contains elevated dissolved metal sand sulfate salinity. Although NMD is often not recognised as being related to AMD and sulfide oxidation processes, it occurs as a result of the same geochemical reactions.

Sulfide oxidation and associated AMD generation proceeds for as long as there remains sulfide minerals in exposed geological materials. The duration of acid generation, and its associated liability, can last for hundreds of years after mining operations have ceased.

AMD can be generated in waste rock piles, tailings dams, pit wall rocks, heap leach pads, ore stockpiles and underground mine voids.



## HOW EARTH SYSTEMS CAN HELP

Regulators and mine operators are now developing a better understanding of the impacts of AMD on the environment, infrastructure and the short- and long-term viability of mining operations. Accurate identification, characterisation and prediction of AMD is essential to understand and manage AMD risks and to develop appropriate prevention, control and, if necessary, treatment options for both short- and long-term mine management. Significant advances have been made over the past decade in our understanding of AMD and the ways in which it can be managed.

Earth Systems is a global leader on AMD issues, with over 20 years of research and field experience. Earth Systems has developed a detailed scientific understanding of the geochemical process associated with sulfide oxidation, and continues to research more accurate methods of characterisation and more effective technologies and strategies for AMD management. This expertise is recognised by Earth Systems' lead author role in the preparation of the Australian Federal government's leading practice guide *Managing AMD* for the mining industry.





## SERVICES PROVIDED

Earth Systems provides specialist expertise in all aspects of acid drainage management throughout the entire life cycle of a mine's development, from exploration and prefeasibility, through to development and mining, closure and rehabilitation and beyond.

Developed closely with the needs of our clients, Earth Systems can integrate AMD management with mine planning and operations to minimise operational and post-closure AMD risk. Key and specialist AMD services include:

- AMD audits, including AMD risk assessment and management system audits throughout all phases of project development.
- AMD baseline surveys and impact assessments.
- Assessment of AMD potential and development of comprehensive site-specific management and monitoring plans that can be integrated with existing mine planning.
- Mine material characterisation, including geochemical characterisation, static geochemical parameters, advanced AMD risk classification.
- Advanced, rapid kinetic geochemical testwork using Earth Systems' oxygen consumption test (OxCon) or conventional column leach and humidity cell tests for the prediction of annual acidity generation rates and optimisation of waste storage strategies.
- Waste rock pile construction design and management including waste segregation, selective placement, encapsulation, blending and cover systems.
- Water quality assessment and monitoring, including sampling protocols, total acidity and acidity load assessment, analytical data assessment and calculation of treatment reagent requirements.
- Computer-based modelling and assessment of AMD potential including site water balances, acidity/contaminant load balances, pit lake modelling and geochemical equilibrium modelling.
- Mine waste management including tailings storage facility design, management and decommission planning, assessment of in-pit and mine backfill tailings disposal and storage options.

- Mine block modelling for AMD risk evaluation and scheduling of different waste rock categories.
- Site-specific AMD minimisation and treatment, both active and passive, including contract treatment for pit lakes and other water storages for risk mitigation, re-use and emergency discharge.
- Development of site rehabilitation and closure plans, incorporating long-term AMD management and prevention strategies.
- Leading-practice environmental training workshops for regulators, managers, supervisors and operators on AMD issues.

## PROJECT EXPERIENCE

- Senior authors of the Leading Practice Handbook, *Managing AMD*, for the Australian Federal Government.
- Identification, characterisation, prediction and management of AMD at sites throughout Australia, China, Indonesia, Kyrgyzstan, Laos, Mali, New Zealand, Papua New Guinea, Peru, Senegal, Solomon Islands, South Africa, Tanzania, Guinea, Thailand, the United States and Vietnam.
- Provision of AMD characterisation and management services to various mining operations including coal, gold, silver, copper, lead, zinc, uranium, tin, iron ore, diamond, mineral sands and pyrite mines in all phases of project development — exploration, feasibility, impact assessment, construction, operations and post-closure.
- Provision of AMD characterisation and management services to various government departments and authorities to assist with the management of both decommissioned mine sites and AMD associated with acid sulfate soils.
- Development of the OxCon method, a new kinetic geochemical test for rapidly and more accurately quantifying sulfide oxidation rates and acidity generation rates.
- Development of innovative, cost-effective technologies for preventing and minimising AMD from underground mines, tailings and waste rock (eg. GaRDS, NBT, AcidBLOCK).
- Development of AMD treatment equipment.

