Water, water everywhere

Every year when preparing this article, the importance of water resources is so evident, John Chadwick reports

In January 2017 the ICMM put out a position statement setting out its members' approach to water stewardship. This provides excellent guidelines for all operations to follow.

"Water stewardship is the use of water in ways that are socially equitable, environmentally sustainable, and economically beneficial. Effective stewardship requires collaboration and concerted action from all parties, including government, civil society, business and local communities through inclusive stakeholder engagement."

Member mining companies of the ICMM are required to:

- Apply strong and transparent water governance
- Manage water at operations effectively
- Collaborate to achieve responsible and sustainable water use.

ICMM principles of particular relevance to water stewardship are:

- Principle 3: Uphold fundamental human rights and respect cultures, customs and values in dealings with employees and others who are affected by our activities
- Principle 4: Implement effective risk-management strategies and systems based on sound science and which account for stakeholder perceptions of risks
- Principle 6: Pursue continual improvement in environmental performance issues, such as water stewardship, energy use and climate change
- Principle 7: Contribute to the conservation of biodiversity and integrated approaches to land-use planning
- Principle 10: Proactively engage key stakeholders on sustainable development challenges and opportunities in an open and transparent manner. Effectively report and independently verify progress and performance.

ICMM members recognise that:

1. Water is a precious shared resource with high social, cultural, environmental and economic value. Access to water has been recognised as a right3; integral to wellbeing and livelihoods and the spiritual and cultural practices of many communities. It is also essential to the healthy functioning of ecosystems and the services they provide
2. Water is a vital input for all mining and metals operations – required for the health and wellbeing of employees and at every stage of an operation's life cycle including closure. The dependency and impact on a shared resource creates material risk for the mining and metals sector that requires effective management
3. Water challenges are increasing around the world. Earth's freshwater resources are finite and under pressure from industrialisation, urbanisation, climate change and the needs of a growing global population
4. These challenges are shared across countries, industry sectors and society. In order to meet demand, a change is needed in the way water is used, managed and shared. This will require collaboration and concerted action from all parties, including government, civil society, business and local communities
5. Through the Sustainable Development Goals, world leaders have publicly acknowledged the urgency of using and managing water sustainably. The business sector can play a significant role in supporting this approach including through ensuring access to clean water, sanitation and hygiene (WASH) for employees in the workplace. There is further opportunity for the business sector to support government initiatives through leveraging capital or expertise to improve community WASH and other water related outcomes
6. Water-related risks and impacts are predominantly experienced by people and ecosystems at the local/catchment level. Therefore companies need to look beyond traditional operations-based water management to the dynamics and interactions of various water users in the wider catchment. Effective water management requires a holistic understanding of hydrology and land use, as well as broader political, economic, social and ecological dynamics that influence water availability and quality
7. The mining and metals industry has an important role to play in the sustainable management of water resources where companies are active. Proactive and holistic water management strategies can create substantial competitive advantage through reducing water-related risk, identifying opportunities, attracting investment and

Pretium Resources is constructing the high-grade Brucejack underground gold mine in northern British Columbia. Veolia is supplying proven proprietary processes to treat up to 10,000 m³/d of effluent water from the mine

building trust through improved transparency.

ICMM member companies are committed to publicly disclose the company's approach to water stewardship. They must allocate clear responsibilities and accountabilities for water – from board and corporate to site levels and integrate water considerations in business planning – including company strategy, life of asset and investment planning. They must also publicly report company water performance, material risks, opportunities and management response using consistent industry metrics and recognised approaches.

To manage water at operations effectively, members are expected to maintain a water balance and understand how it relates to the cumulative impact of other users. A water balance is an approach used to measure the flow of water in and out of an operational facility. This provides the basis for understanding, managing and communicating the site's water requirements and use. A site water balance is comprised of three main components, namely: water withdrawals, water discharge and water consumption. The formula for calculating a site water balance is: withdrawal volume = discharge volume + consumption volume + any change in the volume of onsite water storage.

Cumulative impacts are changes to the environment that are caused by an action in combination with other past, present and future actions.

Companies will set context-relevant water targets or objectives for sites with material water-related risks. They will also proactively manage water quantity and quality to reduce potential socio-environmental impacts and realise opportunities.

All employees must have access to clean drinking water, gender-appropriate sanitation facilities and hygiene at their workplace.

Collaborating to achieve responsible and sustainable water use:

- Identify, evaluate, and respond to catchment-level water-related risks and opportunities. A catchment is "the area of land from which all surface run-off converges through a sequence of streams, rivers, groundwater aquifers and lakes into the sea or another outlet at a single river mouth, estuary or delta. The term catchment is sometimes used interchangeably with drainage basin or watershed"
- Identify and engage proactively and inclusively with stakeholders that may influence or be affected by a site's water use and discharge
- Actively engage on external water governance issues, with governments, local authorities and other stakeholders, to support predictable, consistent and effective regulation that underpins integrated water resource management
- Support water stewardship initiatives that promote better water use, effective catchment management and contribute to improved water security and sanitation.

Barrick says its "water management is as crucial and important after a mine closes as it is during a mine's active life cycle. We must return the environment to a stable condition in accordance with strict permit requirements, moving towards the ultimate goal of protecting the long-term viability of the land and water.

"We recognise that our responsibility to local stakeholders and the environment doesn't end when mining activity does," says Patrick Malone, Barrick's Vice President of Environment. "Part of building partnerships of real depth means making good on our commitment to return the land and water to a stable state, and our Eskay Creek closure site is a great example of that."

Located in northern British Columbia, Canada, Eskay Creek operated from 1994 through 2008 and produced more than 3.3 Moz of gold. The operation benefited the Tahltan First Nation, providing employment and supplier contract opportunities; 34% of the mine's employees were from First Nations communities.

During the closure phase, the Tahltan Nation

An Eskay Creek employee takes a water sample from one of the monitoring points near the former mine

Development Corp and other Tahltan-owned businesses actively participated in areas such as road maintenance, labour, material movement and food services.

Because Eskay Creek is located next to two deep, non-fish-bearing lakes, the operators were able to store tailings and waste rock under water, cutting off the oxygen that would otherwise have caused them to generate acid. The two lakes, Tom Mackay Lake and Albino Lake, never contained fish because the streams and creeks that flow from them are rocky and the water flowing through them is too fast-moving for fish to swim upstream. The lakes are monitored for water quality on a quarterly basis in accordance with permit requirements.

Despite the advanced closure status of the site, Barrick will continue to be responsible for Eskay Creek for the foreseeable future, or until new owners are found. "Site relinquishment was once the goal of every closure program; however, in many jurisdictions that is simply no longer attainable," says Dan Bornstein, Barrick's Director for Mine Closure Strategy and British Columbia Properties. "Companies need to be more creative now than ever before in finding new owners and new uses for their brownfield properties that gain the support of local communities in order to achieve something akin to site relinquishment."

Similarly, as part of its mine closure obligations, Barrick's Pierina mine in Peru has built two new water treatment plants to safeguard local water quality. It has also installed a cyanide detoxification plant, which will operate until all cyanide has been consumed or destroyed on site.

Pierina is located about 300 km north of Lima in a high precipitation region of Peru. Average annual rainfall is 1,200 mm which, combined with natural conditions of the area, make conditions ripe for acid rock drainage.

The water treatment plants conduct daily water sampling and on-site analysis, measuring various metrics including water acidity, or pH levels, and turbidity. The new treatment plants

replace existing treatment facilities on site and underscore Barrick's commitment to proper mine closure.

All water that comes into contact with the mine site is funnelled to the water treatment plants before being discharged off site. Discharged water must comply with new regulations that recently went into effect in Peru. "There are limits for content of various metals, salts and the acidity level of the water," explains Wesley Ubillus, Process and Water Treatment Manager at Pierina.

Most of the water treated at the plants is not used by local communities, but some of it is channelled into several communities in the nearby Pucaurán and Pacchac valleys for irrigation use. Both treatment plants at Pierina contain reverse osmosis technology—sophisticated water purification technology that removes sulphate, carbonate and other salts from water.

Another important consideration here is to reduce exposed areas that might be susceptible to generating acid rock drainage.

The water treatment plants conduct daily water sampling and on-site analysis, measuring various metrics including water acidity, or pH levels, and turbidity. The environment team also regularly collects water samples off site and sends the samples to an independent, certified laboratory for analysis. Results from these analyses are reported to authorities on a quarterly basis to ensure Pierina is in compliance with its permit and Peruvian regulatory standards.

Reliable solutions

Flowrox technology is widely used by waste water treatment facilities. One such in the USA several years ago purchased two LPP-D25 peristaltic dosing hose pumps for control of sodium hypochlorite for disinfection and four LPP-M peristaltic metering tube pumps for pumping of sodium bisulphite and sodium hypochlorite. Flowrox LPP-M pumps are a highly sophisticated and fully equipped metering tube pumps.

LPP-D pumps were ordered with a special Halar coating for protection against the aggressive sodium hypochlorite in the unlikely occurrence of a hose failure. They were also equipped with hose leak detection to shut the pump down in the event of a hose failure and were with an integral variable speed motor with 4 – 20 mA input for control.

"Flowrox pumps offer stable flow and metering capabilities under varying operating conditions, and their energy requirement is constant", says the customer. "They can also handle severe variation in suction line condition in regard to suction lift and viscosity, and they are also very user friendly", he continues.

Simpson Environmental water treatment systems for B2 Gold Fekola mine in Mali

Flowrox engineered peristaltic pumps combine smart intelligence with superior turndown. Another remarkable advantage is that peristaltic pumps will not experience vacuum degassing in summer months like other designs.

Flowrox was selected as equipment supplier based on the superior tube pump and control technology of the LPP-M tube pumps. Flowrox won on the technical merits, commercial merits and long-term operational advantages.

New plants

Veolia is supplying proven proprietary processes to treat up to 10,000 m^3/d of effluent water from the mine. The permanent effluent treatment system will consist of several technologies which were selected for their robustness and compactness, starting with the Actiflo® clarification process for primary metals removal. The water will be further polished by a highly-efficient Hydrotech™ Discfilter, which gives added insurance in meeting very stringent discharge criteria. Start-up of the new effluent treatment facility is scheduled for spring 2017.

The contract followed months of extensive collaboration and testing to ensure that the most stringent environmental discharge limits will be met. The exhaustive test work that was carried out at Veolia laboratories in Montreal has been largely used in support of the extensive permitting work that has been prepared by Pretium for the Canadian and Provincial authorities. "Based on Pretium's investment in several months of test work, it was clear how committed they are to ensuring their environmental stewardship", stated David Oliphant, Vice President Business Development Heavy Industry for Veolia Water Technologies Canada.

Klaus Andersen, CEO of Veolia Water Technologies Americas, stated: "The Brucejack project is a great example of how Veolia can partner with industrial clients over several years, from rapidly providing a temporary solution to working through months of testing and navigating the steps to secure required permitting, and coming up with the best water treatment solution possible. We are very proud to be working with Pretium on this exciting mining project".

Veolia started working with Pretium in spring 2014 when the company needed to dewater Brucejack's underground workings during its exploration phase. Veolia then supplied a mobile Actiflo water treatment plant, which it has operated since. This temporary facility has provided Pretium large amounts of extremely valuable seasonal operational data for future reference. As the Actiflo clarification process will also be installed in the new effluent treatment facility, it gives Pretium the confidence that the system meets the stringent requirements of low level metals and Total Suspended Solids (TSS) while dealing with variable feed water.

In 2011 **Simpson Environmental Corp** developed the concept of pre-engineered, packaged potable water and wastewater (sewage) treatment systems. The company's go-to-market strategy involved partnering with a select number of major global shelter manufacturers active in the remote camp market. These shelter manufacturers have strong working relationships with key global customers like B2 Gold, a Vancouver-based gold producer with four operating mines in Latin America, Africa and the Far East.

As a result of market development activity with **ATCO Structures and Logistics**, one of Canada's premier shelter manufacturers, Simpson was successful in securing a major supply contract for potable water and sewage treatment systems for an 800 person mining camp in Mali, West Africa.

The project commenced in the spring of 2015 with a purchase order from ATCO for two potable water SIMPODs to treat 75,000 gallons/d of borehole sourced water, seven sewage treatment

SIMPODs to treat 60,000 gallons/d of black and grey water sewage from all camp toilets, showers, sinks, and kitchen/laundry points of use and three large steel bolted storage tanks.

There are two 40' refurbished reefer containers containing three stages of media filtration, plus ultra violet units to treat source water contaminated with low traces of arsenic (one live SIMPOD and the second as a hot standby unit).

The potable water facility includes on board manufacture of chlorine for disinfection and oxidation using chlorine generators manufacturing chlorine from common food grade salt to mitigate against health and safety issues related to the handling of liquid chlorine.

There is a 155,000 gallon steel bolted tank for treated potable water storage.

The SIMPOD sewage treatment solution involves a single 40' container designed to screen primary sewage piped from 10 separate pumping stations throughout the camp. Two primary clarifier SIMPODs using revolutionary screw press dewatering technology remove suspended solids. Four trickling biofilters provide secondary treatment of clarified sewage product water.

There is a 70,000 gallon steel bolted sewage storage tank and a second 45,000 gallon steel bolted storage tank for process water from the screening and dewatering processes.

A single administration SIMPOD containing final ozone tertiary treatment for sewage water being returned to the environment as well as the control console for a custom-built Delta V automation and control system is connected to all SIMPODs via coaxial and fibre links. This system enables B2 Gold to monitor all system activity from one single console and as well enabling Simpson to monitor performance from its headquarters.

The refurbished reefer containers were selected for this project in order to provide protection against mould and insect infestation in that all internal walls, floors and ceilings are lined with aluminium or stainless steel. All SIMPODs are climate controlled with onboard ventilation and air conditioning systems used to maintain ambient temperatures in the sub 25°C range in a local climate region where external day time temperatures can reach as high as 45°C.

The Simpson solution was shipped from the company's location in Burlington, Ontario in November and delivered to the Mali, West Africa Fekola mine site in late December. Installation coordination with ATCO Structures and Logistics and B2 Gold site personnel commenced in late December and was finalized in a staged commissioning and B2 Gold staff training exercise during the spring of 2016.

Subsequent to the commissioning of the above system, B2 Gold has extended its procurement program with Simpson Environmental with the purchase of additional water treatment systems to provide camp-wide softened water as well as elution treatment water for the mine plant under construction. This phase of Simpson's support to Fekola mine is scheduled for delivery, installation and commissioning in the first quarter of 2017.

Osmoflo has secured the contract to provide a custom built water treatment plant in Chile to **Outotec**. Outotec is expanding and modernising a copper smelter in Potrerillos, Chile. The expansion requires a water treatment plant to assist in treating cooling tower blowdown for water reuse in the facility. Osmoflo's extensive experience in the mining industry showcased the required capability to secure the project.

Osmoflo is providing a custom-engineered plant to support the expansion, using a combination of ultra filtration followed by two-pass brackish water reverse osmosis designed for high salinity/high recovery. The water that was typically discharged as blow down waste will now be recovered through the water treatment system and will be fed back into the circuit for reuse with some of the water being polished further for use in high purity applications.

As a part of Osmoflo's solution, the plant will also feature Plantconnect automation technology allowing remote monitoring and control from Osmoflo's 24 hour Control Centre.

Being pre-packaged as discreet skids, the plant will be sea-freighted to Chile following pre-assembly and factory testing.

STANTEC

Osmoflo say it is "Australia's largest desalination company." This picture shows a plant it provided to Consolidated Tin Mines' Mount Garnet mine

Although this is the first project between Outotec and Osmoflo, the two companies have been in collaboration, developing a range of water solutions, globally. "This partnership between Outotec and Osmoflo is quite unique in that it provides a combination of skill sets, mining technology with specialist water treatment and recycling." Ajay Jaggi, Osmoflo's General Manager, Sales – Australia, APAC and Africa explains.

"This particular project also showcases Osmoflo's global ability, with engineering, project management and operations coming from Osmoflo in Australia, India and Chile." Jaggi continues.

The project is forecast to be completed in May of 2017.

PROXA says that "through our in-house process development laboratory, PROLAB®, and the support of PROSERV® – which optimises life cycle costs for chemicals, consumables and spares – we're able to assist with the rapidly changing requirements of mining clients.

At the Acacia mine located in Tanzania, a plant was built as two-process trains to treat water from a tailings storage facility (TSF) and water from open pits for reuse and discharge.

PROXA was able to maximise the throughput of the plant, while optimising and reducing the operating costs by >70%, which was of critical importance to the strained gold mining sector.

In Zambia, Konkola Copper Mines needed to treat a raw water supply from the Kafue River to meet four different grades of water for use at the smelter. PROXA's responsibility included the pumping, control and supply of the raw water at a rate of 1,500,000 litres/h. The plant was commissioned to produce: process water, cooling tower feed water, boiler feed water and potable water, through a series of unit operations. These unit steps included clarification, media filtration, reverse osmosis and ion exchange. PROXA also optimised the plant to cater for fluctuations in feed water composition related to seasonal changes.

"Given PROXA's experience in operating in challenging conditions with limited resources, we were able to increase the plant availability and decrease the operating costs – associated with chemicals and consumables – by more than 30%."

The Neves-Corvo mine located close to Castro Verde, in southern Portugal, operated by SOMINCOR (Soc Mineira de Neves-Corvo), a subsidiary of Lundin Mining, is getting a new water treatment plant. Neves-Corvo is the biggest

copper and zinc mine in the European Union and has been in operation since 1988

The mine was one of the first plants to adopt thickened tailings disposal (TTD), installing an **FLSmidth** Deep Cone Thickener as part of a project to convert the sub-aqueous tailings pond to a paste-filled impoundment over ten years ago. The TTD plant was expanded in 2008, accelerating the rehabilitation of the dam, largely removing free water from the surface of the Cerro de lobo tailings facility for storage in a new dedicated water dam, Cerro de Mina.

An unintended consequence of the reduction of water in the Cerro de Lobo tailings impoundment has been a build up of dissolved metals and thiosalts in the plant process water as the overall volume of process water was reduced. As the plant uses lime for pH control in the flotation process, and these metals increase in concentration, associated lime use would accelerate the precipitation of gypsum, creating multiple maintenance problems with scaling in the plant.

A water treatment plant installed in the 1990s was re-commissioned as a temporary solution while a permanent solution was put in place.

After a design phase led by an international consulting engineer, SOMINCOR contracted FLSmidth for the detail design and supply of the necessary equipment for a Fenton-HDS water treatment plant. Under a joint process review, and an additional pilot testing campaign, FLSmidth was able to double the throughput capabilities of the plant using the same equipment sizes as originally specified, using the proprietary FLSmidth MaxR process.

The new plant, currently under construction, will initially accept water from Cerro de Mina, sparge the incoming water with hydrogen peroxide to convert the thiosalts to sulphates, and then, in a series of conditioning and reaction tanks, precipitate the dissolved heavy metals as hydroxides, combined with carefully precipitated calcium sulphate, before settling the precipitates in a 30 m diameter Eimco Clarifier. The MaxR process uses a controlled recirculation of clarifier underflow, conditioned with the necessary quantity of fresh lime to reduce the levels of dissolved metals and sulphates.

The final clarified overflow will be conditioned with CO_2 to bring the pH in line with requirements for the plant process water.

There is an occasional need for discharge of water from the operation and in order to meet this, the overflow will be further treated by reverse osmosis as required, depending on the season and water condition.

Driving change

Dr Hubert Fleming, Anglo American's global lead for water management, is keen on "driving change and defining our water future.

"The world needs water. According to the World Economic Forum, a shortage of clean fresh water presents the greatest global, societal and economic risk over the next decade. By 2030, the global population is expected to reach 8.5 billion and the human race could face a 40% water shortfall. This means that we have little to spare: steps must be taken to ensure water is conserved as much as possible, starting now.

"With around 75% of our mining operations located in high water-risk regions, we recognise the need to conserve water wherever possible. Most of the water is used by our tailings disposal facilities – where we store the non-valuable parts of ore after separating the valuable fraction – and through the control of dust on our haul roads.

"Effectively managing water shortages also mitigates the risk of operational disruptions and presents an opportunity for us to play a leadership role in water catchments. We are six years into an ambitious 10-year water strategy, focussing on achieving water resilience. Our success so far can be attributed to two areas of focus: driving operational excellence and investing in technology.

"To achieve operational excellence, we have set quantifiable water usage

goals for every site worldwide, targeting a 14% reduction from our projected water consumption by 2020.

"In 2015, for the third year in a row, we managed to exceed the 2020 target by achieving an estimated 16% water saving against our projected water usage. This saving is predominantly due to projects such as more effective dust suppression, dewatering of tailings and more efficient ore separation – all of which contributed to the approximate water saving of 25 million m^3.

"As well as saving water, we improve efficiency by increasing how much water is recycled and re-used at our sites. For example, production at Los Bronces copper mine in Chile was constrained by water supply challenges in 2015, which provided an extra impetus to reduce our fresh water consumption. To overcome this particular challenge, we implemented a number of measures including running the recycling system at maximum capacity. We continued to transport water via a 56-km pipeline from the Las Tortolas tailings dam in Chile to Los Bronces, using a special water-recycling system. Los Bronces now currently recycles more than 78% of available water. Overall, this has helped us meet 64% of our total operational water requirements with recycled or re-used water – a key milestone as we move towards our long-term goal of 80%.

"Investing in new integrated water solutions is one of our most important technology focus areas and is fundamental to achieving a step-change in water-efficient mining. Over the last six years this investment has enabled us to introduce several cutting-edge technologies. These innovations include separating water streams that do not contact waste water; discharging less water to tailings; remote monitoring of water flows and levels in dams and tailings as well as piloting passive water treatment technologies. We are proud of the fact that many best-practice technologies that improve water efficiency are now standard procedures at the majority of our operations.

"In June 2015 we were thrilled to hold our first FutureSmart™ Technology Open Forum in London, gathering worldclass experts from a variety of industries to help solve some of our big challenges. The ultimate goal of the Open Forum was to find more efficient ways to mine but also, crucially, to reduce our impact and create a positive legacy for the surrounding environment and local communities.

"Our first forum had representation from more than 75 different market sectors, 30 companies, 16 countries and six continents. The outcome was more than 1,150 hours of discussion and 1,000 generated ideas.

"Potential solutions identified at the Open Forum include reducing the quantity of tailings that we produce through an increased focus on rejecting water earlier in the process. In some other cases, where there is too much water rather than too little, the forum developed ideas on high volume, low-cost water treatment to return the water safe for human use.

"Growing regulatory and social pressure, increasing demands for limited natural resources, climate change and the changing costs of water all highlight the business imperative of achieving water resilience. Our immediate focus is on securing adequate supplies and using resources more efficiently so that we can ultimately reduce our reliance on 'new' water to near-zero."

Water recovery pumping station at Anglo American's Las Tortolas tailings storage facility

Impact without major capital expense

Nalco Water considers that "today's challenging economic environment requires more creative solutions that can reduce freshwater usage and minimise discharge without major capital expenditure whenever possible.

"The first step in any water management plan is to ensure production is optimised with process water programs that maximise yield and recovery in mining operations. Keeping more of the valuable product that you want to recover out of any effluent stream simply makes good business sense and minimises environmental impact. Nalco Water has helped the mining industry maximise profits and minimise problems with effective process chemical programs and dependable service for decades."

It is now offering the Environmental Analysis and Chemical Treatment, (EN/ACT®) program, a total systems approach to aid in water clarification and conservation that helps customers comply with environmental regulations. As mine water applications tend to be highly variable in terms of flows and/or contaminants EN/ACT programs include practical application equipment design and ongoing field and analytical service, to make program management easy and economical. Each EN/ACT program is designed to fit the individual equipment, operating conditions and specific goals of the operation, and can include:

- Run-off/discharge water treatment programs including heavy metals removal, emulsion breakers, and "fish-friendly" water clarifiers
- WaterShed™ tailings management programs with additives that bind the solids within tailings slurries to create a free draining structure and provide immediate water release for recovery and reuse.

Poor water quality and clarity can have significant negative environmental impact, not to mention incurring costly compliance citations and the negative attention in the community. A customized EN/ACT program can settle solids to help control clarity, remove heavy metals and correct acidic mine run-off problems that can occur when processing minerals, (re)handling tailings refuse or treating water from run-off or underground mine works. Components of the program include:

- A complete line of clarification aids effective over a broad range of conditions
- "Green" coagulants for sensitive applications where discharge is bound for fish-bearing streams
- Passive flocculants designed to be used year round whenever water volumes and flows dictate discharge
- Metals removal technologies to address soluble metals such as aluminium and selenium
- Emulsion breakers to ready water from underground workings for discharge to open surface streams

- Feeding equipment well-suited to hard-to access locations.

Increasingly aggressive and less selective mining methods have come into wide use to improve mine productivity. However, the same methods can generate an exceptionally high volume of waste fine particles. At the same time, more stringent operating restrictions and regulations have begun to limit the permitted space and location of tailings impoundments and tighten restrictions for building new or modifying existing tailings ponds. Older impoundments are rapidly reaching capacity, constrained by permits, geological issues and terrain. Such functional space limitations narrow an operator's options for placement of refuse slurry. Popular alternatives to refuse impoundments and slurry cells that can accelerate solids densification and limit the active footprint for waste disposal site include:

1. Thickener underflow filtration, using twin belt filter presses or vacuum filters to remove sufficient water to make waste solids easily conveyed or hauled away
2. Paste or deep cone thickeners to increase the specific gravity of refuse slurry before it is deposited in the impoundment and speed up the process of refuse dewatering.

However, Both of these approaches require significant capital investment and substantial time for planning and installation. With Nalco Water's WaterShed program customers have an easily implemented low capital cost alternative to a paste thickener or belt filter press. Associated chemical costs for a site-specific WaterShed program can be similar to the chemical costs of a twin belt press filter application and the overall program is far more flexible. Existing underflow pumps and pipes are used and can be easily moved from cell to cell in the impoundment area.

*The **McElroy** TracStar Series 2 tracked fusion machines are used on mine sites all over the world. McElroy notes that "their mobility and ability to handle most any terrain and grades up to 30% make them a great asset in remote areas and at high altitudes." They are easy to manoeuvre on site, having everything needed on board including a generator to provide electricity and hydraulic power. Each machine's diesel engine has the fuel tank and operational capacity to perform a full day's work bringing fuel efficiency to the tasks. TracStars are offered in a wide range of pipe sizes from 51*

Related benefits of a Nalco WaterShed program include:

- Additives bind the solids in the tailings slurry for rapid water recovery
- Enhanced beaching to maximise tailings storage capacity and generate a load bearing structure
- Improved decant water quality for potential water reuse applications

NORMET

- Reduced water losses via evaporation or seepage
- Dramatically reduced land rehabilitation time, often weeks compared to years with untreated tailings.

New technologies

Mineral processing specialist **Multotec** says its continuous ionic filtration (CIF) process could change thinking on wastewater treatment and also offer an income stream while treating contaminated water to achieve potable water quality.

According to Multotec Environmental Process Engineer, Carien Van der Walt, the technology augments existing solutions such as reverse osmosis by achieving higher water recoveries and delivering a zero liquid discharge solution. "It is a significantly improved version of the familiar and widely accepted ion exchange methodology," says van der Walt, "and has been tested and proven in treating wastewater in various applications around the world."

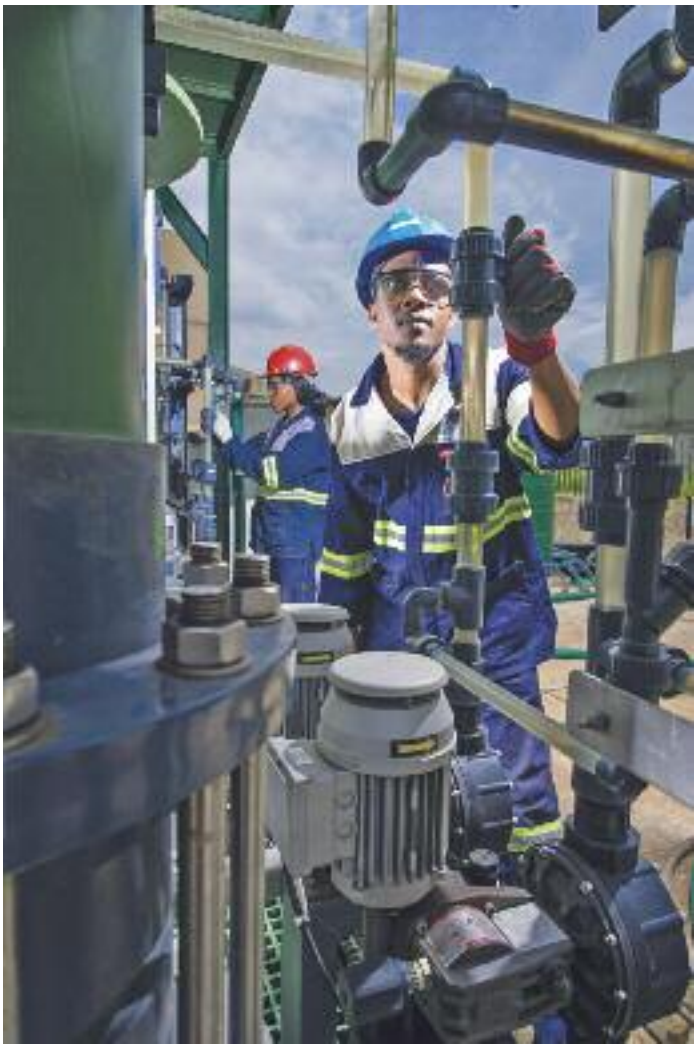
With local representation rights from Australian water treatment and metals recovery specialist **Clean TeQ**, Multotec sees the process as an ideal long term solution to Acid Mine Drainage (AMD) in South Africa, especially as options are being explored to upgrade the output of the three Witwatersrand AMD treatment plants to achieve a potable standard.

"Adding a secondary solution that fits onto the backend of the current treatment plants is not only cost effective, but also much faster to implement," she says.

Among the system's novel features is the continuous and counter-current movement of resin – in contrast to a conventional fixed bed arrangement –that allows the process to operate closer to ideal equilibrium conditions to improve process efficiency. The movement of resin counter-current to the solution also creates a concentration gradient, which drives the ion exchange reaction, thereby reducing reagent consumptions and improving recovery.

"The movement of the resin also eliminates the potential for scaling and fouling," she says. "Any suspended particles in the feed water do not interfere with the primary desalination operation of the technology, and are filtered out."

"The DeSALx process uses two stages of CIF to desalinate brackish water, and produce potable water," she says. "In the first stage, a cationic resin is used to remove cations from the water, while an anionic resin is used in the second stage to remove anions."



A single-stage Clean TeQ CIF module can be used for a range of treatment applications. Multotec focuses on the Dual-stage Iconic Desalination (DeSALx) process in South Africa, to produce water with low total dissolved salts (TDS) and a neutral pH

The resins are regenerated with sulphuric acid and lime respectively for the cation and anion sections. Due to the continuous movement of the resin through the system, the process is able to handle any in-column formation of precipitated gypsum, eliminating the need for expensive regeneration chemicals. This also means the spent regeneration solution (or brine) is precipitated gypsum slurry, which can be recycled to the front-end of any existing neutralisation process, thereby closing the loop and facilitating a zero-liquid discharge process.

Using the same principles as CIF, the Clean-iX metals recovery technology is available to remove and recover metals present at low concentrations in mine-impacted waters – creating a revenue stream from a range of metals including gold, silver, platinum, nickel, copper, uranium and rare earth metals.

"Revenue from these additional by-product metals can help off-set the cost of installing a water treatment plant and eliminates a waste sludge or brine that has to be environmentally managed and contained," says van der Walt.

Last November **Dow Water & Process Solutions** (DW&PS) launched the next generation of ion exchange resins re-engineered specifically for efficiency in industrial water treatment applications. DOWEX MARATHON™ ion exchange resins, in combination with optimised system design, can offer up to 10% greater productivity from raw water, or more, the company says.

It "brings together the best that Dow's DOWEX MARATHON and AMBERJET™ technologies have to offer. Its enhanced capacity and ideal balance of properties allow operators to experience maximum usable capacity of the resin with minimal use of chemicals and rinse water."

"Operators need to consider a host of factors when deciding on a water treatment process," says Rajat Mehta, Global Business Director for Ion Exchange, DW&PS. "When resin price, life, performance and reliability are considered, Dow's advanced ion exchange technology helps

reduce operating costs and deliver lower total cost of water to operators across the industrial water market spectrum. The change to an operator's system is at the molecular level, but the impact on potential water efficiency is big."

This family of products includes a comprehensive suite of strong and weak acid cation exchange resins, and strong and weak base anion exchange resins for use in both packed bed and layered bed systems. Different combinations will result in various levels of efficiencies. The line-up allows operators to use the best combination of resins with their vessel type to achieve extremely low unit cost of demineralised water, high regenerability, and reduced waste volume.

Other features of the product family include solutions that help operators minimise corrosion, protect equipment and reduce scaling and operational downtime.

"With the next generation DOWEX MARATHON product family, customers are getting the best product design and the highest quality and performance we can offer to the industrial water treatment and fossil power industry," says Marlin Kinzey, Global Marketing Director for Ion Exchange, DW&PS. "By consolidating and building our offering under this new line, we've optimised the solutions and help to deliver a step-up in operational benefits for our customers."

Water filtration

Ultra filtration (UF) and nanofiltration membranes have come a long way as solutions for water treatment, reports **I-CAT**. A significant amount of research and development goes into improving these technologies. Most recently mechanical evaporation systems, which ensure effective and environmentally safe reduction in excess wastewater for mining, have also come to the forefront of water management.

I-CAT Director of Business Development and Marketing Lourens Jansen van Rensburg reports that his company has been awarded several contracts to monitor, manage and recycle water at several mining groups over the years. "Our methods are preferred because we do not believe in using or adding chemicals to wastewater to purify it or to get it to discharge standard. We make mechanical purification systems and have an excellent technical and design team that is focused on innovation and coming up with solutions for challenging projects."

According to van Rensburg, I-CAT Environmental Solutions uses a combination of technologies to provide its clients with the best and most cost effective solutions, while maintaining a consistent awareness of the environment, energy and social demands. "Our filtration systems are cost effective, as they have no recurring chemical costs, require low maintenance and are self-cleaning. The technology we use is considered world-leading, affordable and effective. We have developed solutions to clean process water where many older technologies and processes have failed."

Ulan Coal Mines' complex operating near Mudgee in NSW, Australia, has both underground and open-pit operations. This requires the extraction of large volumes of water. The on-site water treatment facilities need to be able to produce sufficient permeate to blend with other on-site waters to generate up to 30 million litres/d of blended water of suitable quality for environmental river discharge.

A reverse osmosis (RO) plant and UF pre-treatment system provided by Osmoflo currently treats water from East Pit, which is a large capacity surface dam. This enables the water to be recycled back into the ecosystem along with on-site irrigation.

Water requiring treatment includes water that has been accumulated on-site (East Pit) and water pumped from underground and open cut mine workings, as well as surface run-off from rainfall that makes its way to East Pit from the site catchment. The mine water, including that from East Pit, is generally very high in dissolved manganese (approximately 3 mg/litre). Some raw water streams from individual pump stations can exhibit manganese levels significantly above 3 mg/litre. (e.g. pump station E20 generates mine water containing approximately 9 mg/litre of

SPS used its experience in mine water treatment to fast track the construction of a plant to remove dissolved heavy metals from up to 100 m³/h of water being pumped out of the Bana Maria mine near Roznava, eastern Slovakia

manganese.) High manganese concentrations similar to iron have a tendency to foul up UF and reverse osmosis systems with a black sludge that can restrict the flow and performance.

Osmoflo is now using the water filtration media technology known as **DMI-65**, a catalytic filter media that is designed to remove high concentrations of manganese from the feed supply when operated in the presence of chlorine. Experience to date has found that DMI-65 is the best available catalytic material for removing high concentrations of manganese and iron to pre-treat and protect UF and RO technology.

The DMI-65 consists of grains of sand that have had proprietary products infused into them. This means that the active ingredients do not form a coating but become homogenous within the grains of sand. The DMI-65 acts as a catalyst in the presence of an oxidation environment created by the continuous injection of chlorine. The chlorine injection must be maintained to yield a free chlorine residual of 0.1 to 0.3 ppm at the filter effluent. The oxidation reaction causes dissolved manganese and iron to form a solid, insoluble precipitate that is captured by the DMI-65 filter media. The captured iron is released during the filter backwash cycle.

The DMI-65 has been tested in applications for reducing manganese levels in excess of 3 ppm down to less than 0.01 ppm. Based on Australian experience in the mining and municipal drinking water industries the DMI-65 is expected to have a lifespan of up to 10 years of continuous use.

Clean-up for mine reopening

In the UK, **Siltbuster Process Solutions** (SPS) is taking part in trials to show the treatability of the mine water from the closed tin mine at South Crofty in Cornwall. Once completed, the results will be used to show the viability of dewatering and the reopening of the mine. SPS has been asked to treat the mine water (which includes

dissolved contaminates and metals in solution, principally iron) by reducing the metal content to allow safe discharge of the water to the nearby Red River. If successful, the trial will be an important next step for Strongbow Exploration which plans to re-open the mine.

SPS has successfully completed many mine water treatment plants, designs and feasibility studies in the UK, Greece, the Slovak Republic, France, Canada and Australia. These include Wheal Jane, also in Cornwall, one of the largest active mine water treatment projects in the world, which over the last 14 years has involved treating over 100 million m^3 of water. SPS also designed the Dawdon mine water treatment plant for the UK Coal Authority, which won the 2010 Eddie Award for the best water treatment plant in the UK. Last year it finished a turnkey contract to design, construct and commission a water treatment system for Wolf Minerals' new Drakelands tungsten mine, near Plymouth in Devon.

Commenting on South Crofty, Chris Bullen, SPS Technical Manager said: "It is great to have been chosen to work on such an important and high profile project. We have a long history not only of working with mines but also of this region, we understand the local geology and have consulted heavily with the Strongbow team on the best way to dewater the mine. This initial trial phase is very important; it will not only show that the required environmental standards can be met, but will also demonstrate the viability of the whole mine."

The trial will see SPS's High Density Sludge process treat 18 m^3/h of mine water over the next two or three months. This will not only provide performance data to support Strongbow's discharge consent permit application but will also be used in the design of the full-scale plant; if the trial is successful the company would like to scale things up, to treat and discharge up to 25,000 m^3/d of mine water. This will enable the mine to be dewatered over an 18-24 month period ahead of reopening. The South Crofty tin project area covers 1,490 ha, and includes 26 former producing mines.

Avoiding contaminants

In South Africa's increasingly water-scarce and environmentally regulated mining industry, **BME's** emulsion explosives help keep nitrates out of mine water – preventing possible groundwater contamination and allowing optimal recycling of water on site. "Recent international studies suggest that up to 28% of nitrates from traditional ANFO explosive can leach into water draining through underground mine workings during a blasting campaign," said BME Operations Manager Neil Alberts. "These levels can be reduced to as little as 2% by applying best practice, but the long-term solution lies in explosives that do not release nitrates into water sources."

As the pioneer in cold emulsion explosives in South Africa, BME has evolved this technology to new levels over the past three decades, said Alberts. "Among the characteristics of our emulsions range is its excellent water resistance, which means that the explosive material does not dissolve readily in water," he said. "This reduces the amount of nitrate leaching to negligible levels." Tests conducted by BME indicated that, after being immersed in water for a month, its emulsion released only about 0.7% of its nitrate content.

High levels of ANFO wastage – mines typically accept that about 30% of ANFO delivered to a blast site is not consumed in blasting – suggest that it may be a contributor to nitrate levels in water passing through mine workings.

Another advantage of these emulsions is that no oil is released, ensuring that water contamination by oil is also prevented; both the nitrate and the fuel phases of the mixture are bonded tightly by the emulsifier. "BME emulsions have already contributed to environmental sustainability on mines by incorporating and consuming previously used oil in its emulsion products, helping mines to dispose of these liquids safely and cost-effectively," he said. "The way we have evolved the matrix also ensures that no oil is released when our emulsion comes into contact with water at the stope face." ***IM***