Profits from the past

In Colombia, AuVert's technology is being combined with CDE's experience in dewatering and tailings management to extract the remaining precious metals existing in the ground, while removing up to 93% of residual mercury which has to date prevented this land from being used by the local population

While tailings dam liabilities and falling water resources are affecting the ability of miners to start new mines, or expand existing ones, these issues are strengthening the case for reprocessing and retreating 'waste' sites or streams. Dan Gleeson explores an increasingly diverse market focused on revenue generation and risk reduction

With improved transparency around tailings dams and waste stockpiles now part and parcel of being a responsible mining company, investors and the wider mining world are becoming aware of the opportunities to clean up legacy operations, while, at the same time, generate extra revenue.

These opportunities are growing in value and quantity as water scarcity in many major mining hubs accelerates and the ability to expand existing tailings impoundment areas diminishes. The trend is further aided by the fact costs and liabilities associated with these facilities continue to increase.

At the same time as this, these opportunities are becoming more feasible as the cost of specialised equipment drops – making the upfront capital expense more manageable – and the number of large mining companies looking at removing these 'liabilities' from their portfolios expands.

This has seen a new generation of 'miners' spring up intent on profiting from processing material previously categorised as 'waste'.

New Century Resources, for instance, emerged in 2016 to restart the Century mine in Queensland, Australia, through an initial tailings reprocessing operation after the much larger MMG had decided the asset had reached the end of its profitable life earlier that year. The Australia-based base metal producer is now aiming to become one of the world's top 10 zinc producers through a ramp up of operations at Century to 12 Mt/y.

GoGold Resources, in Mexico, is using the proceeds from heap leaching the Parral tailings operation, in Chihuahua, to progress with its exploration projects in the country. The recent addition of a sulphidisation, acidification, recycling and thickening, or SART, plant from BQE Water will only bolster cash reserves through the recovery of a high-grade saleable copper sulphide product, the re-generation of cyanide (a major operating cost at Parral) and an improvement in the leaching efficiency of the heap.

In Africa, the likes of Goldplat and Jubilee Metals Group have been profitably processing gold and platinum group and base metals from waste streams for many years.

Central Asia Metals built its name on the Kounrad asset, a copper dump leach operation in Kazakhstan, which, through reprocessing and SX-EW, has produced more than 100,000 t of copper cathode since operations began in April 2012.

The list goes on.

Removing the ant heaps

"Reprocessing is one strategy, if it's worthwhile from an economic standpoint," Theo Gerritsen, **Stantec**'s Global Tailings Practice Lead, said in response to a question about what strategies miners were evaluating for legacy tailings dams/waste stockpiles within their portfolios.

Speaking from his home office in Brisbane, Australia, in April, he reflected on his time working in South Africa to provide some evidence: "For example, at one point, in the middle of Johannesburg, there were these giant 'ant heaps', old tailings which were processed 100 years ago by gold mining companies.

"These 'ant heaps' had more gold in them than most current day gold mines. Because the technology at the time was not very sophisticated, they could not recover as much as they can now. Most of those historic tailings have now been reprocessed."

This reprocessing opportunity is one of the reasons why mining companies may be cautious about using tailings as backfill material or relocating current day 'waste' to an inaccessible area of the mine, according to Gerritsen.

"As technology improves, the opportunity to recover more of the metals/minerals increases," he said. "There are elements where that may not be the case – coal ash, for example, cannot be reprocessed but can be used to produce cement. There are certainly opportunities with gold, copper and even coal, for instance."

The strategies companies ultimately pursue for these 'waste streams' depend on the technology available and the safety of the facilities, Gerritsen remarked.

"For instance, it may not be economically viable to reprocess the material currently in a tailings storage facility and, therefore, the owner may decide to close it or put it into a non-active state," he said.

One company looking to address the availability and cost of specialised technology for reprocessing tailings and other 'waste' is **CDE**.

An industry-leading manufacturer of wet processing equipment for materials processors, CDE has seen a significant rise in proposal requests for dewatering and dry stacking equipment over the previous 12 months, according to Kate McCormick, Mining Sector Executive at CDE Meta.

Most requests have focused on re-processing existing tailings, recovering the valuable fractions, and dewatering and dry stacking the waste products, she explained.

"We are increasingly approached by clients seeking to recover value from their waste stockpiles, which have accumulated in times where high-grade ore was abundant and lower grades were set aside as waste, or processing technologies were not sophisticated enough to capture fines fractions or suitably upgrade the ore deposit," she told ***IM***.

McCormick said CDE was receiving these requests from smaller mining companies looking to specialise in reprocessing brownfield sites.

"Increasingly we are seeing junior miners adopting a strategy of purchasing waste dumps or historic tails for re-processing as an economic source of commodities," she said. "This value is easy to recover as the material has already been mined and avoids the substantial extraction costs of virgin mining, yet these tailings deposits contain high recovery rates with existing projects, for example, recovering 2 g/t Au and achieving 63% Fe grade at 50% yield."

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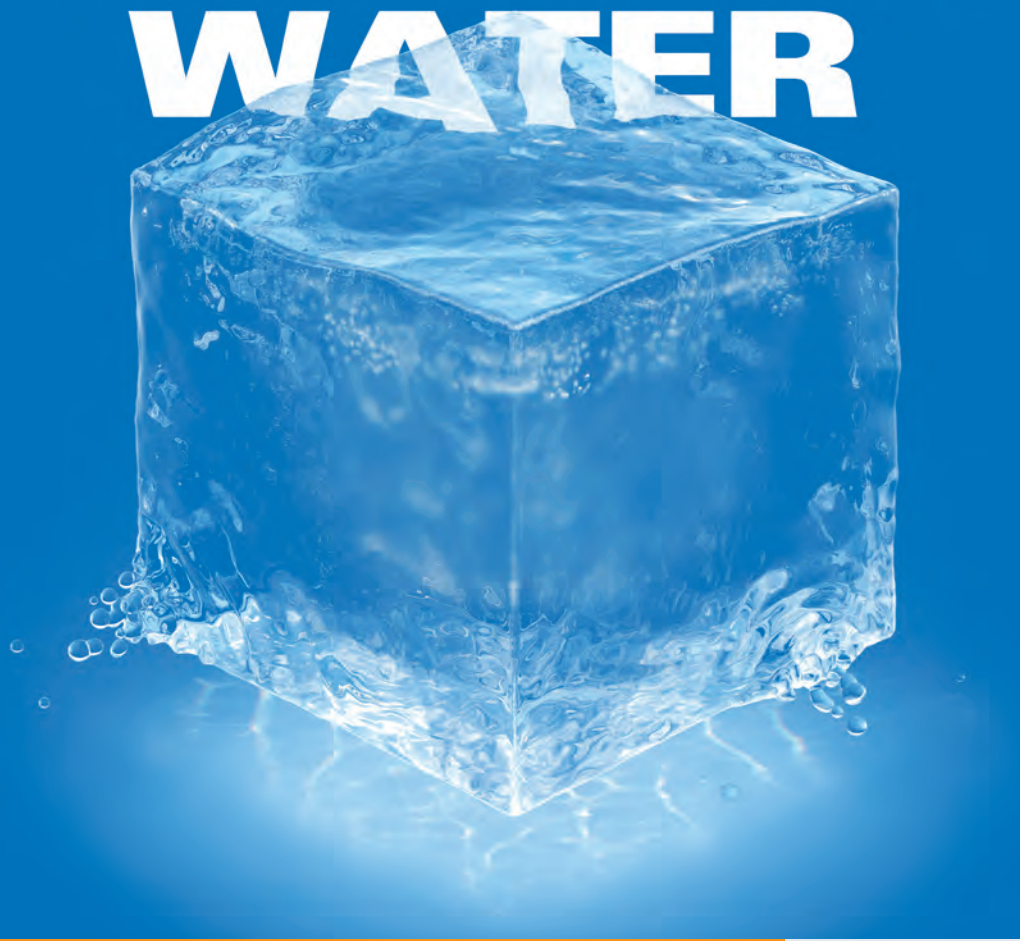

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It is the junior and mid-tier miners – not the Tier 1 outfits – able to more easily incorporate the new technologies CDE and others offer to carry out such processing, according to McCormick.

"Contrary to the assumption, I think the transition to dry stacked/filtered tailings is more accessible to junior and mid-tier miners who have increased flexibility to incorporate new technologies into their plant design," she said. "For Tier 1 miners, the scale of dewatering existing and historical dams presents significant commercial risk due to the expense involved."

The company has a few case studies to back this opinion up.

Zero-waste initiative

In working with junior miners from prefeasibility through to development stage, CDE offers cost-effective modular equipment design to achieve minimal tailings and minimise environmental footprint, while also opening new revenue streams for customers, McCormick explained.

One of the company's differentiators is its focus on "life-cycle economics", with CDE working to identify markets for by-products of mining as part of its zero-waste initiative.

This initiative sees the company look at the entire supply chain in which its customers operate.

In South Africa, for example, CDE has a customer purchasing historic mine waste dump material that it processes through one of its plants to produce a fine sand gold-bearing concentrate that is sold back to the mine for reprocessing.

Simultaneously, the plant produces one sand and two aggregate materials which are sold to the construction industry, while the land where the dumps were once situated is repurposed for development.

In Latin America, the company is also working on projects such as AuVert Mining's asset in Colombia. Here, AuVert's technology is being combined with CDE's experience in dewatering and tailings management to extract the remaining precious metals existing in the ground, while removing up to 93% of residual mercury which has to date prevented this land from being used by the local population.

CDE's plant designs might also factor in supplying 'by-products' to other industries.

"At CDE we try to identify alternative markets for the by-products, such as creating sand and aggregates suitable for construction, as well as land rehabilitation and paste and backfill," McCormick said. "For us, it is important that we strive towards a zero-waste goal."

The company's largest reprocessing project to date has come in Australia and involved "a first-of-kind opportunity" to design a turnkey solution for the upgrading of legacy iron ore waste to a high-value product, she said.

At a combined throughput of 950 t/h, the SIMEC installation is the company's largest processing facility for low-grade beneficiation.

The project will see almost 18 Mt of low grade, extremely abrasive hematite iron ore turned into a saleable product for SIMEC in South Australia.

The two plants on site remove silica and alumina from the feed material, gravity separating low-grade from high-grade ore in the process. Silica levels, which range from 14% to 20% in the barren ore, have reduced to 6.4% after processing; while alumina levels, which range from 5.9% to 8.8%, have reduced to 2.8% after processing.

The iron ore wash plant also removes clays from the feed material, with the combined effect moving the iron content from between 43.4-52.7% Fe in the feed to 63-64% Fe at a yield of 50%, according to McCormick.

The plant consists of an initial washing and screening stage using CDE's M-Series™ modular range equipment followed by scrubbing of the coarser fraction by RotoMax™ log washers. Dry screening using CDE's patented Infinity Screen™ range follows prior to gravity beneficiation in the coarse and fine jigs, and dewatering and conveying to stockpiles via more than 20 CDE conveyors across the two processing plants.

The finer fraction is further washed and separated prior to being de-slimed in cyclones at 200 mesh and gravity beneficiated through a series of spiral banks. Three of CDE's A1500 AquaCycle™ thickeners are deployed across the two plants to form a concentrated tailings sludge and recycle process water, the company noted.

McCormick said these projects have sparked the interest of many similar providers on a global basis who are increasingly recognising the value retained in legacy waste.

A fitting solution

While all in the industry would agree that providing an effective and sustainable tailings management and dewatering solution is easier on greenfield sites, there are few opportunities such as this on the market.

As a result, CDE has designed its EvoWash™ and AquaCycle™ combination to slot into a wet processing circuit for tailings dewatering, while its Plate Press filtration system, which has been in demand as of late, is able to be incorporated into the mix and achieve higher levels of water recovery and dry stacking.

Adam Holland, Head of Mining at CDE, walked *IM* through the offering.

"The EvoWash is a compact, modular washing system which integrates a high-frequency dewatering screen, sump and hydrocyclones to provide unrivalled control of silt cut points and eliminate the loss of quality coarser articles to the fines dewatering circuit," he said.

The system effectively deslimes and dewaters the tailings, while simultaneously creating valuable materials for the construction market and incorporates patented Infinity Screen technology for optimal dewatering results, Holland added.

The CDE AquaCycle water management system provides the required high rate thickening to recover up to 90% of the process water for re-circulation around the washing plant while thickening a tailings sludge.

"The AquaCycle M offers a fully modular skid mounted option for customers who want to avoid civils work," Holland added.

CDE's Plate Press filtration system is designed and built to deliver maximum plant efficiency, eliminating the need for tailings dams, or settling ponds and significantly reducing waste handling, according to Holland. "The market-leading automated cloth wash system delivers maximum dewatering performance, recycling up to 95% process water," he said.

The company is also working on an "Ultra-fines solution" to provide a modular tailings dewatering and beneficiation unit that will accept a dredge or dry feed to recover and upgrade the target mineral, while retaining the by-products for use in other applications, according to Holland.

"The vision is that of a compact footprint system that can be easily relocated as each area of a tailings deposit is reprocessed," he said, adding that a combination of this solution with the Plate Press filtration platform, using both membrane squeezing and cake blowing, could achieve moisture contents as low as 8-9%.

Such a solution appears to be aimed at the junior and mid-tier market McCormick previously spoke of, allowing for progressive rehabilitation/reprocessing at lower throughputs and cost.

Holland said the company is working with strategic partners, customers and academic institutions to progress the Ultra-fines solution during 2020.

Conceptual thinking

Speaking of reducing the moisture content of tailings, the **Metso** VPX filter made a big splash when it was unveiled to the mining world last year.

Not only did the filter provide the pressure, throughput capacity and electromechanical operation miners had been calling for, it also helped form Metso's tailings management concept.

This concept, which envisages filtered tailings as the most promising and sustainable way forward, addresses not only the demand for dewatering fresh tailings, but also the ability for miners to reprocess existing dams, turning 'waste into value'. On the latter, the company has conducted studies that showed processing one unit of tailings could be up to three times more cost-effective than processing virgin material.

The tailings management concept is hitting home in South America where Metso recently set up its pilot VPX unit, according to Rodrigo

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Gouveia, VP, Tailings Management Systems for the company.

The machine, equipped with the same advanced control system, sensors and functionality the commercial units have, was installed in March, in Brazil, and is now ready to perform all tests on an industrial scale, according to Gouveia.

"At least four customers have already scheduled their tests, while others in Chile, Peru and Australia should start sending samples to Brazil in the coming weeks," he told ***IM*** in early April.

Gouveia expects these test results to be available in the near term. They will provide data on how the VPX unit can treat material from iron ore, copper and gold operations.

"There is big interest in those tests in Brazil right now," he explained. "The main point of the tests for these companies is to understand how the VPX processes the material, but they also want to use the results to dimension their circuits for tailings."

Metso has built the VPX filter to manage varied input materials with pressure up to 25 bar (and perhaps even higher). The company eliminated the use of hydraulics on this new filter, instead using electromechanical screws to achieve the high-pressure closing that turns wet material into dried cakes with as low as 7% moisture content in some applications.

The modular design allows the filter to be scaled to any size, plus fit it into a container for easy logistics.

The fast opening and closing mechanism, meanwhile, means the units can provide the high-capacity dewatering large mines require.

Lars Gustavsson, Director, Filtration, Metso, said there has been lots of interest in the VPX filter since launch in June 2019 and the company has many units in negotiation with companies in South America, Australia, Europe and Asia.

Despite both Gouveia and Gustavsson explaining the majority of this demand has come from miners looking to process fresh tailings as they made moves away from wet tailings operations, Metso's most advanced discussions have been with a miner in Latin America looking to treat a high tonnage and difficult to dewater copper concentrate. The miner in question is also interested, longer term, in applying the VPX filter to its tailings operations, Gouveia clarified.

Metso's pilot VPX filter press unit is installed in Brazil and is ready to perform all tests on an industrial scale, according to Rodrigo Gouveia

Gustavsson explained: "The VPX, as we designed it, is not only for high pressure capacity filtering of tailings; we can also use the air blowing to reduce the cake moisture of a concentrate."

He said Metso is also starting to include details of the VPX unit in filter press quotes it sends to hematite miners in India. "We see a big potential for the VPX25 filter in India for Indian hematite," he said. "This material can be as difficult to dewater as tailings and we are also talking about high tonnage applications."

Tailings will continue to remain the focus for Metso going forward, according to Gouveia.

"With the reduction of ore head grades and the increased demand for metals, we have seen increases in the volumes of material produced," he said. "This has seen the volume of tailings also increase.

"After the most recent tailings dam accidents, there has been more concern about using dam capacity. Authorities are paying a lot more attention to this and, in many cases, are not providing authorisation to increase dam capacities.

"Water scarcity in some areas is another issue. When we talk about recovering or dewatering the tailings, it also becomes a source of water that can be reused in the mining process or returned to nature."

He concluded: "These factors, plus the more cost-effective nature of new filtered tailings technology; the high cost of – and cover restrictions associated with – insuring tailings dams; and the increased risk associated with operating wet tailings dams, has made dry stack tailings a much more viable solution," Gouveia says.

Yet, it should be remembered that, with Metso's ability to offer a complete processing offering through its expertise in comminution and beneficiation, the VPX could be used in

Waste to paste

Faced with a significant and potentially costly challenge relating to tailings disposal, The Ural Mining Metallurgical Company (UMMC) mining and processing plant in Uchaly, Russia, turned to **Outotec** and its thickened tailings and paste expertise.

The existing disposal pond at the plant was close to capacity, and constructing a new facility would be costly, time consuming and significantly expand the mine's environmental footprint.

The plant used the traditional impoundment method to dispose of tailings and, by 2014, the existing pond was almost full. With the mine continuing to operate underground, there were two options: either build a new tailings pond, or use the depleted open pit to store tailings.

UMMC chose to implement an Outotec HCT paste thickening plant to turn concentrator waste into an environmentally friendly paste product that can be used to restore the depleted crater of the site's open pit.

The existing mine was at a depth of 400-600 m under the open pit, meaning safety was of utmost importance.

To ensure safety, several factors had to be considered, according to Outotec:

- Reducing the amount of water in the tailings to minimise mine drainage;
- Increasing the solids content from 20% to 68-70%; and
- Finding a sustainable solution for managing tailings.

The Outotec Thickened Tailings and Paste Plant not only reduces the area occupied by the tailings pond and the risk of environmental pollution, but also allows efficient recovery of process water for reuse and reduces the energy consumption of slurry and water pumping, the company said.

In addition, by moving away from the traditional method of disposal, the operating life of the tailings pond was increased from 20 years to 50 years.

Together with its partner, the Institute of the Urals Branch of the Russian Academy of Sciences in Yekaterinburg, Outotec developed an approach that would meet all project requirements and avoid the underflow flooding into the underground space, it said.

Work began in 2010 when the first laboratory tailings thickening tests were performed. Pilot tests were carried out in the autumn of 2011 and the first technical and commercial quotation was prepared in 2012. In 2014, the joint engineering solution successfully passed state expert appraisal. In 2017, the plant successfully passed all the tests, with the desired solids content of 70% achieved almost immediately after start-up of the paste tailings plant, Outotec said.

When mixed with cement, the paste from the thickening plant can be used for backfilling the depleted open pit or underground mine space, both decreasing the area of the tailings pond and increasing safety by improving the stability of the mine.

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combination with thickeners, hydrocyclones and other equipment to create an integrated system able to reprocess existing or legacy dams, to both generate additional revenue and clean up the facilities.

Upping the flotation threshold

Eriez believes there is a different way to reduce the production of wet tailings at the same time as recovering more metals and minerals. That is through re-engineering the flotation process.

As Eric Bain Wasmund, Global Managing Director of Eriez Flotation, says, conventional sulphide flotation technology is not effective at floating particles greater than about 200 microns, leading to this threshold being the practical end point for grinding operations.

"Grinding energy increases dramatically as the size decreases, and over-grinding creates additional flotation efficiency challenges because 'slimes' do not float with high efficiency," Wasmund said.

"But the most serious consequence of current grinding practise is that the entire volume of mined ore is necessarily reduced to a slurry of fine particles, predominantly less than 200 microns."

The handling and long-term storage of this cumulative volume is a major cost and long-term risk management concern for mining companies and other stakeholders.

This is where coarse particle flotation and the HydroFloat® comes in, Wasmund said. The commercially available solution uses fluidisation to effectively float sulphide particles up to 700 microns, upping the flotation threshold.

The HydroFloat has already been used to scavenge sulphide tails and allow operations like Newcrest's Cadia copper-gold mine in New South Wales, Australia, to coarsen its grind size, according to Eriez. It is also helping the miner recover gold and copper from the concentrator tailings stream.

Wasmund explained: "While this allows only a marginal bump in the size distribution of their tails, it does allow the reduction of grinding energy and the recovery of payable metals in the waste, as well as proving the long-term operability of the HydroFloat as a technology platform for coarse particle flotation."

The next opportunity being developed for Eriez Coarse Particle Flotation is to use the HydroFloat to allow coarse gangue to bypass conventional flotation, "acting analogously to an ore-sorting application, and thereby generating a significant fraction of the total volume of tailings in a primary size range two-to-three-times coarser than the fine tails produced by conventional flotation", Wasmund said.

The accompanying block diagram (opposite) shows how the coarse gangue rejection application works.

Wasmund said: "In a conventional mill circuit, the product of secondary grinding in a ball mill is fed to a sizing unit, typically a cyclone. The cyclone is configured so that the overflow produces the right size distribution for conventional flotation, while the mainly coarse-sized underflow, which also contains some 'misplaced fines', is returned directly to the mill."

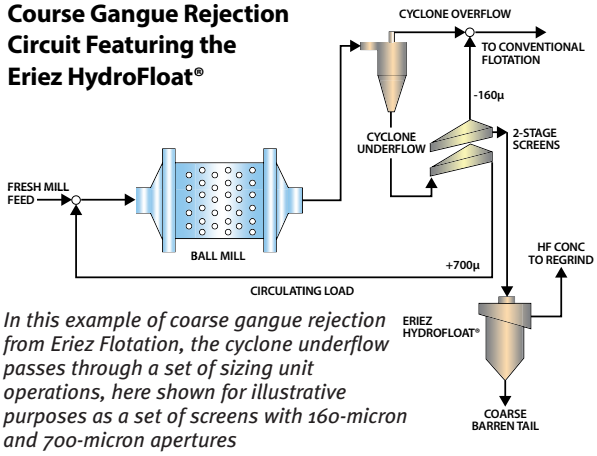
In this example, which illustrates the idea behind coarse gangue rejection, the cyclone underflow passes through a set of sizing unit operations, here shown as a set of screens with 160-micron and 700-micron apertures for illustration purposes.

Wasmund said: "The screens split the cyclone underflow into three sizes classes: a fine stream less than 160 micron, typically about 20% by mass, which can be added back to the conventional flotation feed; a coarse stream greater than 700 micron, typically 20-30% by mass which can be returned to the grinding mill; and a mid-range stream between about 160 and 700 microns, typically 50-60% by mass, which can be used to feed the HydroFloat."

Because the HydroFloat has very high recoveries in this size range comparable with conventional flotation at conventional grind sizes, it can perform as a pre-rougher flotation unit on this mid-range material and generate a coarse barren tail permanently removed from the flotation circuit at an 80th percentile size typically between 500 and 600 microns, according to Wasmund.

"While fine grinding is still required for

Course Gangue Rejection Circuit Featuring the Eriez HydroFloat®



In this example of coarse gangue rejection from Eriez Flotation, the cyclone underflow passes through a set of sizing unit operations, here shown for illustrative purposes as a set of screens with 160-micron and 700-micron apertures

conventional flotation and to regrind the HydroFloat concentrate, a significant portion of the tail will now be in the coarse size range."

The proportion of final tailings that can be produced in the coarse size class will depend on the optimisation of the flotation process for the HydroFloat, which will increase as the effective size range of feed to the HydroFloat also increases.

"While the results will be application specific, it is expected that the mass of final fine tails could be reduced by at least 30% and replaced with the same amount of coarse tail," Wasmund said. "This would mean less grinding energy, smaller mills and a smaller fraction of the overall concentrator output that needs to be dewatered and stored in a conventional fine tailing impoundment."

It would also potentially result in more metal and minerals being recovered as cutoff grades fall in line with the reduced need for grinding.

Treating water right

Water specialist **Talbot**, in January, launched a state-of-the-art mobile unit that enables mining and mineral resources players to test a highly efficient and cost-effective water treatment and mineral product recovery solution right on site.

The mobile unit is able to demonstrate the effectiveness of Vibrating Sheer Enhanced Process (VSEP) technology, a solution developed by US company New Logic Research Inc, which not only treats highly contaminated and difficult water streams to municipal quality, but is able to recover valuable product from residue that would otherwise be consigned to waste.

The VSEP membrane typically out-competes other technologies on highly contaminated streams that have elevated concentrations of scalants, which exceed the feed concentration of conventional membranes, according to Claire Lipsett, General Manager – Consulting Services at Talbot.

"If you concentrate a compound beyond precipitation potential, you will produce solids/salts," she told ***IM***. "The vibration on the VSEP module prevents these blocking or damaging the membrane pores and flushes them out with the brine. You can push the system much further with minimal pre-treatment."

In mine waters, this is critical, according to Lipsett, as elevated and broad range contaminants are often present. "We also see extreme pHs and variability which simply cannot be tolerated on traditional membrane systems."

While treating contaminated and difficult water streams is the main order of business for Talbot and the VSEP, Lipsett said product recovery also comes into the mix.

Precious metals operations, for example, provide a strong business case for the VSEP as the membrane can remove micro and nano particles, where centrifuges and presses only remove the micro particles. Should mining companies recover this metal from the membranes, there remains the potential for additional revenue.

And looking beyond simply metals/mineral recovery revenue, VSEP could also allow mines to generate general use "permeate" from their process water. This can be used as a raw water source or processed further to potable quality and distributed to local communities, according to Lipsett.

Lipsett said: "This guarantees their operating licence and ensures their compliance to community sustainability" – an aspect of operating a mine that is becoming increasingly valuable. IM

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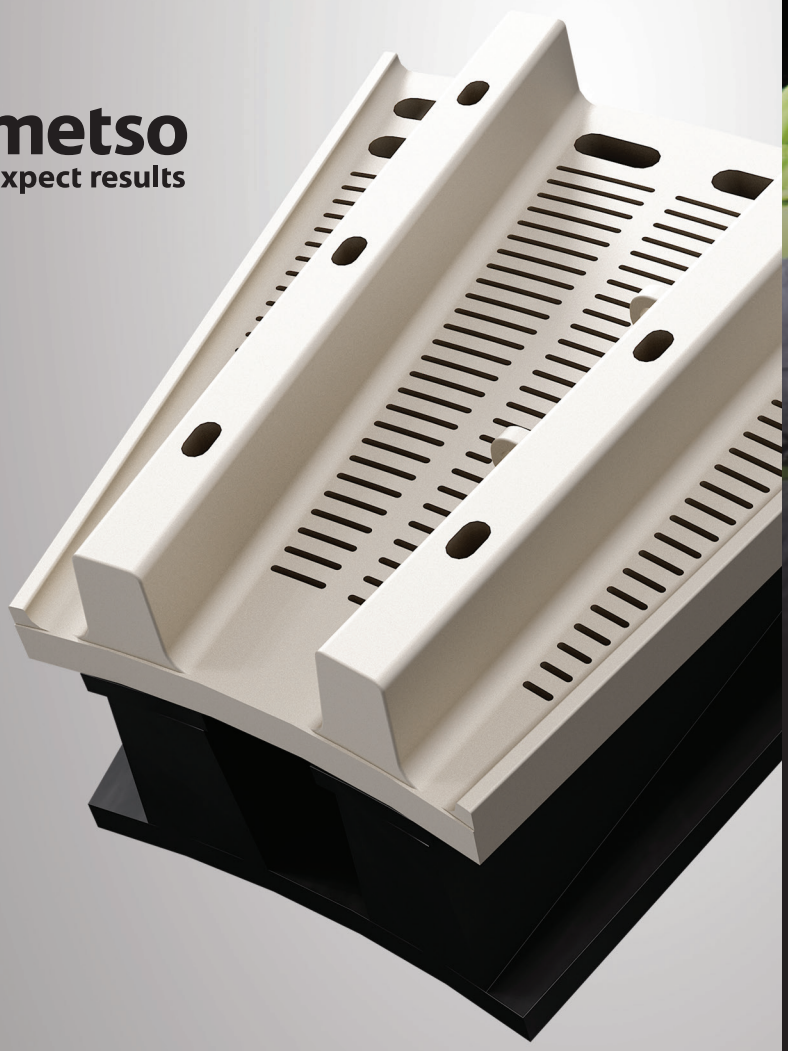

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