Tailings are perhaps the most common way of getting value from old mines, in addition to redeveloping old mines. DRDGOLD is a mid-tier, unhedged gold producer and the only South African mining company to focus solely on the retreatment of surface gold tailings. It has bold plans with Sibanye-Stillwater for a massive dump retreatment project.

DRDGOLD CEO Niël Pretorius says the proposed transaction with Sibanye-Stillwater, based on the latter’s West Rand Tailings Retreatment Project (WRTRP) “is well within DRDGOLD’s capacity to execute, and is capable of delivering both short-term value and long-term optionality”.

In November last year, DRDGOLD and Sibanye-Stillwater announced the proposed transaction, in terms of which DRDGOLD would acquire portions of Sibanye-Stillwater’s WRTRP in exchange for some 38% of DRDGOLD’s ordinary share capital. In addition, there is an option agreement in terms of which Sibanye-Stillwater can increase its shareholding in DRDGOLD to 50.1% for cash during the 24 months following implementation of the acquisition.

Pretorius says that, in assessing the deal, the company was mindful of execution risk and dilution. “While the doubling of reserves in a resource with a higher average gold grade is clearly value-accrative, our objective remains to avoid or limit dilution of earnings by doing our best to ensure that the 38% dilution in equity is either offset or, ideally, altogether avoided by earnings from the project from a very early stage.”

DRDGOLD’s proposed phased approach, Pretorius says, is intended to “bring this goal within range”. The selected surface assets comprise part of the WRTRP, a large-scale, long-life project to reclaim gold and uranium from historical tailings deposits situated in the greater Carletonville/Randfontein area. These assets include the following:

<table>
<thead>
<tr>
<th>Asset</th>
<th>Mt</th>
<th>g/t</th>
<th>Moz</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSFs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Driefontein 3</td>
<td>49.8</td>
<td>0.470</td>
<td>0.752</td>
</tr>
<tr>
<td>Driefontein 5</td>
<td>27.9</td>
<td>0.469</td>
<td>0.421</td>
</tr>
<tr>
<td>Libanon</td>
<td>73.3</td>
<td>0.272</td>
<td>0.641</td>
</tr>
<tr>
<td>Kloof 1</td>
<td>27.9</td>
<td>0.325</td>
<td>0.292</td>
</tr>
<tr>
<td>Venterpost North</td>
<td>54.5</td>
<td>0.274</td>
<td>0.480</td>
</tr>
<tr>
<td>Venterpost South</td>
<td>12.7</td>
<td>0.331</td>
<td>0.135</td>
</tr>
<tr>
<td>Active TSF</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Driefontein 4</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Active TSFs: to be transferred once decommissioned

<table>
<thead>
<tr>
<th>Asset</th>
<th>Mt</th>
<th>g/t</th>
<th>Moz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driefontein 1</td>
<td>38.2</td>
<td>0.200</td>
<td>0.245</td>
</tr>
<tr>
<td>Driefontein 2</td>
<td>48.0</td>
<td>0.229</td>
<td>0.354</td>
</tr>
<tr>
<td>Kloof 2</td>
<td>61.0</td>
<td>0.235</td>
<td>0.462</td>
</tr>
<tr>
<td>Leedooorn</td>
<td>0.00</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Among DRDGOLD’s reasons for the transaction are:

- Operating surface gold processing plants (DP2, DP3 and WRTRP pilot plant)
- An active tailings storage facility (TSF), Driefontein
- Land required for future development of WRTRP, Central Processing Plant (CPP) and Regional Tailings Storage Facility (RTSF)
- TSFs as indicated in this map below:

Among DRDGOLD’s reasons for the transaction are:

- Increase of about 91% in gold reserves: 2.99 Moz to 5.71 Moz
- Acquisition of surface assets capable of providing cash flows in short term with low initial capital expenditure and to support future growth and development of the project
- Potential to increase production, revenue
- Increase DRDGOLD’s reserve base which extends life of mine

John Chadwick considers one of the world’s largest gold-from-tailings recovery operations and some of the technologies available.
Reduction in overhead unit costs through increased production

RTSF large enough to receive most Regional West Rand tailings

Securing significant long-term growth in a new operating region

Opportunity to leverage proven experience to optimally develop the WRTRP

Phase 1, including both early-stage production as well as design and planning, will involve the upgrading of the Driefontein 2 and 3 plants to process tailings from the Driefontein 5 dump at a rate of between 400 000 and 600 000 t/month and depositing the residue on the Driefontein 4 tailings dam.

Targeted for commissioning within 12 months of implementation of the acquisition, it is expected to be cash-generative with a “modest” upfront capital investment of R288 million. Assuming this initial capital outlay, its NPV is estimated at around R1.3 billion.

“We believe the information we gain from Phase 1 test work will enable us to refine the original WRTRP process and engineering design, as well as financial and capital models for Phase 2,” Pretorius says.

Phase 2 envisages the construction of a high-volume central processing plant capable of processing at least 1 Mt/month and the development of a new regional tailings storage facility. In this phase, reclamation will be from the Driefontein 3, Libanon and Kloof 1 dumps initially and then from the Venterdorp North and South dumps.

Phase 2, Pretorius says “will provide a compelling advantage insofar as future regional consolidation is required” – meaning the scale of the infrastructure established would allow for reclamation from other sources in the region.

As an alternative to Phase 2, or in the event that Phase 2 is delayed, Phase 1 will be capable of extension by blending in material from the Driefontein 3 dump. It envisages the treatment of 77.7 Mt from the Driefontein 3 and 5 dumps and a further upgrade of the Driefontein 4 tailings dam. The estimated NPV of the alternative option is R2.7 billion, assuming a capital outlay of R397 million in addition to the initial Phase 1 capital outlay.

DRDGOLD estimates the NPV of the entire WRTRP at R2.1 billion.

Tailings management

Whether tailings are being reclaimed or not, their management has always been a challenge in terms of first handling the volumes of material and secondly ensuring environmental safety. The technology exists in the form of thickened and paste tailings and associated equipment to make tailings management much safer and more efficient; and the industry is now finally taking steps to move away from wet tailings impoundments where possible.

FLSmidth is at the forefront of working with mining customers on these system designs and technologies – in the first of International Mining’s Insight Series of videos, Liam MacNamara, FLSmith VP Sales, addresses some of the key questions in this subject area including outlining some recent innovations. https://im-mining.com/interviews/mine-tailings-management/

For example, FLSmidth’s millMAX-e™ pump is a high efficiency slurry pump designed to maximise efficiency and minimise cost of ownership.

This is a further optimisation of the world-renowned millMAX design for slurry applications. The hydraulically advanced impeller and an extremely efficient design, gives users a maintenance friendly pump that will often enable downsizing of the drive motor, “thus further minimising cost while maximising efficiency,” the company says.

“With a low upfront cost and increased power savings, the millMAX-e can pay for itself in less than a year of operation.”

Evaluating potential

Gekko and CSIRO are partnering to commercialise a new technology that will be very useful in evaluating the potential of tailings and other solution streams to yield economic value or in the monitoring of recovery plants. It provides real-time analysis for gold content in a slurry or stream, delivering an updated sub-parts per million (ppm) Au measurement every 10 minutes. The OnLine Gold Analyser (OLGA) provides analysis and insights into process performance that are unobtainable with assayed sample sets. While traditionally assayed
samples consist of homogenised samples that are collected and then delayed up to 12 hours by lengthy processing, OLGA provides live data. This enables real time monitoring and adjustment of process systems and empowers mining operators to minimise gold losses from process excursions.

Complimenting Gekko’s existing Carbon Scout measurement system, OLGA will enhance Gekko’s metallurgical accounting system which is currently under development in collaboration with Rockwell Automation.

OLGA is specifically designed to enable direct measurement of gold in tailings, feed and concentrate slurries streams down to sub-ppm levels, unlike conventional X-ray fluorescence (XRF) systems that have detection limits in the tens to hundreds of ppm range. The system is delivered to site fully pre-calibrated using a range of samples representative of the plant stream allowing fast installation and commissioning into the existing process plant. As the system measures a sample slurry stream, it can be taken offline without interruption to production.

Following successful in-house testing at CSIRO, OLGA is now being field-tested at Australian gold mines and should see OLGA undergo full product release early in 2019.

Managing tailings slurries

Xylem notes that “slurry tailings are sometimes an ugly by-product of processing...and they are everywhere. Considerable time and effort is spent pumping tailings around, sometimes because they are ‘just in the way.’ However, more and more operators are reprocessing slurry tailings.

“You generally have two options with processing slurry tailings: Bring the pump to the solids or move the solids to the pump. Xylem offers the following products and support for slurry tailings dewatering:

- A line of submersible pumps ranging from compact, portable units for small drainage jobs to larger dewatering pumps for a variety of applications where corrosion and abrasive conditions exist
- Fully automatic diesel, electric or natural gas-powered, solids-handling dry priming pumps

for high-volume and high-discharge heads
- A full range of hydraulic submersible pumps for general duty in dewatering, bypass, drainage and sludge applications
- An exhaustive range of pumps and accessories for rent, with over 20,000 portable pumps and related equipment located around the globe
- Pipe, fittings, and all other accessories in a one-stop shop.

Rugged reliable and cost effective, Xylem’s Flygt 5000 series of submersible slurry pumps handle, it says, “transportation of the most abrasive solids that are suspended in liquid”

Vale from old mines

Weir Minerals has come to a strategic cooperation agreement with international technology group Andritz to supply equipment for processing tailings in the mining industry. As part of this agreement, Andritz will supply proven separation and dewatering technologies, thus enabling Weir to offer complete tailings solutions to its customers.

“The tailings market is experiencing growth driven by environmental and governmental pressures. We understand our customers are under increased pressure to further improve the management of their mine tailings, which is why we have partnered with Andritz. We are industry leaders in mineral processing equipment, with well known brands Warman®, GEHO® and Cavex®, all of which are backed by our global service footprint. Our capabilities, teamed with Andritz extensive knowledge on tailings thickening, will ensure our customers receive a complete tailings solution,” said Ricardo Garib, Weir Minerals Division President.

“Our separation technologies have been proven in a large number of industries. We are very proud to work with Weir Minerals, who operate in over 70 countries worldwide and in the most remote locations, and to contribute to their offering of sustainable and value-added tailings solutions with our expertise and product know-how,” says Olaf Müller, Business Area Manager of Andritz Separation.

For a number of decades, Weir has been providing mines around the world with sustainable and cost-effective solutions for the management, disposal, and recycling of mine waste. The renowned GEHO® positive displacement pumps transport ores, minerals, and tailings under extreme conditions, while minimising both water and energy consumption at the same time.

In 2016, the Weir Technical Centre was opened, which has enhanced the company’s global tailings offering by developing and testing pipeline and tailings solutions as well as manufacturing specific tailings-based products.

Garib adds, “This latest agreement complements our overall tailings offering and enables us to provide our customers with a complete tailings solution. Under the brand name IsoDry, we will now offer customers a range of mechanical separation technologies, such as thickeners, filter presses, centrifuges, and vacuum belt filters.”

Weir Minerals GEHO® TZPM pump is a crankshaft driven three cylinder single-acting piston diaphragm pump. The unique preformed GEHO® diaphragm protects piston and liner from abrasive slurry contact. Weir says “abrasive tailings slurries are handled highly efficiently (up to 96%) and the pumps ensure a high availability up to 98%.” Key features/benefits include:

- This heavy-duty industrial pump is designed for pumping solids/liquid mixtures and high pressures/high heads
- Diaphragm protects piston and liner from contact with abrasive slurry
- High availability; continuous duty 24/7
- Low energy consumption due to very high efficiency up to 96%, so a low carbon footprint

For similar applications to the GEHO TZPM pump, the DHC pump, with cone valves designed for extremely viscous pastes and sludges. “This pump type ensures uninterrupted, trouble-free operation, high reliability and low operational costs.” It can be equipped with the GEHO VZ system for pulsation free operation, preventing damage, excessive wear and noise.
Long maintenance intervals
No external water flushing required.

Metso's MD series of pumps are based on its long history, extensive know-how and experience. The MDM hard metal and MDR rubber lined slurry pumps ensure sustained performance with maximised time between rebuilds.

The hydraulic design of MD series pumps is consistent across the entire range and reduced impeller overhang restricts shaft deflection across a wide range of flows. All these factors help ensure sustained performance, reduce wear and extend the life of components and the entire installation.

The extensive range of Metso’s MD series of pumps cover flows of up to 6,000 m³/h. With inlet sizes currently ranging from 300 to 550 mm with either metal or rubber lining

They have been built to last using high-performance materials with excellent resistance to abrasion and erosion. Special emphasis has been placed on components that have to withstand exceptional wear from coarse heavy solids and flow turbulence. An oversized robust steel shaft and extra thick casings and liners are just some of the heavy-duty components.

**Mintek water treatment**

Mintek recently showcased a number of its process technologies associated with tailings.

SAVMIN™is Mintek’s cost-effective technology for the treatment of mine-impacted water, including acid mine drainage (AMD). It is a precipitation-based process, operating at atmospheric temperature and pressure, and removes heavy metals and sulphates from mine-impacted water.

Mintek says implementation of the SAVMIN technology has the following benefits:

- Can treat a variety of waste streams and the process is not limited by the concentrations of pollutants such as sulphates and heavy metals
- Can reduce sulphate concentrations to less than 200 mg/litre
- Recovery of metals of interest and value
- Regeneration and recycling of the key reagent aluminium hydroxide - thereby limiting the operating costs associated with fresh reagent addition
- Low electrical power consumption as the process is operated at ambient temperature and pressure
- Waste products from the process can be disposed of as a stable waste or, in certain instances, constitute a usable byproduct.

Biological Sulphate Reduction is a process to remove metal sulphates from waste waters using sulphate-reducing, naturally-occurring bacteria that are immobilised on a suitable substrate, such as woodchips. The process can be used for the treatment of AMD to remove the sulphates from solution and stabilise the toxic metal ions present as metal sulphides.

The NiCMembrane™ is a low-fouling ultrafiltration membrane that can be used for the treatment of AMD and mine-impacted water for the removal of turbidity.

Metal Recovery through Ion-exchange (MetRIX™) is a continuous resin-in-pulp ion exchange process for the removal of uranium or base metals from dense slurries. The process can operate with slurries containing up to 50% solids and therefore does not require any upfront filtration.

Mintek has conducted intensive research and development over the past 10 years on the recovery of uranium from low-grade uranium slurries. Recent developments in the RIP technology have focused on the recovery of base metals from slurries. Evaluations have been carried out on the recovery of nickel, zinc, cobalt and copper at laboratory-scale, and zinc at pilot plant-scale.

Some of the unique benefits of the MetRIX process include:

- Elimination of solid/liquid separation steps; the process recovers uranium and base metals directly from leached pulp, consequently lowering the capital and operating costs
- The RIP adsorption circuit, Stage 2 of the MetRIX process, is a truly continuous, counter-current circuit, resulting in reduced reagent inventory, improved control of resin residence time, and minimise resin fouling and loss due to breakage.

Finally, biological oxidation is a process to extract precious and base metals from sulphide-containing ore with the aid of naturally-occurring micro-organisms. The micro-organisms act as a catalyst and oxidise the solid metal sulphides into soluble sulphates. The metals can be subsequently recovered from solution using hydrometallurgical standard techniques.

Biodeviation of refractory gold concentrates in agitated tanks has become an established commercial technology over the past three decades and Mintek is one of the leading technology suppliers.

**Managing muckpiles**

First Cobalt Corp has begun a metallurgical study on a high-grade inventory of refinery residue and crushed waste rock material located near its mill facility in the Canadian Cobalt Camp. This study is intended to advance the company’s early cash flow strategy by assessing an optimal flow sheet for recovering cobalt and silver.

The program will provide further insights into opportunities for early cash flow from processing surface muckpiles from historic underground mining operations. The testing will be done on three piles with a historic resource estimate, prepared before the company acquired an interest in the properties, totalling approximately 6,500 t with average grades ranging from 0.65% to 1.55% Co (non-compliant with NI 43-101).

The test work is aimed at elaborating a
process flowsheet based on analytical characterisation of the samples, gravity concentration, hydrometallurgical recovery of cobalt and silver, as well as arsenic removal and stabilisation.

Success could have broader implications for the ongoing assessment of processing options for historical mine material throughout the Cobalt Camp using First Cobalt’s mill and refinery.

First Cobalt has partnered with Dundee Sustainable Technologies in Quebec to develop a flowsheet for potentially processing the piles using the First Cobalt mill equipment and the First Cobalt refinery and to understand the benefits of integrating Dundee’s arsenic removal and stabilisation technology. IM