SRK News
Focus on Tailings

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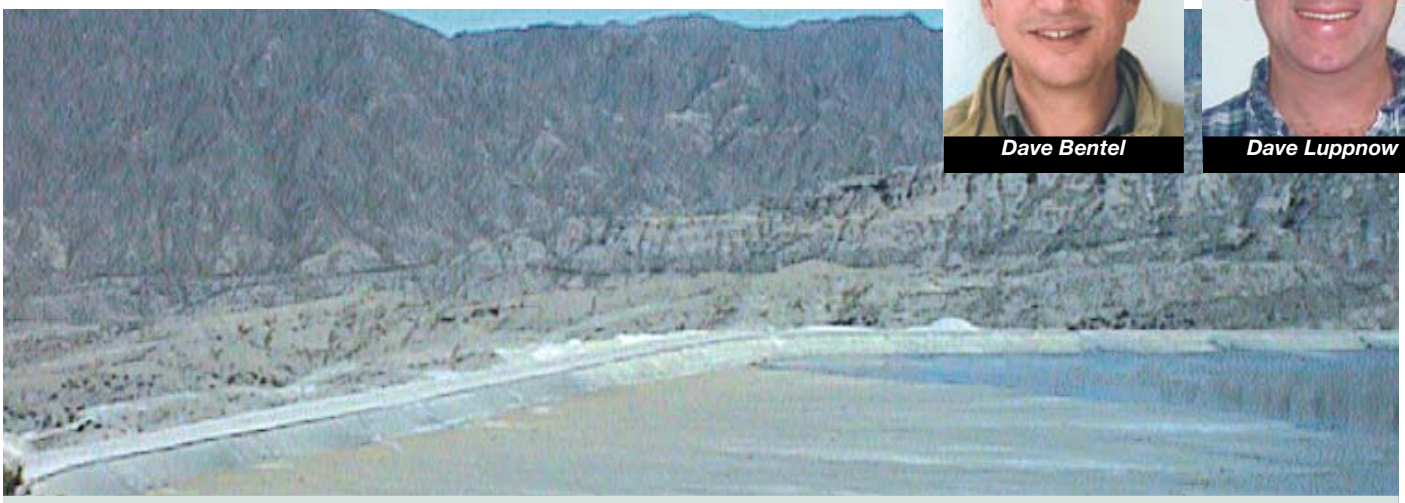
Newsletter

Operational tailings management for successful closure

SRK's approach to closure of tailings disposal facilities is influenced by the approach used to manage the facility during operation.

Dave Bentel

Dave Luppnow



Large dry beach of well operated tailings impoundment

Good operational management encompasses fluid and tailings solids management elements, and both aspects are integral to the formulation of the impoundment closure strategy. Also critical, from costing and risk management perspectives, are final beach profiles, supernatant pool location and storm diversion characteristics.

Generally tailings impoundments are closed 'dry', with a cover to reduce meteoric recharge and reduce the potential for ponding of surface water and consequent infiltration, percolation and leaching. To construct the cover, impounded operational water has to be removed and disposed of, and the tailings solids allowed to consolidate.

Good operational fluid management can greatly reduce requirements for post-operational fluid disposal, accelerate consolidation and generally reduce the time required to close the impoundment.

Reducing the amount of entrained moisture in the tailings has a number of benefits. It helps consolidate the tailings and provide a stable working foundation for earthmoving equipment. Further, it improves the long-term mass stability of the impoundment.

Proper consolidation of the impoundment reduces the impacts of differential settlement, which can cause cover failure and/or changes to surface topography and drainage patterns. An additional advantage is that the amount of seepage from the tailings diminishes as driving hydraulic head is reduced.

Operational tailings solids management allows for control of the size and position of the supernatant pool and the density of the tailings at closure. It also allows for control of the beached characteristics of the tailings to shed water at closure while reducing earthworks costs.

If the depositional sequence allows, it may even be possible to begin closure of portions of the impoundment concurrently with the final years of deposition. For example, if raising of the impoundment can be completed several years prior to closure, then the crest and slope of the embankment can be shaped and covered with resources available during operation, thereby reducing overall closure costs.

Introducing risk assessment specialist Tatyana Alexieva

Tatyana Alexieva

As leader of the Risk Assessment Initiative of our Denver practice, Tatyana Alexieva is focused on satisfying the growing need for evaluation of the economic, engineering and environmental risks of mining projects.

With a strong background in conducting static and dynamic stability analyses, seepage analyses, dam break studies, flow slide analyses, numerical modeling and settlement analyses, Tatyana has carried out many investigations, site selection, design, monitoring, and supervision for tailings and waste disposal projects around the world.

Over the years Tatyana has managed to integrate her knowledge of mining with her risk analysis skills in conducting failure modes and effects analyses to evaluate the range of risks associated with mining and industrial site operations.

Some of her recent projects include a risk assessment for a tailings storage facility in Indonesia to assist in the selection of a closure option. In Northern Canada, she has completed a comparative study of the risks associated with a range of remedial options for an underground mine. And, in New Caledonia, she has carried out a failure modes and effects analysis required for the permitting of a new tailings storage facility.

Disposal system for Corridor Sands

Ken Mercer

Based on its international track record for innovative and cost effective solutions, SRK was commissioned to develop a disposal system to handle both coarse and fine materials from the processing plant at the Corridor Sands Heavy Mineral Sands Project near the town of Chibutu, Mozambique.

The Corridor Sands reserves are the world's largest, and made up of approximately 10 individual 'deposits'. Open-pit dry mining will commence in a high grade section within Deposit 1 known as the West Orebody, which has an estimated life-of-mine of 20 years.

The principal philosophy of disposal was to use separate disposal whereby coarse tailings are returned into the pit and fines slurry is disposed of on a tailings storage facility. Composite tailings (blended coarse/fines) disposal alternatives were also investigated.

Corridor Sands Tailings Storage Facility

"For the tailings storage facility," explains SRK's Ken Mercer,"a configuration which uses a thickened slurry (paste) central discharge system with an outer impoundment wall was chosen. The dam has been designed to receive thickened slurry centrally discharged via risers situated within the drying basin of the dam.

"Some 195-million (dry) tons of fines/ coarse material will be deposited into the dam over the 20 years," Ken continues.

"The fines will require a storage volume of 168-million m^3 and an evaporation area of 12.5 km^2."

Part of the design was undertaken with the aid of Gemcom software. Simulations were used to ensure that the required volumes of material generated could be accommodated, given limiting criteria such as adequate pit floor areas, safety and water handling requirements.

Benefits of dry tailings disposal

Dry tailings disposal is the most water-efficient waste management system and should be considered for both existing and all new mining projects. To achieve real cost benefits, it is necessary to integrate the design of process plant with that of tailings disposal while giving consideration to all design aspects, from site selection to closure of tailings impoundments.

That's the view of SRK director Adriaan Meintjes, who recently published a paper on waste management in the South African mining industry, with special reference to the advantages of dry tailings disposal. In the document, Adriaan discusses the geotechnical properties of tailings and shows how water savings can be made and groundwater pollution reduced by changing the tailings from wet slurry into a dry product.

Adriaan Meintjes

Key drivers for Adriaan's focus on this subject include the long-term imperative to consider innovative methods for water savings, in response to both the requirements of South Africa's new Water Act and, more importantly, the need for mines to attain a competitive advantage in terms of water use.

"Another key objective is to limit ground and groundwater pollution," Adriaan remarks, "to ensure water sources are not contaminated and are available for all potential users. In the case of dry tailings, seepage of water from tailings impoundments to groundwater is limited to available supernatant water. Surface management of rainwater on impoundments can be engineered to limit ingress of water and reduce available supernatant water in tailings dams.

"The attendant benefits are relevant to not just South Africa but also to other regions where water is scarce and environmental performance is critical."

To obtain a copy of Adriaan's paper, "Dry Tailings Disposal – Increased Production & Potential Water Savings", contact him at ameintjes@srk.co.za.

SRK consultant profile: Pepe Moreno

We are delighted to welcome Pepe Moreno, a respected Peruvian geotechnical engineer with over 11 years of experience in mining, infrastructure, transportation and natural gas projects, to our team.

As Senior Geotechnical Engineer in the Lima office, Pepe leads the development of tailings and geotechnical projects in Peru, combining SRK's worldwide experience with his knowledge of local engineering practice.

Pepe Moreno

Pepe says: "Until recently, mining operations in Peru have usually disposed their tailings without taking into account safety and environmental issues. Furthermore, mining projects are often located in steep terrain at high elevations, imposing additional constraints on typical tailings disposal arrangements.

Since the 1990s, the Peruvian government has placed more emphasis on tailings disposal, dictating strong environmental and safety requirements that obliged every mine to present a revised plan for their tailings disposal program. Some mining companies have been forced to modify the current configuration of their tailings dams or to close those that cannot adapt to the new standards.

This is a challenging opportunity for SRK to provide engineering services and solutions that meet engineering and environmental goals, introduce new technology and help clients to improve their tailings management systems while maintaining environmental compliance and profitable operations."

Innovative dewatering plan for uranium tailings impoundment

SRK was retained by Pricewaterhouse Coopers to develop a dewatering plan for the Atlas Moab uranium tailings impoundment in preparation for closure of the site. The project was controversial due to its location on the banks of the Colorado River, just upstream of the Grand Canyon.

The unlined impoundment was used from 1956 to 1984, and contains some 13-million tons of tailings. The closure plan proposed to cap the impoundment with a soil cover, and dewatering was necessary to minimise the amount of water entering the groundwater through the base of the impoundment during cover placement.

SRK conducted geotechnical and hydrogeological investigations of the tailings to develop options for dewatering the pile. There had also been controversy over the geochemical content of the tailings pile, which had never been thoroughly examined. A geochemical investigation of the tailings solids and porewaters was also conducted to determine what contaminants were contained within the pile.

A large portion of the tailings were found to have a consistency similar to toothpaste, with low conductivity. Vertical wick drains were selected as the best option to dewater this material.

"Wick drains are corrugated strips of plastic covered with a mesh to filter sediment," explains Tracy Delaney. "Under the pressure of the soil cover, water is forced up the wicks and onto the surface of the pile where it can evaporate.

"Wick installation partly overlapped with cover placement, so that in some places wicks were installed in areas where a surcharge was already in effect. The effectiveness of the wicks was seen immediately, with water ponding on the pile surface."

Tracy Delaney

The Atlas Uranium Mill site

The lake proposed for use as the PKCA

Cam Scott

Diamond tailings disposal in a northern Canadian environment

Jericho pit area

SRK Consulting completed the feasibility study for the Jericho diamond project in Nunavut, Canada's newest Territory, in June 2000 on behalf of Tahera Corporation.

The project is located at approximately 65.5°N latitude, in a zone of continuous permafrost. Kimberlite will be processed on site in a 50 tph plant. Coarse tailings, representing approximately 85% of the tailings product, will be dewatered, trucked and dumped in a pile adjacent to the plant site. Fine tailings, referred to as processed kimberlite, will be pumped as a slurry to a containment area (PKCA) situated within 1 km of the plant site.

A long, shallow lake with a very small catchment and marginal fish habitat was selected for PKCA development.

Confinement within the lake will be provided by a series of low dams and dikes. One or, possibly, two internal dikes will be used to develop cells. Deposition to the tailings cells will be cycled in a way that maximises the thawing of tailings deposited during winter and facilitates discharge of the maximum amount of water from the PKCA during each summer 'window'.

SRK's Cam Scott says: "The quality of the tailings supernatant is expected to be quite good, but in the event it does not meet discharge criteria, a variety of alternatives are available."

Commercial diamond production may commence as early as 2003, and the life of mine is approximately eight years.

Caribou near the camp

Northeast view over project area

Risk assessment & audit of tailings dams in Zimbabwe

Ed Matinhari

Danie Venter

In the 1999 – 2000 rainy season persistent heavy rains, including the flooding and destruction caused by Cyclone Eline, prompted the mining sector in Zimbabwe to review the safety and risk of failure of tailings dams.

This move was in line with the mining sector's desire to attain a high standard of safety and environmental management.

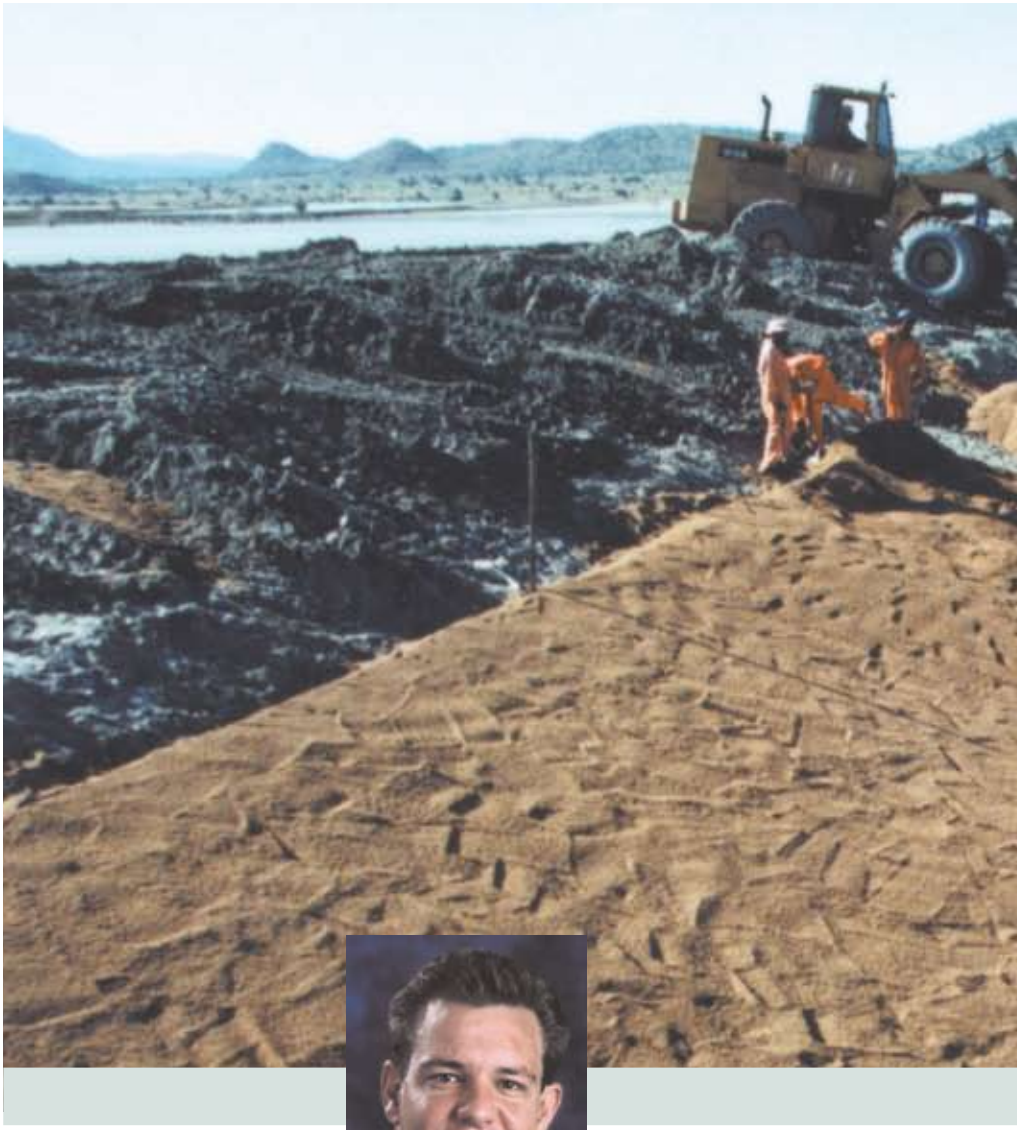
As part of this effort, SRK recently completed a technical risk assessment and audit of the tailings dams at the Mimosa, Railway Block and Peak Mines and the Kwekwe Ferrochrome Smelter of ZIMASCO. The recommendations made in the report submitted by SRK's Ed Matinhari and Danie Venter are currently being implemented by the client.

Ed, buoyed by ZIMASCO's appreciation of the team's efforts, notes that: "Tailings dams are designed to be operated and developed within a certain set of parameters, to ensure stability and long term integrity.

"It is essential, therefore, to monitor certain performance criteria to ensure compliance with the design or allow timely remedial action. To ensure safe, economic, efficient and environmentally responsible disposal of tailings, it is necessary to manage, operate and monitor by design and not by chance."

SRK is now anticipating installing piezometric monitoring systems at ZIMASCO's tailings dams. Safety monitoring will be integrated with the company's environmental management programme to ensure compliance with the new Zimbabwe National Water Authority (ZINWA) Water Act and all other legislation.

Monitoring of tailings facilities offers inv



Johan Boshoff

Implementation of monitoring and management reduces the risk of failure of tailings disposal facilities and provides a system by which minor faults, which could lead to possible failure, are identified and remediated at an early stage.

That's the view of SRK's Johan Boshoff, whose wide-ranging project experience has caused him to conclude that the monitoring of tailings disposal facilities provides an invaluable 'early warning system' to guard against possible failure of the impoundment and to ensure operational efficiency. Conversely, a lack of adequate monitoring, and failure to achieve legislative or regulatory compliance, can cause a tailings disposal facility to fail.

valuable ‘early warning system’

slope angles & other aspects are monitored

multi compartment tailings disposal

supernatant pool within poolwall confines

Continuous drainage installation as part of operation

Inspections, monitoring and dam safety observations are conducted through daily routine inspections and observations during dam operations, monthly inspections and meetings where all areas of concern are tabled and attended to timeously. Also important are quarterly inspections and formal meetings attended by mine management, representation from the tailings dam operators and personnel from the mine’s appointed professional engineer.

Aspects to be routinely monitored and recorded include freeboard, rate of rise, seepage and drainage, phreatic surface, penstock inlets and pool control, and groundwater. Other elements requiring scrutiny include return water dam, rainfall and evaporation recording, outer slopes and step-ins, catchment paddocks, solution trenches, and delivery/return water pump stations, pipelines and valves.

“Operation of a tailings disposal facility is the realisation of the design and any modifications to the design and the control of operation,” Johan continues. “An operating manual should be available and cover all points of operation. The monitoring operations and results should be incorporated into a formal checklist so that no important aspect is omitted. This should include a contingency and emergency action plan in the event of any reasonably anticipated failure.”

SRK consultant profile: Maritz Rykaart

Maritz Rykaart

Maritz Rykaart joined the SRK Vancouver office in November 2001. Maritz brings over 9 years of mine closure and surface water management design and construction management experience, primarily from a geotechnical engineering viewpoint.

Maritz currently provides specialist consulting services in mine closure, with special emphasis on waste rock dump, heap leach pad and tailings soil cover design and construction. A particular area of expertise of his is numerical modeling and calibration of soil cover performance using unsaturated soils theory. He has recently completed his Ph.D. in this area and has developed important new tools to help solve the complex water balance issues of soil covers in multi-dimensions. Maritz has applied his expertise in South Africa, Australia, Canada and the United States, both in consulting and construction, as well as in teaching courses in cover design.

Maritz is currently working on a number of mine closure plans in Canada, Germany and Australia as well as providing senior review for cover design and numerical modeling for mines in the USA.

Silvermines rehabilitation, Ireland

View past mining subsidence to abandoned plant structures and tailings lagoon

Snuggled against the Silvermines Mountain in County Tipperary is laid out a row of abandoned mines like a theme park on the history of mining in Ireland. The area has been exploited for over a thousand years for lead, silver, zinc, copper, barytes and sulphur. The mining remains range from shallow open-pits from the Middle Ages, through nineteenth century beam engine houses and furnaces, to extensive underground lead-zinc workings from the mid-twentieth century, finally ending with a large open-pit for baryte which closed in 1992.

Ian Brackley

The old miners were not always tidy people, and the waste deposits scattered over the area have discharged tailings and heavy metals to streams and the atmosphere. Following problems with severe dust blows from one impoundment and cattle deaths caused by lead poisoning, the Department of Marine and Natural Resources undertook to develop a remedial or management plan for the area, and appointed SRK to carry out a study and prepare conceptual designs. Apart from the obvious problems related to tailings, mine workings and plant structures, it was recognised that the mining heritage of the area is an important national asset, and must be conserved and made accessible as part of the overall plan. The concerns of the local community and other interested parties was also an important factor.

SRK formed a multi-disciplinary team, including internationally-recognised experts, to develop a detailed integrated plan including the removal of waste from some areas and its consolidation on a single site, as well as the establishment of wetland areas to improve the quality of water discharges. A risk-based approach was used to assist in deciding priorities for remedial works on the basis of urgency and cost.

Implementation of the proposed works after approval in 2002, will restore the area to the community and open up the rich mining heritage to visitors.

Drainage system for Missouri's Brushy Creek Mine

Tim Coote

Brushy Creek Tailings Dam - Initial drain flow (DH-1) of 35 GPM

Rob Dorey

Safety, integrity and performance of the Brushy Creek tailings dam in Missouri's Mark Twain National Forest have been significantly improved by an SRK-designed and installed horizontal drainage system.

The impoundment is associated with the Brushy Creek Mine & Mill, operated by the Doe Run Company, and consists of a cycloned sand embankment with a sloping slimes and whole tailings beach. Throughout the dam's life, maintenance activities have been carried out to mitigate erosion related to elevated seepage levels in the toe area. Seepage has historically been related to the level and proximity of the free water pond to the upstream edge of the sand embankment.

Elevated pond level in the fall of 2000 suggested that high seepage and increased erosion of the sand would occur in 2001.

As an effective method of draining the sands in the toe area, SRK analysed and designed the installation of a series of horizontal drains.

"The objective was to rapidly lower the phreatic surface within the dam," say SRK's Rob Dorey and Tim Coote. "The drains were drilled with a track-mounted rig using a conventional tricone wash-drilling method to advance the holes to the target depth."

The seven drains, totaling 2,370 lineal feet, encountered a peak total flow in excess of 200 gpm. Up to 9 feet of draw-down were induced in the lower dam, and up to 3.5 feet in mid-dam.

"Areas of seepage and general wetness at the toe of the dam had begun to drop noticeably by the end of the drainage drilling work," reports the SRK project team. "Overall, the potential for erosion resulting from the phreatic surface daylighting was significantly reduced."

Rate of rise optimisation for a platinum tailings dam

Typical platinum tailings dam

A major client in the platinum industry intends to increase production at one of its mines at the earliest opportunity. SRK was appointed to determine the maximum allowable rate of rise on the tailings dam.

Johan Boshoff

As a first step, an SRK team carried out a detailed site investigation and used the results in a stability assessment and advanced simulation modelling to determine the optimum rate of rise for the current geotechnical parameters and monthly tailings production rates.

SRK's Johan Boshoff remarks: "A detailed geotechnical investigation was conducted to identify and characterise the material types present in the tailings dam and foundation and to provide information on the variation in properties of the tailings material. The static stability of the tailings dam and the dissipation of excess pore pressure under the increased rate of rise was evaluated through simulation modelling while the probability of failure was calculated using the point estimate method. The overall probability of failure of the tailings dam was determined by means of a fault-event tree."

Four independent primary (initiating) faults were identified that could result in a large-scale failure of the dam. However, overall probability of loss of life and extensive damage to the downstream infrastructure resulting from a flow failure from the tailings was calculated and found to be within acceptable limits.

From the investigation it was found that the maximum allowable rate of rise on the tailings dam can be increased to above the current allowable rate of rise of 2.5m/yr.

"The increased rate of rise will not impact negatively on operational issues such as deposition cycle times, drying times, access onto the tailings dam or installation of curtain drains," Johan remarks, "though certain operational issues will have to be modified.

"To contribute to the continuing safe and successful operation of the tailings dam as a result of the increased rate or rise, we proposed additional monitoring systems. These include the installation of observation well piezometers, bi-annual piezocone testing and establishment of survey pegs at strategic positions on the tailings dam."

Feasibility study emphasises environmental management

Alive to the need to conserve the abundant and unique local flora, SRK's recently completed feasibility study for the proposed Goro nickel mine in New Caledonia made particular provision for environmental management.

The Goro concessions are located within the Massif du Sud, a large ultramafic outcropping that covers 25% of the island of New Caledonia. These are plateau type deposits consisting of residual, in-situ laterite and saprolite developed from peridotite bedrock.

The owner, INCO, had investigated the deposits over a period of 20 years. Tapping SRK's extensive international experience of mine feasibility projects, INCO retained the consultants to complete a comprehensive viability study covering geology and mine planning, water management definition and conceptual design, tailings management and conceptual design, closure and reclamation planning.

Don Beesley

Involving personnel from five countries to bring the best expertise available to this demanding project, SRK developed a plan for a 20-year mine life that will produce nickel at a rate of 120 Mlb per year. It is anticipated that mining and Ni and Co production will continue well beyond the 20-year mine plan currently under development.

The feasibility study was a 12-month effort, and was completed in the first quarter of 2001.

Fundamental principles for designing the overburden and tailings management facilities were established at the onset of the project, to ensure that impacts to the environment would be minimised and that the facilities would be designed to remain safe during the life of the project through decommissioning and closure.

Stockpiles

Views from the INCO pilot plant

Michel Noël

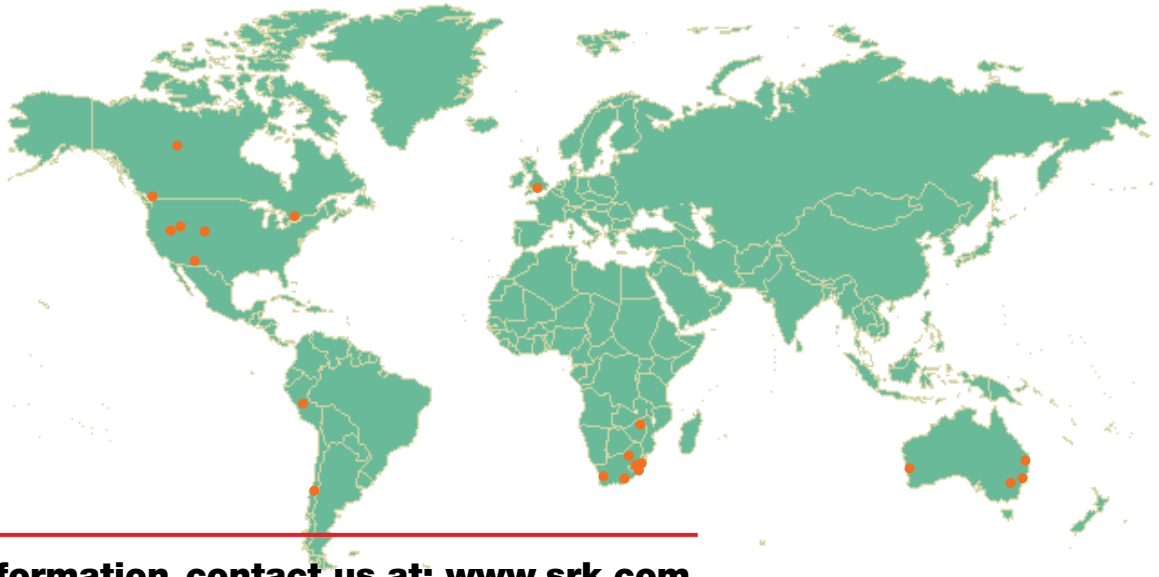
SRK consultant profile: Michel Noël

Michel Noël joined SRK's Vancouver office after spending four years with the research team on acid mine drainage at the Australian Nuclear Science and Technology Organisation in Sydney, Australia. His affiliation with ANSTO enabled Michel to develop an expertise in the unsaturated properties of soil and rock material, the design of soil covers, and the modelling of oxidation processes in tailings and waste rock.

Michel has a degree in civil engineering and a graduate degree in geotechnical engineering. His background includes more than fifteen years of experience in consulting and research, primarily on mine related projects. This includes periods as an environmental engineer at the Heath Steele Mines and as a geotechnical engineer with Geocon.

Michel will be working in SRK's Geo-Environmental Department, and will be applying his skills to mine environmental, mine closure and acid mine drainage projects in Canada, U.S. and Australia.

Michel's background complements the expertise provided by Dr. Maritz Rykaart, who also joined SRK Vancouver recently. The two add significant depth to SRK's capabilities, particularly in the area of soil cover design and modelling.



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