

## Mine water supply in SA's Limpopo province

**SRK** and a joint-venture partner can be credited with helping to breathe new life into the mining of platinum group metals, chrome and andalusite in South Africa's Limpopo Province.

Historically development of these resources in the area north-west of Burgersfort has been only partially possible due to the lack of water.

In response to mining requirements, the SA Department of Water Affairs & Forestry (DWAFF) set up a steering committee to co-ordinate the planning of water supplies to a number of mines in the region.

The committee subsequently evolved to become the Lebelelo Water User Association (LWUA), comprising six mining houses and the local communities.

In 2000, SRK and Ninham Shand were appointed to carry out an initial feasibility study, followed by a comprehensive appointment to complete an environmental scoping report as well as detailed designs and contract management. The project entailed the supply of 84 ML of raw water per day from the Olifants River.

SRK was responsible for the environmental and geotechnical aspects of the project, as well as the pipeline design, desilting works, pump stations, housing services and earth dams.

Project director Peter Labrum comments: "The total project cost was R230 million, which was within 0.5% of budget. The mines' requirements necessitated a very tight project schedule. Construction commenced in April 2001 and water was available for delivery to the mines almost exactly a year later."

In a subsequent phase, DWAFF will be responsible for the distribution of a portion of the water to nearby communities for domestic use.

Peter Labrum: [plabrum@srk.co.za](mailto:plabrum@srk.co.za)

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## John Harman now heads water group in Chile office

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**John Harman**

John Harman joined SRK early in 2001 and now heads up the Water Group in the Chile office following the return of Lyle Davis to SRK Tucson.

John has over 25 years of experience in a broad range of groundwater and surface water engineering, and for the past 15 years has been involved predominantly in projects for the mining industry.

John moved to South America after working for many years in Australia on mining and water resource projects and has also worked extensively throughout the Far East and Africa.

In the time that John has spent in South America he has been involved with development of key areas of SRK activity such as ARD studies and other mine closure issues, waste rock and tailings operations, mining environmental studies and groundwater supply schemes. He has worked for some of the key new mining developments in Chile and Peru, as well as for other types of industry.

John Harman: [jharman@srk.cl](mailto:jharman@srk.cl)

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## Water to the power industry

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**A pressure transducer allows flow rate to be continuously monitored and recorded**

Electrical power demands in the southwestern United States have increased as the population has grown. To meet the demand, utility companies are constructing a number of gas-fired generating plants but dependable, cost-efficient supplies of cooling water are a critical concern for developing plants in this arid region. That's where SRK's Paul Hackenberry and Larry Cope came in.



**Larry Cope**

Paul and Larry evaluated the potential for groundwater development, then designed and installed large capacity groundwater supply wells for the Nevada Power Company and Pinnacle West Energy near Las Vegas. The first phase of the project involved researching records for existing wells in the region and reviewing well-drilling and construction techniques.

Typically, wells were drilled using air, air-foam, or conventional mud rotary methods. The drilling method Paul and Larry selected for the new wells used dual-tube, flooded reverse circulation drilling technology.

Where conventional rotary drilling pushes cuttings to the surface with a heavy, viscous drilling mud, this method uses airlift to

circulate drilling fluids and lift drill cuttings. The reverse circulation method also lessens or eliminates the need for the bentonite additives that can diminish well yield. SRK designed and oversaw the installation of the wells. They were a success, demonstrating higher production capacities than wells previously installed in the immediate area.

Larry Cope: [lcope@srk.com](mailto:lcope@srk.com), Paul Hackenberry: [hackenberry@sbcglobal.net](mailto:hackenberry@sbcglobal.net)

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## Water supplies for mining in Saudi Arabia

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**B**ased on many years' experience evaluating groundwater supplies for various mining prospects and projects in the Kingdom of Saudi Arabia, SRK recently embarked on two significant assessment projects – one in the Arabian shield rocks, the other in sedimentary rocks.

The first requires a supply of 2,000 m<sup>3</sup>/day, though borehole yields are dependent on significant structure with some recharge from alluvial sediments in dry river beds (wadis).

“The wadi sediment is recharged periodically and sustains the fractured zone aquifer,” says SRK’s Richard Connelly. “In the area in question

there are very few true wadis, so we are carrying out an air-photo, satellite imagery and geophysical survey of target sites over an initial radius of 25 km from the proposed mine site. We have planned 20 exploration holes and hope that some produce water.”

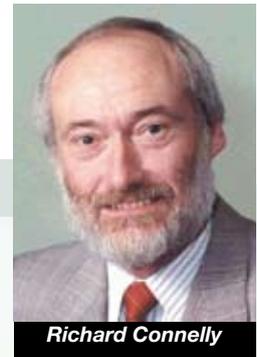
The second project has a projected water demand of 30,000 m<sup>3</sup>/day, and will involve the exploitation of major sandstone basin aquifers at depths of 700 and 1,500 m. Potential borehole yields are 40 l/s.

Beyond the numbers lie significant real-world challenges. The site is near the international borders of Iraq and Jordan,

and there is no recharge, meaning that groundwater will have to be “mined” from storage. The aquifer is already over-exploited in parts, and in need of overall management to sustain supplies in the future.

The first stages of the project include a detailed conceptual model, preliminary aquifer model and drilling test production and observation holes, scheduled for completion in May 2003.

Richard Connelly: rconnelly@srk.co.uk



**Richard Connelly**

*The surface is desert but at 700 m there is abundant water*



## Quebrada Seca tailings impoundment design



*Rio Manque at the Quebrada Seca tailings dam site*

**N**ew tailings disposal facilities for the Minera Los Pelambres copper mine in Chile were designed by a consortium consisting of SRK and CADE-IDEPE of Santiago, Chile.

SRK's primary responsibility was the design of the tailings dam, including hydrologic analyses related to the design of diversion facilities to route floods around the dam.

Lyle Davis, principal engineer, says: "The proposed Quebrada Seca tailings dam is located in the Rio Manque drainage basin west of the Rio Cuncumen basin in which the mine is located.

"Both rivers are tributaries of the Rio Choapa, a major watershed in central Chile with significant agricultural activity. As a result, relatively extensive precipitation and runoff records are available.

"The climate of the area is fairly dry but both precipitation and runoff data periodically demonstrate wetter than normal years, thought to be associated with the El Niño phenomenon.

"This dual-mode precipitation distribution makes it difficult to use traditional statistical methods to predict

floods with return periods of more than about 100 years.

"As a result, a combination of theoretical and statistical methods were used to predict discharge hydrographs for 500-year, 1000-year and 5000-year floods as well as the Probable Maximum Flood.

"These inputs were used for the design of operational diversion structures and for the preliminary closure plan design for the tailings impoundment."

Lyle Davis: [ldavis@srk.com](mailto:ldavis@srk.com)

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## Water balances for tailings dams

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**SRK** Consulting has been in the forefront of the development of water balances, and has been instrumental in the verification of water balances as part of a continuing drive to take the guesswork out of water balance design and operation.

A water balance, explains SRK's Peter Shepherd, is a tool used to represent the flow of water between the various infrastructural components of a mine. It should be used to optimise the water usage on the mine, and should show the water supply sources and discharge

locations, evaporation areas and potential seepage points. In addition to highlighting shortfalls and excesses of water, it should also show estimated values for the flow between the various components.

"In the South African mining industry, the water balance for a tailings dam is complex and the control mechanisms are fraught with unknowns and estimates," Peter elaborates. "However, in order to comply with the new National Water Act (Act No 36 of 1998), which aims to ensure that major water users behave in



**Peter Shepherd**

a responsible manner, it is important that the recovery of water from the tailings dam for reuse in the plant be optimised. This

reduces the need for additional make-up water, which will impact on already scarce water resources in semi-arid SA.

Peter Shepherd: [pshepherd@srk.co.za](mailto:pshepherd@srk.co.za)

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## Meet our team in Ankara

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**SRK's** office in Turkey, with an address in Ankara, boasts a team of nine in-house professionals and several external consultants.

The office, established in summer 2001 primarily serves Rio Tinto's Kazan project, where SRK is assisting with evaluation of the hydrogeology of the area and preparation of the EIA permit application.

The team is led by Cevat Er, who has more than 16 years' hydrogeological and geochemical investigation experience. Dr. Hasan Yazicigil, a hydrogeology professor

at the Middle East Technical University, is the outside consultant managing the groundwater modeling and evaluation aspects.

The SRK team also features geologists, geochemists, hydrogeologists, environmental engineers and GIS specialists. All are working closely with colleagues in North America and the UK.

In addition to the Kazan project, the Ankara office recently completed a hydrogeological evaluation for Tuprag Mining Company, a health and safety audit for Cayeli Copper Mine, and a due diligence assessment for the

Cayirhan Coal Mine in conjunction with SRK specialists from the UK.

Cevat Er says: "Part of our aim is to assist with watershed management studies by using state-of-the-art numerical models and GIS techniques."

You can reach the Ankara office at their new number: 90 312 266 1800

Cevat Er: [cer@srk.com](mailto:cer@srk.com)

**L to R: Arda, Bahar, Ibrahim, Tuba, Cevat, Banu, Uygur, Jale, Ilhan**



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## Mike Smith joins Denver Office

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Mike Smith

We are pleased to announce that in September 2002, R. Michael Smith joined the team at SRK as a principal in our Denver office. Mike comes to us from Knight Piesold and Co. where he rose from senior geotechnical engineer to vice president over his 14 years in their Denver office.

At Knight Piesold, he was involved in the design and construction management of water resource projects including dams, pipelines and diversion structures, in construction management, mine closure design and geotechnical assessment and civil design as that relates to mining projects. He also managed the company's staff of 135. His previous experience with the firms of Ground Engineering and Chen and Associates in Denver involved him in soil and foundation investigation, construction management, construction oversight and materials testing.

"My primary focus will be to augment SRK's already considerable technical talents and to expand our market share into halo markets such as Water Resources – dams, urban drainage and groundwater – and the Industrial Minerals sector," said Mike. "I'm excited at the prospects that exist out there and am eager to work with our domestic and international staff in putting together exceptional teams that clearly show that SRK is the firm of choice."

"Mike has been a fixture in the mining community in Denver for years now," said Andy Barrett, SRK President for North America, "and we're glad he's finally crossed the street to join SRK."

Mike Smith: [mikesmith@srk.com](mailto:mikesmith@srk.com)

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## Water management for the Colomac mine closure

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Stephen Schultz



**SRK** is working with Indian & Northern Affairs Canada and Public Works & Government Services Canada to develop a closure plan for the remote Colomac mine site in the Northwest Territories.

Colomac is an open pit gold mine that ceased operating in 1997, after less than five years of production. The owner became insolvent in 1999, leaving the federal government with the task of closing the site.

Water management is the central issue in developing a closure plan for the site. The mine operated a 'total containment' tailings disposal facility, and had no permit to discharge treated effluent to the environment.

Due to production shortfalls and operating problems, the tailings system failed to manage water effectively, leaving 9.5 million cubic metres of water on site, contaminated with cyanide and related compounds. A positive water balance in the tailings disposal basin means that long-term water management plans must be

developed, permitted and implemented by 2005.

SRK's Stephen Schultz and Daryl Hockley are leading a multidisciplinary team of consultants, including SRK experts and others, to develop a number of complete water management alternatives for the site, and to assess the environmental impacts and costs of these alternatives. The federal government will work closely with the local Dogrib First Nation to choose a preferred alternative.

Stephen comments: "Water management measures under consideration include geotechnical methods to increase water storage capacity, combined with enhanced natural degradation of contaminants. We're also looking at several water treatment methods that could be applied under short-term or long-term schedules. The current focus of project activities includes geotechnical investigations of potential dam sites and pilot testing of water treatment technologies."

Stephen Schultz: [sschultz@srk.com](mailto:sschultz@srk.com)



*Benchmarking can help to reduce unnecessary water losses*



*Fiona Cessford*

## **Benchmarking water use in industry**

**SRK** is currently working on two prestigious projects for the water management regulators in South Africa and the UK that aim to derive water use standards for industry.

SRK was commissioned by the South African Department of Water Affairs & Forestry (DWAF) to develop benchmark values and best management practices for the industry, mining and power generation sectors in a bid to support the conservation of water resources and the development of demand management.

The project unfolds against the backdrop of the development of Water Conservation & Demand Management (WC/WDM) National Strategy to meet the goals of

basic water supply and sustainable use of water resources. The strategy forms part of the National Water Resources Strategy and recognises the need for a paradigm shift to the principles of WC/WDM by all water use sectors.

Fiona Cessford, principal scientist in SRK's Johannesburg office, comments: "Phase 1 of the program to establish the framework in which benchmarking values can be determined is now complete. Phase 2 is now underway, and is looking at some of the prioritised industries."

The UK's Environment Agency is carrying out the next phase of its award-winning R&D Study of Optimum Water Use in Agriculture & Industry. The study aims

to develop baseline values that will help companies set realistic targets for water consumption in line with specific production figures, thus allowing the assessment of potential cost savings.

SRK Cardiff has been asked to extend the current information base and produce a document that will include benchmark water use and best practice methodologies across a range of industrial sectors. The study involves preparation of questionnaires, consolidation of returns, literature review, water use surveys at a number of volunteer sites, and production of an updateable report with an operational feedback loop.

Fiona Cessford: [fcessford@srk.co.za](mailto:fcessford@srk.co.za)

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## Welcoming home Lyle Davis

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Lyle Davis

Principal engineer Lyle Davis recently rejoined SRK's Tucson office after a three-year assignment in Santiago, Chile.

With consulting experience spanning nearly 25 years, primarily related to water issues at mines, Lyle's expertise includes surface water hydrology, open channel hydraulics, and groundwater hydrology with an emphasis on numerical modeling.

Lyle has applied his surface and ground water modeling skills to new mine facility design, optimisation of water management schemes at operating mines, and development of strategies for closing mines which are no longer viable.

During his South American assignment, his work focused on the design of new facilities at operating mines in Chile, Peru and Argentina.

Lyle says: "My first major assignment back in Tucson is to provide hydrologic and hydrogeologic expertise to the team preparing the closure plan for the BHP Copper San Manuel mine.

"I will also be working closely with Tucson colleagues to develop new work related to mine closures in the southwest, while continuing to provide services to clients in Latin America."

Lyle Davis: [ldavis@srk.com](mailto:ldavis@srk.com)

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## Wetland habitat mitigation

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*Engineered wetlands to offset aquatic habitat disturbance*

**SRK**, on behalf of Mineral Recovery Systems, recently developed a wetland habitat mitigation plan to offset proposed disturbances to native aquatic and terrestrial habitat areas resulting from construction of a pilot-scale titanium sand mining and extraction operation in rural Benton County, Tennessee.

SRK's Mark Willow notes: "Integral to the mitigation strategy was the creation and enhancement of additional wetland and upland grassland terrestrial habitat areas. Recent photos of the area demonstrate the success of the project."



Mark Willow

Because this titanium sand mining and extraction project is the first of its kind in the state of Tennessee, SRK proactively sought input from the regional permitting authorities, including the Tennessee Department of Environment & Conservation (TDEC), the US Army Corps of Engineers (COE), and the Tennessee Valley Authority (TVA) to develop a blueprint acceptable to all parties. The plan was ultimately submitted

to the TDEC, Division of Water Pollution Control, Mining Sector, as part of their Aquatic Resource Alteration Permit/Clean Water Act Section 401 Certification program.



## 20 year milestone for Rosewarne

**P**eter Rosewarne, principal hydrogeologist and director in the Cape Town office recently passed the milestone of 20 years of service with SRK. He had previously spent seven years with the Department of Water Affairs and Forestry in Cape Town and Pretoria after emigrating to SA in 1975.



**Peter Rosewarne**

Starting out in SRK's Johannesburg groundwater department under Richard Connelly, he worked on mine dewatering and water supply projects. Peter relocated to Cape Town in late 1984 to start up a groundwater section in what was then a five-man civils/geotechnical office. The rest, as they say, is history. At its peak, the Cape groundwater department numbered 16 hydrogeologists and technicians. The Cape team has hosted several seconded SRK luminaries, including individuals from Santiago and Vancouver.

Peter was also instrumental in establishing regional offices in Port Elizabeth and East London.

Today Peter focuses on groundwater supply and management, mine and civils dewatering, subsurface contamination, hydrogeological mapping and waste disposal. He has carried out major projects in SA, Namibia, Zimbabwe and Chile for clients such as Rio Tinto, World Bank, African Development Bank, CMDIC, the Southern African Development Community, numerous municipalities, the Department of Water Affairs and Forestry and Water Research Commission.

Peter Rosewarne: [prosewarne@srk.co.za](mailto:prosewarne@srk.co.za)



After a detailed delineation of habitat at the site (including limited stream and wetland areas), a determination was made by the TDEC that the proposed disturbance would impact no more than 500 linear feet of streambed and less than one-third of an acre of jurisdictional wetland habitat. As such, the project would qualify for federal

permitting under the COE's Nationwide Permit No 26, for which TDEC certification was required. The affected areas included small standing water pools, streambeds, wet areas and limited upland grass areas. Nesting boxes for water fowl were also introduced.

Mark Willow: [mwillow@srk.com](mailto:mwillow@srk.com)

## The fairest Cape's aqueous treasure

Sir Francis Drake described the Cape as 'the Fairest Cape in the whole circumference of the earth'. Little did the circumnavigator know that he was also looking at one of the fairest aquifers in the world – certainly one of the most important in arid SA.

Sir F was, of course, gazing inadvertently upon the Table Mountain Group Aquifer (TMGA), a thick, mainly sandstone sequence similar in lithology to the rocks that built the famous Table Mountain overlooking Cape Town.

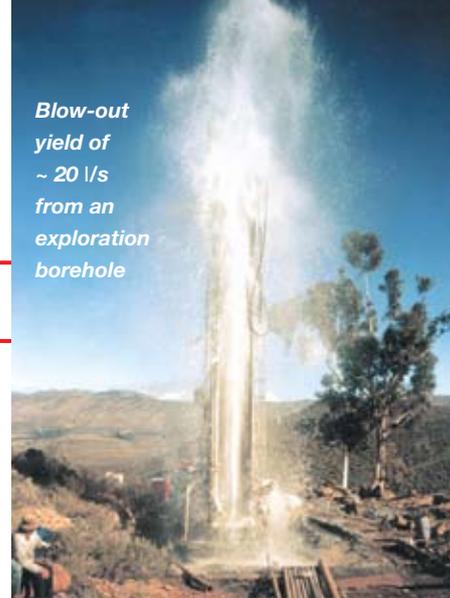
SRK's Cape Town groundwater department has been involved in numerous investigations and research into groundwater abstraction and occurrence in the TMGA. Peter Rosewarne, department head and principal hydrogeologist, was one of the first to

recognise the regional potential and promote its use for large-scale water supply.

Borehole blow-out yields of up to 120 l/s have been obtained, and hot spring flows of up to 127 l/s and 64°C occur. A number of centres, including Cape Town and Port Elizabeth, are located on or near the outcrop and could benefit from exploitation of the resource.

Peter is currently working on four projects dealing with different aspects of the TMGA. One is developing a wellfield to supply 2 million m<sup>3</sup>/year for irrigation of orchards in the Koo Valley north-east of Cape Town. The blow-out yield from one of the exploration boreholes is shown in the accompanying photograph.

The second is looking at selecting suitable target areas to investigate the environmental



*Blow-out  
yield of  
~ 20 l/s  
from an  
exploration  
borehole*

impact of large-scale groundwater abstraction from the TMGA. The third is developing a monitoring network in a pristine catchment to establish a baseline for groundwater levels, river flow and rainfall. This is prior to establishing a wellfield to increase catchment water yield in an area of intensive export table grape cultivation. The fourth is acting as the managing agent for the Little Karoo Rural Water Supply Scheme.

Peter Rosewarne: [prosewarne@srk.co.za](mailto:prosewarne@srk.co.za)



**Franciska Kok**

## Sharing mine water management information

Though most mines are involved in monitoring water use and quality to comply with licence requirements, few use the results for effective on-site water management. Fewer still share their water management experiences, despite the general recognition that this would boost the industry as a whole.

Adoption of a water management system based on targets can reduce demand significantly and thereby benefit the water service provider, associated communities and mine shareholders alike, according to Franciska Kok and Fiona Cessford, scientist and principal scientist respectively in SRK Johannesburg's Water & Environmental Technology Department.

To meet the aim of improved water management, a general process for target setting is being successfully applied at a number of southern African mines. The key elements of the process are as follows:

- Conduct on-site water survey to identify intakes/losses of water;
- Develop updateable water/salt balance;
- Install flow meters/weirs at strategic locations;
- Set water use targets for overall make-up demand (litre/tonne milled, fresh water intake, discharge volume, etc);
- Incorporate all into a documented water management strategy for ongoing proactive water management;
- Assess results regularly to identify unexplained water losses and enable predictions to be made.

Franciska and Fiona believe the results of the above should be used as an ongoing water management tool, and should be reported.

"At a minimum," they state, "reporting to line management should occur. But extra value will be added if the results are also used for public awareness, authority consultation and comparisons with similar operations."

Franciska Kok: [fkok@srk.co.za](mailto:fkok@srk.co.za)



## Risk based quarry water management

To access economic resources below the water table meant that UK company, Hanson Quarry Products, needed to monitor the potential effect of dewatering on the local surroundings in order to satisfy planning requirements.

SRK was commissioned to develop a risk-based monitoring scheme that protected the potentially vulnerable receptors; an abstraction borehole down hydraulic gradient of the quarry, and a wetland classified as a Site of Special Scientific Interest located slightly upgradient of the quarry.

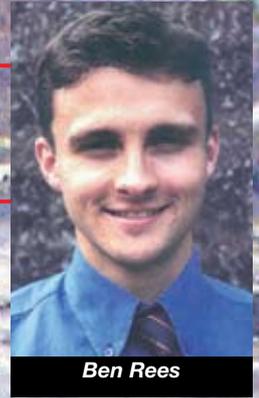
The perceived risks were that dewatering would lower the water table in the wetland, potentially affecting certain important plant species and limit the capacity of the abstraction borehole.

UK-based Ben Rees reports: "To assess potential future impacts, baseline conditions were established prior to dewatering through implementation of a monitoring network comprising boreholes and piezometers in and around the quarry. A study of the geology indicated the underlying karst limestone to be overlain by superficial deposits. Therefore, to fully understand the hydrogeology, boreholes and piezometers were placed in the limestone and superficial layers."

Monitoring was initiated in 1996 and undergoes regular review governed by a Scheme of Working. Hydrochemical monitoring is conducted every 4 months and water levels are automatically logged using down-hole data loggers. An ecological evaluation is undertaken annually.

Quarry dewatering commenced in the autumn of 1999, when baseline conditions were well established. This has enabled the effects of quarry dewatering to be assessed against 'natural' groundwater seasonal variation, allowing the quarry operator and the Mineral Planning Authority to fully assess the actual effects and future risks.

Ben Rees: [brees@srk.co.uk](mailto:brees@srk.co.uk)



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## SRK UK's Rob Howell

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With 15 years' experience in a wide range of mining and engineering projects, SRK UK's Rob Howell is fluent in the application of geochemistry and mineralogy to a wide range of problems.

Rob's background is in mineral exploration in deeply weathered environments, as well as in academic research in exploration and environmental geochemistry, environmental engineering and mineralogy.

His main field of expertise is in mineral processing and geochemical treatment of mine waste and water (including arsenic-rich waste, cyanide solutions, acid rock drainage and saline water). With more than 100 papers on environmental and exploration geochemistry, and the treatment of mine waste and water he has gained considerable experience in these fields.

As principal geochemist with SRK, Rob has been deeply involved with Getchell Gold Corporation (now a subsidiary of Placer Dome). Rob was also consulting geochemist for the closure studies at San Manuel and Robinson mining complexes for BHP Minerals, and he has played leading roles in extensive ARD evaluations for Las Cruces mine, Spain, Los Pelambres, Chile and for Sukhaybarat gold mine, Saudi Arabia.

In a further ARD project, this time at the Geita Gold Mine, Tanzania, Rob additionally conducted baseline studies and completed an evaluation of water treatment requirements.

Rob Howell: [rhowell@srk.co.uk](mailto:rhowell@srk.co.uk)



*Ferric sulphate arsenic precipitation plant*

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## SRK expertise applied to arsenic treatment of mine water

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Knowledge gained by SRK principal geochemist Rob Howell during post-doctorate studies at the Natural History Museum in London on stabilising arsenic in mine waste and effluent has been applied by SRK to evaluate, scope, and design several arsenic treatment plants in Africa, Europe, Canada and the US.

"Mine water chemistry can show significantly different hydrogeochemical characteristics," says Rob, who works out of SRK's Cardiff office. "These variations can be used to classify mine waters and identify those constituents that are likely to cause a negative environmental impact in the receiving water environment."

The variations will also determine the most appropriate strategy for the treatment of mine water effluent. Various treatment options are available to mitigate potential impacts, and involve physical, chemical and biological processes. The selection of a treatment option is primarily dictated by

hydrogeochemical characteristics of both the discharge and the receiving water. The adoption of a single or combined process will depend on economics and on the suitability of the method to remediate an effluent at any particular site.

"For example," Rob elaborates, "when dealing with arsenic as the primary contaminant, it is possible to achieve effluent goals of 10 µg/l by using iron co-precipitation, provided:

- pH is controlled to a range of 4 to 6 su
- arsenic is present in the pentavalent state, and
- iron:arsenic ratio is of the order of 8:1

However, such a system does not work where calcium or magnesium levels are high. In such cases the hydrogeochemistry of the effluent becomes the primary focus of treatment options."

Rob Howell: [rhowell@srk.co.uk](mailto:rhowell@srk.co.uk)

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## Numerical groundwater modeling to support mine permitting

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**SRK's** engineering expertise includes the use of various numerical groundwater flow models to evaluate specific groundwater flow systems to provide flow regime estimates for tailings impoundments, underground mines and open pit mines. The models are also used to estimate seepage through tailings dams and conventional water storage dams.

As an example, SRK recently completed a 3D flow model as a supplement to an expansion permit for a sand and gravel mining operation owned by Aggregate Industries – WCR, Inc. The model provided an estimate of impacts from the proposed aggregate mining operation to the local groundwater system during mining operations. It also provided

an estimate of groundwater inflow to the property following implementation of a proposed reclamation plan.

SRK's Mike Sieber elaborates: "The 3D finite element code, FEFLOW, was selected to simulate the shallow alluvial groundwater system in the area. The model was calibrated to pre-mining conditions as well as existing conditions in the operating aggregate mine.

"The interaction of the groundwater system with two adjacent creeks as well as the dewatering of an active gravel pit were accounted for in the flow simulation. The calibrated model was then used to estimate the impacts to the local



groundwater system, and especially impacts to local groundwater supply wells, due to the dewatering activities associated with the proposed expansion of aggregate mining operations."

A conceptual reclamation plan, proposed by SRK, includes a series of wetlands and ponds that will serve as open space and wildlife habitat property for a local community. The calibrated flow model provided an estimate of groundwater inflow that is currently being used in the engineering design of the proposed reclamation ponds and wetlands.

Mike Sieber: [msieber@srk.com](mailto:msieber@srk.com)

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## The use of quantitative risk assessment to help resolve hydrogeological problems

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**R**isk analysis has become an increasingly important method by which government and industry assess such issues as safety, reliability and effectiveness of products, processes and facilities.

Though risk assessments are in widespread use, it is not every circumstance that requires this approach. In general, situations that qualify are those in which the problems are complex, the variables poorly constrained, and the financial and technical implications of failure considerable.

Example applications in the water and environmental industries include waste disposal, contaminated land, groundwater control and water resources.

SRK's William Harding has been involved in a number of risk assessments over the

years, mainly in the waste and mining industries. An example is a dilute-and-disperse landfill located close to the banks of a river in northern England that had been designated a Ramsar Site and a Site of Special Scientific Interest in recognition of the importance of the nearby estuary for birdlife.

"The landfill received a heady concoction of wastes including List 1, Red List, very low radioactivity materials and sewage," William remarks. "We performed a probabilistic risk assessment on the landfill to assess the likely impact of these contaminants on the river and to see whether expensive engineering was required to counter their potentially adverse effects.



The model predicted negligible impact because of the low permeability, high retardation potential and high cation exchange capacity of the clays, which underlie the site, and the sewage cake, which was emplaced in the base of the landfill prior to the introduction of other wastes.

Furthermore, the sewage cake was perceived as being highly beneficial on the grounds that it speeds the stabilisation of waste and promotes the decay of organics by inoculating the landfill with a diverse culture of micro-organisms."

William Harding: [wharding@srk.co.uk](mailto:wharding@srk.co.uk)

## Bellavista stormwater management and sediment pond design



*Annual rainfall of more than a meter and steep terrain challenged stormwater design solutions*

**S**oil erosion and degraded water quality that could result from construction of mine facilities, particularly in wet environments, are preventable through prudent and early planning of surface water management.

This principle is carried through many SRK projects, including the planned Bellavista gold mine in western Costa Rica, owned by Wheaton River Minerals. SRK has been the client's chosen consultant for several phases of work, including heap design and the project EIS.

Receiving more than a meter of rainfall annually, the steep, mountainous terrain yields a paucity of sites feasible for both planned mine facilities and for stormwater impoundments.

Wheaton River contracted SRK to produce a site-wide Surface Water Management Plan (SWMP), along with the detailed design of the first stormwater/sediment control impoundment, Pond RD1, intended to be operating during initial mine facility construction.

The SWMP identifies the stormwater control requirements for the initial four operating years. It includes design for diversion channels and erosion control, and specifies effluent quality and design storm criteria.

SRK's Rob Dorey and Ivy Wu were key personnel in designing a sediment control pond that would detain the design storm, provide sediment removal capability that meets the stringent effluent criteria, and was geotechnically stable. Pond RD1 is the downstream point in a

diversion channel and catch basin network conveying sediment-laden runoff from the rock dump. Sediment removal was modeled using SECDAD4 sediment routing software, and was achieved using flow-activated dosing of chemical flocculant.

"A critical aspect was modeling sediment load from seasonal and peak storms to Pond RD1," says SRK engineer Ivy Wu. "If the pond's sediment storage was not sized for the load and flocculated particle size, the resulting undersized pond would fail to meet the effluent criteria."

"Strategic placement of upstream catch basins and balancing of outflow versus storage capacity were required to reduce the size of Pond RD1 to within siting limitations while achieving required settling."

Ivy Wu: [iwu@srk.com](mailto:iwu@srk.com)  
Rob Dorey: [rdorey@srk.com](mailto:rdorey@srk.com)

## Britannia Mine remediation project

Britannia Mine, located 55 km north of the City of Vancouver, British Columbia, has been described as one of the largest metal pollution sources in North America.

The mine's underground workings incorporate naturally-occurring metal sulphide ores, which have been exposed to air and rain as a result of over 70 years of mining. Acidic drainage has historically discharged from two sources: the 2200-level tunnel, which discharges into Jane Creek and subsequently into Britannia Creek, and the 4100-level tunnel which discharges to Howe Sound via a deep outfall.

In September 2001, the Province of British Columbia appointed four specialist technical consultants to undertake projects associated with the remedial activities at the site. SRK, in a joint-venture with Klohn Crippen, was awarded the mine safety and hydrogeochemical components of the project.



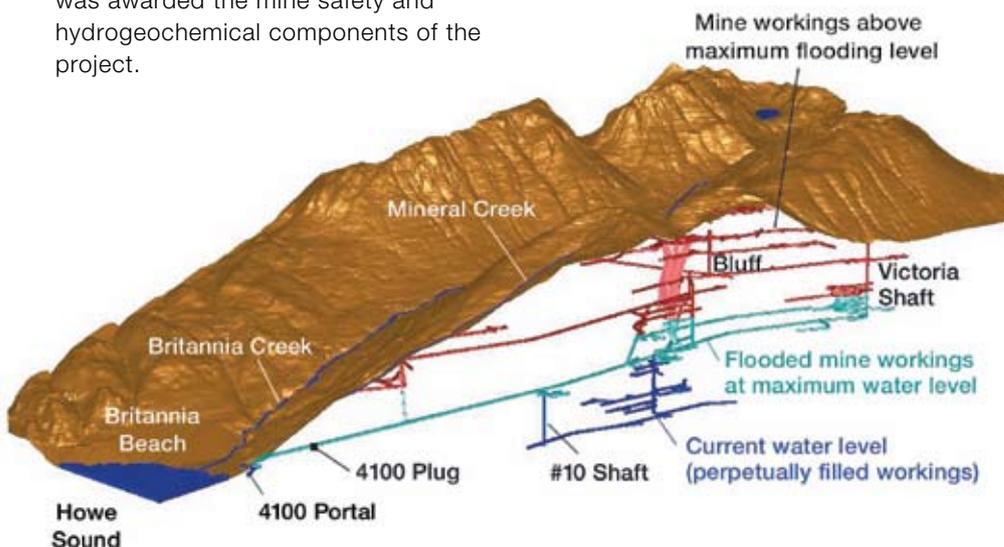
Peter Healey

SRK's initial task, completed by February 2002, involved safety inspections and rehabilitation of the 4100-level tunnel that were required prior to undertaking a program of geotechnical investigations and safety tests on an existing concrete plug, 400 m from the tunnel entrance.

Peter Healey, SRK project manager comments: "The investigation and safety tests were completed by the middle of March 2002 and were followed by a plug test, which SRK and Klohn are conducting to determine the storage capacity, flow characteristics and water chemistry of the mine workings."

The plug test is now complete and work is in progress on the installation of a weather station in Jane Basin and a flow gauge in Upper Jane Creek with remote access.

Peter Healey: phealey@srk.com



Britannia Mine cutaway looking northeast

## SRK Denver's Larry Breckenridge

Focusing on the discovery of the essential and often elusive resource of groundwater using a toolbox of diverse experience and knowledge, Larry Breckenridge, groundwater specialist, wryly describes himself as a 'scientific dowser'.



Larry Breckenridge

"Whether for mining clients, the public or private sector, my career is devoted to identifying, quantifying, and developing water resources in arid environments," he says. "Discovering groundwater under challenging conditions requires the combination of many disciplines, including geology, soil science, botany, surface hydrology, hydrogeology and climatology."

Larry is also experienced in contaminant hydrology and geochemistry, and has used his skills on environmental clean-up sites to ensure that both the quantity and quality of the water meet the project demand. In addition, he has considerable experience creating conceptual and mathematical models to predict the long-term performance of groundwater remediation or extraction.

Recent projects include the discovery and evaluation of a prolific aquifer that will supply 7,000 gpm of process water to a large surface silver mine in the high-elevation desert of Bolivia. In Colorado, Larry has installed and evaluated a water supply well for a fish hatchery that will supply whirling-disease free water. And in Wyoming, he evaluated the impact of large-scale surface coal mining on water resources in the Powder River Basin.

Larry is also a consultant to the Navajo nation, overseeing the groundwater remediation of four abandoned uranium mills on Navajo land.

Larry Breckenridge: lbreckenridge@srk.com

## Innovation the old fashioned way

In this day and age of technological innovation, the tools available to us can yield high quality automated data. However, cost and complexity can limit their use in field applications, especially in remote areas where SRK professionals often find themselves. Such limits have led SRK to build water level sounders from scratch, modify injection packer equipment and fabricate well annulus seals for multiple completion piezometers, using whatever materials are on hand.

One such challenge led Larry Cope to adopt a technique for measuring pump test flow rates that has been virtually forgotten. A groundwater evaluation at a uranium mill tailings site required several long-term pumping tests at flow rates ranging from 1 to 20 gallons per minute. With a total pumping duration of more than 30 days, monitoring pump

rates automatically was important. A simple solution was to combine the modern technology of a pressure transducer with the now rarely used orifice bucket method.

Larry obtained short threaded pipes with diameters of 0.25, 0.375, and 0.5 inches from a hardware store, and welded them to the bottom of a steel drum to serve as drain tubes. A combination of open and capped tubes would pass flows of 0.8 to 20 gallons per minute. A pressure transducer, placed in the drum, recorded the water's depth, which was then related to flow rate by calibration curves that had been generated prior to starting the tests. With this equipment one person was able to complete the aquifer tests.

Larry Cope: lcope@srk.com



***This solution for monitoring pump rate provided high quality data and reduced cost to our client***

## Taking some pain out of compliance reporting

It's no secret that clients find preparing environmental compliance reports from scratch for each reporting period can be time-consuming and costly. Recently, a number of clients have asked for our help in reducing these costs. Larry Cope and Mike Sieber responded to requests from an electronics manufacturing client and a mining client by developing data management systems to handle the work. The systems they developed have yielded such dramatic improvements in the efficiency of reporting that the cost to develop the systems was recouped in less than two years.

Larry and Mike developed custom-built MSAccess database applications that integrate existing data with ongoing data collected in the field and with laboratory electronic analytical results. By automating data input and generating report-ready data tables and graphs, many elements of a compliance report can be printed with a few clicks of the mouse. The database also allows rapid assessment of results to optimize monitoring programs and identify data gaps. It can even provide the basis for requesting a reduction in monitoring.

After seeing the benefits of a coherent data management approach, a client asked SRK to develop a document database application that compiled all environmental documentation relating to closure, post-closure, decommissioning and deed transfer activities. The databases include monitoring plans, characterization reports, Radiation Material License Applications, closure plans, and relevant correspondence. In essence, the regulatory history of the facility fits onto one compact disc.

Larry Cope: lcope@srk.com  
Mike Sieber: msieber@srk.com



**For more information, visit us at: [www.srk.com](http://www.srk.com)**

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