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Mining Industry Gets to Grips with Climate Change

The mining and minerals industry should be the symbolic poster child for climate change adaptation. Mining operations are frequently located in the world's most rugged landscapes, with harsh climates and extreme weather. Increasingly, global climate change is challenging mine operators' ability to operate profitably and safely, with threats ranging from droughts and floods to a greater incidence of vector-borne diseases such as malaria and early thawing that have threatened the vital "ice road" truck deliveries for Canadian Arctic diamond mines.

Chile, the world's leading copper mining country, is a good example of the mining sector's vulnerability. Its Atacama Desert on the Peruvian border is the hottest, driest desert in the world, receiving as little as a half-inch of rain a year. Some years it doesn't rain at all, and some areas never get a drop. Yet desolate Atacama is home to Escondida, the world's largest copper mine, majority owned by BHP Billiton and Rio Tinto, the world's two largest extraction companies, who invested \$3.8 billion to expand the mine—and another \$3.43 billion for a desalination facility to provide what the desert won't—water, the life blood not only for people but for the ore-extracting process.

Mining is a water-intensive industry. And as mining operations expand into

more water-stressed areas and cope with changing precipitation regimes, Global Water Intelligence estimates that mining companies will spend \$11.9 billion on water infrastructure in 2013, up from \$3.4 billion in 2009. (See Sustainable Water for Mining Story on page 17.)

Earlier in 2013, Reuters reported that the rising costs of water prompted Moody's Investors Service "to warn of possible risks to credit ratings." As the ratings agency told Reuters, "In our opinion, the consequences of poor environmental risk management will increasingly lead to production stoppages, protests, fines, and license withdrawals—all factors which may directly impact mining companies' profitability and credit risk profiles." BHP estimated that using desalinated seawater will triple its costs.

Companies like BHP and Rio Tinto endure the Atacama's climate and water scarcity because that's where the copper is. Chile's copper reserves are mouth-watering for an industry with one underlying business plan: get in and out with as much as you can, profitably, while the price is right.

"All investment is related to commodity prices, whether the product is potash, gold or copper. And commodity prices are also associated with the economics of new and ongoing operations," said Sandy Watson, vice president of mining at Stantec, a \$1.68 billion engineering and architecture consulting and design firm based in Canada.

Mining is capital intensive, can be difficult and dangerous, and if not managed

Climate Change and the Mining Industry

Climate change presents opportunities and risks to the mining industry. On one hand global warming creates access to new reserves, but on the other it exacerbates problems faced by mining operations, including transportation access, flood, and drought in a highly water-reliant industry. Firms in this edition report a growing market for adaptation services by the mining sector as it responds to the need to identify and disclose risks and plan for the uncertainties of climate change.

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properly, extremely damaging to local environments, especially water resources. Mining operations rely on a “living document” of procedures that evolves with the mine’s lifespan and its ultimate decommissioning “Mines need to stay at the top of their game,” said Jonathan Pressdee, vice president and managing director of mining at **Black & Veatch**.

Mining is also a cyclical business; it follows the ups and downs of the market as it reacts to whatever stirs the pot—most recently the source of growth in demand has been a huge expansion of projects driven by the lure of boom times in China. As the Chinese boom slowed down, slackening demand suppressed prices and caused project cancellations.

Companies like BHP and Rio Tinto took big stock hits, with investors complaining that mining companies were too careless with their earnings when gold soared to \$2,000 an ounce and copper ticked up to \$4, from its normal mid-\$2 range. According to the New York Times, the “central complaint [by investors] is that the big companies, during a period of high metals prices and strong profit from 2009 to 2011, spent too much money building mines instead of returning money to shareholders.” The chief executives of BHP, Rio Tinto, Anglo American and Barrick Gold—the four largest multinational operators—have all been replaced.

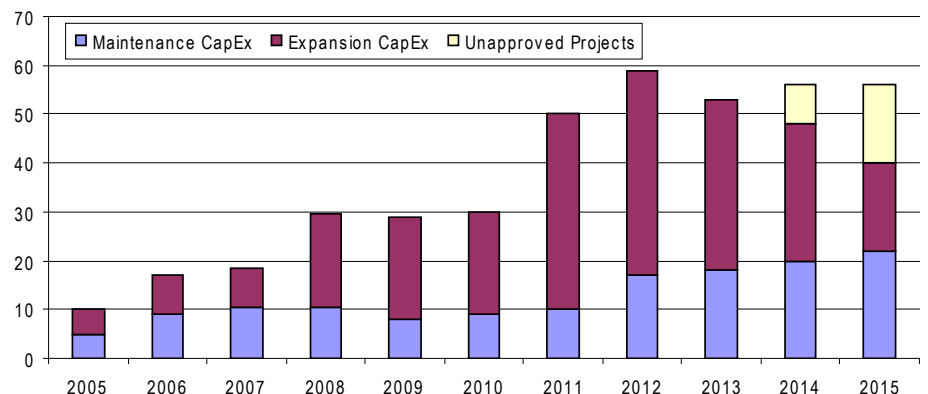
Climate Change Concerns Spread

Every mining operation must deal with the challenges associated with its regional climate, including the extremes. “If they’re in northern Canada, they deal with the extreme cold and blowing snow of the Arctic. If they’re in Mongolia’s Gobi Desert, it’s dust storms,” said Watson. These challenges are known and accounted for whenever a new mining operation is considered; they have to be. As Watson noted, startup costs for a mining operation can range from \$100 million to \$6 billion. Understanding the current climate and how it impacts the operation is standard due diligence.

And increasingly, mine operators must plan for the uncertain challenges of climate change. Engineering and consulting firms interviewed by CCBJ all report increased activity in adaptation services; and they all identify adaptation in the mining sector as a growing market. “Some companies are embracing the challenge. Other aren’t,” said Sean Capstick of \$1-billion **Golder Associates**, adding, “a lot of the action is happening behind the scenes.”

In some cases, mining companies are doing climate change analysis in response to increased incidences of extreme rainfall in recent years causing flooding of mine assets such as open cut mines and tailings dams as well as washing out of rail and

Mining Industry Capital Expenditures 2005-2015 (\$bil)



Source: Deloitte document *Tracking the Trends 2013* citing Credit Suisse First Boston, Datastream and company reports

road assets. “We’ll see a lot more of these [water-related] impacts, which will cause downtime for mines,” said Michael Nolan, AECOM’s global practice leader for resilience and climate adaptation.

Nolan anticipates that over the next decade climate change risk analysis will be a common practice at the corporate and operations level. “For investors, it will be a box they’ll want checked, companies who do choose to adapt will prosper and recover faster than those—their competitors—who don’t.”

“The investors want to evaluate the climate resilience of all their investments, not just mining,” he said. “Industries, infrastructure assets and property developments that are located in the coastal zone or in floodplains will be scrutinized. Those that have progressed a plan to increase their resilience will be safer, more valuable investments.”

Acknowledging that a “changing climate presents physical risks to mining and metals operations”—and to the people and environments attached to those operations—a recent report by the **International Council on Mining and Minerals (ICMM)** lists a number of vulnerabilities, scenarios, implications and solutions for managing the risks.

Disturbance To Mine Infrastructure and Operations

Natural disasters, changes to precipitation patterns, and rising sea levels may damage infrastructure, requiring additional measures to ensure its stability. Existing assets may no longer be able to meet original design parameters, and resource scarcity may constrain operations or increase costs.

Impacts	Companies
More frequent and intense natural disasters may damage mine, transportation, and energy infrastructure and equipment, which in turn will disrupt construction and operations. Heavy rain and increased erosion may affect slope stability near opencast mines, and rising sea level may make coastal facilities harder to access.	Alumina, Anglo American, Barrick, China Steel, Kumba Iron Ore, Mitsubishi Materials Corp., Rio Tinto Group, Teck, Xstrata, Yamana Gold
Hotter and drier conditions may increase wildfires that threaten facilities.	Anglo Platinum, Cameco, Gold Fields
Flooding from increased rainfall in some areas can interrupt production, and may necessitate additional controls to enhance water treatment capacity.	AngloGold Ashanti, Exxaro, Harmony Gold Mining, Limerick Alumina Refining, Newmont Mining
Reduced amounts of water may be available for mining, processing, and refining activities. Costs will increase for preuse and post-use water treatment.	Barrick, China Steel, Teck, Xstrata, Anglo Platinum
Rising temperatures will increase energy demand to cool underground mines and surface facilities. Greater demand and rising prices (driven by limited supply of natural gas, the imposition of carbon taxes, and expensive alternative energy sources) will add to costs.	Anglo Platinum, Mitsubishi Materials Corp., Northam Platinum, Outokumpu, Mining Simms
Temperature fluctuations that increase energy demand and strain the capacity of transmission and distribution facilities can disrupt supply to operations. Energy rationing may lead to permanent decreases in production, affecting profits and commodity prices.	Aquarius Platinum, Barrick, China Steel, Gold Fields, Harmony Gold Mining, Implats, Kinross
Warming ambient temperatures in the Arctic and other cold climates will make it easier to operate and reduce heating costs.	Agnico-Eagle Mines, Cameco, Kinross, Teck

Source: BSR: *Adapting to Climate Change: A Guide for the Mining Industry*

“Higher temperatures, changing patterns of precipitation and higher sea levels, or conversely, lower freshwater lake or river levels, will affect the mining and metals industry in a variety of ways,” the ICMM writes in its March 2013 report, *Adapting to a Changing Climate: Implications for the Mining and Metals Industry*. The ways include: “physical risks to assets and infrastructure arising from flood or storm damage, supply chain risks arising from disruption to transport networks and increased competition for climate-sensitive resources such as water and energy.”

Disruptions to mining operations will also impact the world and its economies, the ICMM warns. “Development of mineral resources is a pillar of many national economies, both in terms of contribution to gross domestic product and tax revenues, and also as an industry that directly employs millions of workers.”

Furthermore, the mining industry’s “vital commodities are used to construct communication and transportation networks, consumer electronics, vehicles, buildings, and many other items that serve as a foundation for society’s material quality of life,” writes the ICMM.

Top 10 Mining Companies in 2013 (Revenues in \$Billion)

Glencore International UK	281.9
BHP Billiton Australia/UK	71.8
Rio Tinto Australia/UK	52.0
Vale Brazil	45.6
China Shenhua Energy, China	40.2
Xstrata, UK	31.6
Anglo American, UK	29.4
Barrick Gold, Canada	14.6
Newmont Mining, U.S.	9.9
Goldcorp, Canada	5.5

Source: FT500, 2013: <http://www.ft.com/intl/indepth/ft500>; 2013 ranking of the global top 10 mining companies based on revenue. Values based on the 2013 Financial Times Global 500 list.

As the ICMM report acknowledges, the industry has long been under the public microscope for its practices, especially on environmental and social issues. Climate change has added another layer to the scrutiny, with, as the report notes, increased external pressures to “identify, disclose and plan for the risks and opportunities” associated with climate change. (Climate “opportunities” include changes in the landscape that will, the ICMM writes, “enable access to new reserves in previously inaccessible areas.”) The melting North Pole opening access to Arctic oil reserves is one prominent, politically delicate and controversial example.)

Worlds Unto Themselves

Mining operations in remote areas like Atacama, or in the tropical forests of South America, in the jungles of Africa or the mountains of Australia, are, by necessity of their isolation, self-contained communities—and can be seen in this poster-child analogy as a microcosm of communities at risk from the extremes of a changing climate.

Mining communities require what any community requires: energy, water,

infrastructure, roads, transportation, housing and human services, food and medical care, all of which has been and remains primarily the province of the mining companies themselves and a standard cost of doing business.

Sustaining these communities and their residents—the invaluable mine workers—is of upmost importance to the investment. And lessons learned in community management over the years are translatable to climate-changing scenarios, including those having to do with both the need to protect and nourish natural resources, like water, and to maintain a safe environment for human resources now and in the future.

As advised by the ICMM report, “The health and safety of employees and the wider communities on which businesses depend can be affected both directly and indirectly by a changing climate.” Among the health threats on ICMM’s radar, particularly in tropical regions under threat of increased precipitation and higher temperatures, the rise of vector-borne diseases such as malaria.

Human and natural resources are issues the industry has long dealt with, voluntarily but primarily through diverse, country-specific policies and regulations, which on the environmental side are most often directed at resource usage (and most often water use) during the life of the mine and, on other end of the equation, the condition of the mine site when the operation packs up and leaves: mining is, in many instances, a transitory industry, its coming and going dependent on the resources available, or as it’s called, “the package of mineralization.” The end goal for mine closure, said Watson, is “to leave the property the same or better than they found it.”

Both the front and back-end environmental regulatory considerations require

long-term planning and calculations, all specific to estimations of any impacts currently foreseen and projected over the lifetime of the mining operation—in other words, the industry is accustomed to gauging the impacts, climate and otherwise, on its operations, a business skill that could be put to use in conjunction with the right climate science.

Australia’s early interest in climate change impacts to assets and operations has also provided companies like AECOM an edge in assessing climatic risks and vulnerabilities there. The climate projection modeling tools used to determine those impacts are “easier to apply” in Australia, said Nolan, because there is one lead government research and industry organization—CSIRO—producing climate projections Australia-wide, while in other countries multiple universities and organizations offer climate projection products and styles.

You Gotta Have Friends

Dependent on what the earth provides, mining is a conservative industry, concerned about the bottom line and dogged when it comes to the economics of its operations. Stability is its end goal, and to that end, mining is sensitive to external input, like public opinion, most of which has to do with environmental concerns.

It’s sensitive, too, to concerns of shareholders and others stakeholders, who are increasingly concerned about the environment and GHG emissions—mining accounts for 2 percent of the world’s emissions, according to the ICMM. And mining is well aware that funding entities are increasingly keeping tabs on mitigation. As the ICMM reported “there are indications that project financiers are beginning to alter lending criteria to take account of climate risks,” adding and underscoring, “Development banks are also beginning to explore investment risks associated with a changing climate.”

Then there's the specter of national policies on limiting GHG emissions, such as the Australia Clean Energy Act, passed in 2012 and imposing a carbon tax on diesel fuel, gasoline, natural gas and purchased electricity. Although the future of the tax is up in the air after the September 2013 election, its potential impacts on mining companies have to be taken seriously. Gold-mining company **Newmont Mining** has reported that the financial impact to its Australian operations "is \$30 million to more than \$50 million annually," the company said. (See Newmont Q&A on page 11.)

Mining pays attention to the above issues because it wants to maintain what it currently enjoys, acceptance. "The world is friendly to mining," said Watson. "It provides jobs, it provides for foreign investment. No country is opposed to mining." And it's not just countries that are mining-friendly. Arizona in the American Southwest, the world's sixth-largest producer of copper, couldn't be happier about the mini-mining boom now occurring in the state. Hit hard by the great recession, the value that the mining industry represents, currently and historically, was underscored by a report released in 2011 by the Arizona Mining Commission, which calculated that the state's healthy mining industry coughed up \$212 million in business taxes that year.

As adept as the industry is in reading the weather, erratic events have begun to erode that long-held confidence. Most often quoted is the melting of the ice roads in the Canadian Arctic—truck deliveries to remote areas and mining operations run on a tight schedule with very little wiggle room. The seemingly subtle variation in temperatures recorded over the past few years has been enough to upset the balance and that, in the case of the De Beers Canada diamond mine in Canada's Northwest Territories, created the worst possible financial scenario: it couldn't get needed equipment into the mine by truck

when the ice road melted in unseasonably warm winter weather. De Beers had to foot the added, and costly bill, for flying the materials in.

Leaping into the Fray

In 2012, BHP pointed a finger at climate change as impetus for upgrading a jetty at its Hay Point coal port in Queensland, Australia, specifically, an official told the Financial Review, due to the increased frequency and strength of cyclones in the area. He added that the decision was based on the recognition "that as these cyclones become more severe, we need to have facilities that are more able to withstand them."

It wasn't BHP's first climate conversation. In 2010, former CEO Marius Kloppers, in a speech at the Australian British Chamber of Commerce, said climate change is "an issue that will profoundly affect all aspects of business and trade in the coming decades."

Kloppers' public statement, which made headlines when he also remarked that "BHP Billiton acknowledges that the mainstream science is correct, and that we need to stabilise (and eventually reduce) the carbon concentration in the atmosphere," wasn't news to the industry itself. The mining industry isn't oblivious to the recent fluctuations in the weather. "Awareness is increasing, quantifying risks is increasing," said Al Douglas, director of the Ontario Centre for Climate Impacts and Adaptation Resources (OCCAR). (See "Canada's OCCAR: Excavating the Nitty-Gritty of Adaptation.")

What's needed is guidance, which came in 2013 when the ICMC released "Adapting to a changing climate: implications for the mining and metals industry," a groundbreaking report that spells out what the

industry will face in a climate-challenged world—and offers a roadmap for facing those challenges head on.

As the ICMC writes, "A changing climate presents physical risks to mining and metals operations because these industries are often located in challenging geographies, rely on fixed assets with long lifetimes, involve global supply chains, manage climate-sensitive water and energy resources, and balance the interests of various stakeholders." Added Douglas, "Even if you don't agree on the causes of climate change, you can appreciate the challenges it can pose for the mining industry." ☼

Top 40 mining companies in the world

Agnico-Eagle Mines Limited, Canada
 Anglo American PLC, UK
 AngloGold Ashanti Limited, South Africa
 Antofagasta PLC, UK
 Barrick Gold Corporation, Canada
 BHP Billiton Limited, Australia
 Cameco Corporation, Canada
 China Coal Energy Co Ltd, Hong Kong
 China Shenhua Energy Co Ltd, Hong Kong
 Coal India Limited, India
 Compania de Minas Buenaventura SA, Peru
 Consol Energy Inc., US
 Eurasian Natural Resources Corporation, UK
 Fortescue Metals Group Limited, Australia
 Freeport-McMoRan Copper & Gold Inc., USA
 Goldcorp Inc., Canada
 Gold Fields Limited, South Africa
 Grupo Mexico S.A. de CV, Mexico
 Impala Platinum Holdings Limited, South Africa
 Industrias Penoles S.A.B De CV, Mexico
 Ivanhoe Mines Limited, Canada
 Jiangxi Copper Company Limited, Hong Kong
 Kazakhmys Plc., UK
 KGHM Polska Miedz SA, Poland
 Kinross Gold Corporation, Canada
 MMC Norilsk Nickel, Russia
 National Mineral Development Corp Ltd, India
 Newcrest Mining Limited, Australia
 Newmont Mining Corporation, United States
 Peabody Energy Corporation, United States
 Potash Corporation of Saskatchewan, Canada
 Rio Tinto plc. / Rio Tinto Limited, UK / Australia
 Shandong Gold Mining Co., Ltd, China
 Shanxi Xishan Coal and Electricity Power, China
 Silver Wheaton Corp., Canada
 Teck Resources Limited, Canada
 The Mosaic Company, United States
 Vale SA, Brazil
 Xstrata plc., UK
 Yanzhou Coal Mining Company Ltd, Hong Kong

Industry Makes the Case for Climate Strategies

Ahardscrabble industry accustomed to plying the harshest climates on the globe for precious and otherwise indispensable minerals and metals, the world's multinational mining companies have the wherewithal to tackle climate change adaptation from the ground up, if they want to. And they now have a framework to guide them, created by the mining industry for the mining industry.

Produced by the **International Council on Mining and Minerals (ICMM)** and released in March 2013, "Adapting to a changing climate: implications for the mining and metals industry" is a comprehensive resource for dealing directly with the risks associated with a changing climate.

It's already making an impact. Sean Capstick of **Golder Associates** refers to the ICMM report as one of two key references he uses when discussing strategies for tackling climate change, the other being the **International Finance Corp. (IFC)**, which has released performance standards that consider climate change (over the past two years the IFC has also invested \$1.7 billion in "climate-friendly" projects). Together, the IFC and the ICMM report, said Capstick, underscore that solutions "can be done in stages and compartmentalized."

The 64-page ICMM report relies on the latest studies and climate calculations, case studies and informational graphics, much of the data sourced from the Intergovernmental Panel on Climate Change (IPCC) and all written specifically to address the issues, concerns and challenges mining companies face on a daily basis. Its basic assumption is, as the former CEO of **BHP Billiton**, Marius Kloppers, declared to an Australian audience in 2010, that the "mainstream science is correct" and

climate change "is an issue that will profoundly affect all aspects of business and trade in the coming decades."

Established in 2001 specifically to address sustainable development and performance within the industry, the ICMM, is a not-for-profit association formed under the Canada Corporations Act. It counts 22 of the world's largest mining and metals companies and 34 industry associations as founding members. Five of the ten largest mining companies in the world are among those founders (their rankings as of 2010): BHP Billiton (No. 1), Vale (No. 2) Rio Tinto (No. 3), AngloAmerican (No. 5) and Barrick (No. 8). Members Xstrata, Newmont, Freeport-McMoRan and Goldcorp all rank in the top 20 largest mining concerns.

"Project financiers are beginning to alter lending criteria to take account of climate risks."

Founding-member associations represent some of the world's key mining regions—Africa and South America among them—and associations specific to key metals and minerals, including copper, cobalt, lead, iron and manganese.

What members get for their participation is exposure for the commitments they make and accomplish as ICMM supporters, including the development of GHG emission reduction strategies, ensuring the efficient use of natural resources and supporting research and development of low GHG emission technologies.

"This report and the others produced by the ICMM help stake out our position on critical issues like climate change and build a foundation for taking collective action as an industry," said Omar Jabara, spokesman for **Newmont Mining** (see Q&A on page 11).

No Mine Is an Island

Acknowledging that a "changing climate presents physical risks to mining and metals operations"—and to the people and environments attached to those operations—the report ticks off a list of vulnerabilities, scenarios, implications and solutions for managing the risks.

In many respects, the mining industry operates at ground zero for climate disruptions—in "extremely challenging geographies and climates," as the report notes, "that are often in isolated 'frontier' locations or unique and fragile environments with ecosystems that are highly sensitive to a changing climate."

"Higher temperatures, changing patterns of precipitation and higher sea levels, or conversely, lower freshwater lake or river levels, will affect the mining and metals industry in a variety of ways," the ICMM writes. The ways include: "physical risks to assets and infrastructure arising from flood or storm damage, supply chain risks arising from disruption to transport networks and increased competition for climate-sensitive resources such as water and energy."

Disruptions to mining operations will also impact the world and its economies, the ICMM warns. "Development of mineral resources is a pillar of many national economies, both in terms of contribution to gross domestic product and tax revenues, and also as an industry that directly employs millions of workers."

Furthermore, the mining industry's "vital commodities are used to construct communication and transportation networks, consumer electronics, vehicles, buildings, and many other items that serve as a foundation for society's material quality of life," writes the ICMM.

As the ICMM report acknowledges, the industry has long been under the public microscope for its practice and practices, especially on environmental and

Framework for Evaluating Climate Change Risks to the Mining and Metals Sector

Impact Areas	Impact Evaluation	Business Implications
Inputs	Description What is the impact?	Financial Higher operating expenditure or unplanned capital expenditure
Supply Chains	Timeframe When will the impact occur? When is action necessary	
Markets		
Exploration	Stakeholders Who is impacted?	Reputational Increased risk of litigation, regulatory non-compliance, inability to operate
Construction	Primary/secondary Does the impact directly affect activities or does it trigger other impacts?	
Operation		
Closure	Likelihood How certain is the impact? How much more often is it likely to occur?	
Post-closure		

Adapting to a changing climate: implications for the mining and metals industry, Intl Council on Mining & Metals

social issues. Climate change has added another layer to the scrutiny, with, as the report notes, increased external pressures to “identify, disclose and plan for the risks and opportunities” associated with climate change. (Climate “opportunities” include changes in the landscape that will, the ICMM writes, “enable access to new reserves in previously inaccessible areas.” The melting North Pole opening access to Arctic oil reserves is one prominent, politically delicate and controversial example.)

Stakeholder Pressure

Much of the climate change-related pressure is coming from stakeholders. “Several investor initiatives, such as the Carbon Disclosure Project (CDP), the Investor Network on Climate Risk, and the Institutional Investors Group on Climate Change, have begun to put pressure on companies to disclose climate-related risks.”

Importantly, too, “there are indications that project financiers are beginning to alter lending criteria to take account of climate risks,” according to the report, noting, “Development banks are also beginning to explore investment risks associated with a changing climate. The

European Bank for Reconstruction and Development, for example, is integrating climate risk management into investment appraisals.”

ICMM ALSO points to Norway’s \$582.7 billion sovereign wealth fund. Assessing the risks of investing in climate-sensitive assets, the Norwegian Ministry of Finance recently released an extensive study indicating that climate change could reduce the fund’s value by up to 10 percent over the next 20 years.

Responding now to these external pressures, as well as to climate change itself, is a strategy that could pay off in the future and prepare the industry for the future. As the ICMM report notes: “The significant expansion of reporting schemes for the private sector, such as CDP, may herald the introduction of mandatory reporting on climate risk management.”

Water Risks Top List

Mining operations in a climate-fluctuating world face a “diversity of risk,” most of it having to do with water: either too much of it or too little, according to the report, which identifies and describes the impacts on operations located in three kinds of at-risk environments: arid or

water-stressed areas, tropical climates and “wet” areas.

Water is critical for mining and metals; it’s used for cooling, crushing and grinding the rock, milling the ore and transporting slurry and tailings to storage. Tailings are also dependent on water, which reduces oxidation and prevents toxins from seeping into the ground—and it’s used to tamp down the dust to protect air quality.

Chile, Peru, the southwestern United States, southern Africa and Australia are already at risk from increased water shortages, the ICMM reports. Chile’s desolate Atacama Desert, rich with copper, is expected to become “severely or extremely more stressed by the end of the century.” The industry must ready itself for reductions in water availability caused by higher temperatures and increased evapotranspiration, as well as demand from other water users, such as agriculture.

African nations, especially South Africa, will face “extremely high stress and are projected to face conditions that are at least twice as severe in the future.” The copper and gold mines operating in the United States and Mexico already operate in areas of “extremely high water stress,”

notes the ICMM. Southern California, Nevada, Arizona and northern Sonora, Mexico, “are projected to become severely or extremely more stressed by the end of the century.”

Tropical Regions

In contrast to arid and water-stressed regions, mining and metals companies also operate in regions where too much water is the threat, resulting from heavy rainfall, seasonal snowmelt or precipitation, inland flooding, coastal flooding and sea level rise. These areas are mostly located at higher latitudes “and in tropical areas that are already ‘wet’ in terms of annual precipitation,” according to the ICMM.

In the tropical regions of Central America, northern South America, West and Central Africa, Southeast Asia and the Pacific, climate forecasts call for increases in temperature, changes in precipitation and extreme weather events such as flooding.

Here the threat is to human health, which in turn affects workforce availability and morale as well as regional commerce in general. People in isolated and low-income areas, said the report, “are vulnerable to multiple health stressors related to vector-borne disease, nutritional deficiencies, HIV/AIDS and diarrhoeal disease.” The threat of contracting malaria, dengue fever and cholera will also be on the rise.

Incremental increases in the “absolute quantity of precipitation and runoff can affect the mine site’s water balance,” writes the ICMM, a threat companies will need to address by increasing the capacity of pumping systems. Moving water out of mining pits or underground mines and into storage areas during heavy rainfalls will become an operational priority.

Changes in seasonal water flows for these areas—projected to arrive earlier in the winter and decline faster in the sum-

mer—could affect treated-water discharges, requiring companies to increase the capacity of water storage or come up with ways to divert runoff away from the site, the report continued. Freshwater supplies could be threatened by saltwater intrusion from sea level rise.

Too much water also has a direct impact on transportation and the supply chain. Along the coast, port and storage facilities may be affected by gradual sea level rise as well as higher storm surges during “extreme events” like tropical cyclones and hurricane. “Roads and railways are also susceptible to impacts in these areas, as well as impacts from inland flooding from increased precipitation and runoff, where wash-outs can damage road and rail segments,” according to the ICMM.

Mine Closure Considerations

Mines come and go, with their lifespans depending on the size of the deposit. Regulations now require operators to determine the costs of the mine closure and to post closure bonds to, as the ICMM writes, “redress any impacts [the operation] causes to wildlife, soil and water quality over its lifetime.” In other words, mines are responsible for mitigating any impact they have on the surrounding environment and communities—leaving the area as good or better as they found it would be the ideal.

These impacts are addressed at the Environmental Impact Report stage, but for now, few of these studies are incorporating calculations and mitigation for changes in the climate. Yet as the ICMM report advises, “A changing climate will result in environmental impacts that are potentially quite large—particularly in the Arctic and in other highly climate-sensitive ecosystems—and this may increasingly factor into the regular reassessment of closure bonds as the risks of climate change are better understood and quantified.”

Particularly important to address as part of the closure-reporting process,

according to the ICMM: the potential for contamination from tailings (waste) storage. The example used in the report cites dams and structures for containing the tailings, which are currently designed to accommodate “Probable Maximum Flood” events—but those events are most likely based on current climate and hydrological conditions, said the ICMM. Climate change will alter these status-quo averages.

Problem Too Big to Tackle Alone

Tackling climate change isn’t about “reinventing the wheel.” It’s about understanding how to incorporate the impacts of a changing climate into familiar territory: managing risk, according to ICMM.

The industry may be in the eye of climate storm, literally, but it has a compass: As the ICMM notes, the nature of the mining and metals business “already requires companies to address risks from variable weather, changing environments and challenging geographies.”

And as the ICMM advises, many of the approaches, tools, information, resources and people necessary for identifying and adapting to climate risks and opportunities “are likely to already exist within companies, even if these activities or resources do not currently incorporate climate change considerations.”

While mining companies may have the resources to address climate risk in-house, the ICMM urges external-facing partnerships and collaborations. Climate risk is new: forging relationships, advised the ICMM, advances the availability of the tools, resources and latest techniques required for success.

Among the ICMM’s suggestions to the world’s mining companies: work with trade and industry associations, civil society groups, academia or mining and metals sector consultants and equipment vendors to test and develop “decision-support” tools. ⚙

Examples of Climate-Related Steps Taken By ICMM Member Companies

From Adapting to a Changing Climate: Implications for the mining and metals industry, a report by the International Council on Mining and Minerals (ICMM)

BHP Billiton: Between mid-2004 and mid-2009, BHP Billiton achieved a 15 percent improvement in water efficiency at Olympic Dam in South Australia through the use of hypersaline (having a higher salinity than ocean water) groundwater for dust suppression and vehicle wash, covering water storage to limit evaporation, and increased water reuse and recycling at storage ponds, tailing dams and in metallurgical processing.

Kumba Iron Ore: Kumba Iron Ore has incorporated climate change risks into its risk management program. The company is currently collecting information on the likelihood and consequence of extreme weather impacts to determine their impacts on structures at mine sites.

Capstone: Capstone installed a new water treatment plant, dug ditches to divert runoff from the mine site and updated its water balance to respond to increased runoff and extreme seasonal water flows at its Minto mine in the Yukon

Vale and the State Government of Espírito Santo (Brazil) : Vale and the Espírito Santo State Government are developing an environmental monitoring and forecasting system to serve the population and improve economic activities in the area, which includes Vale's needs for accurate weather and climate information. The objective of the monitoring system is to mitigate the effects of severe weather events in the state of Espírito Santo in the context of climate change and variability. The system is composed of weather radar, a mesonet network of surface stations, a satellite reception system and a supercomputing facility.

Cerro Verde Complex: Cerro Verde, a copper and molybdenum complex near Arequipa, Peru, is currently a zero-discharge facility that recycles 85 to 90 percent of its process water. To meet the additional water requirements of a planned expansion, Freeport-McMoRan Copper and Gold's majority-owned company, Sociedad Minera Cerro Verde (SMCV), is working with the regional water utility, Sedapar, and local, regional and national governments. SMCV plans to build a waste-water treatment plant for Arequipa. In addition, SMCV has invested directly in the construction of a water treatment plant that will provide potable water to the residents of Arequipa.

Anglo American: Anglo American is working with Imperial College, London, and the UK Met Office to develop a detailed climate change impact assessment of its Minas-Rio project in Brazil. Anglo American will use regional climate change modeling to develop business risk templates to incorporate adaptation actions into new and current operations. The results of this work will also feed into the company's internal climate risk model.

Canada's OCCIAR Excavates the Nitty-Gritty of Adaptation

For the past decade, the Ontario Centre for Climate Impacts and Adaptation Resources (OCCIAR) has focused its educational outreach on helping municipalities and communities understand the risks of a climate in flux. More recently, OCCIAR has turned its sights on natural resource sectors, including the mining industry.

A tough group to work with, the industry is highly competitive and not accustomed to sitting around with competitors chatting about operational matters or, heaven forbid, operational problems.

But these are strange times, and everyone in the business has heard the climate horror stories, like the one about De Beers Canada scrambling in 2007 to open its first diamond mine in the Northwest Territories on schedule and on budget when warmer-than-usual temperatures wreaked havoc on the vital winter ice road.

Setting Up the Challenge

"Awareness is increasing, efforts to quantify risks are increasing," said Al Douglas, OCCIAR director. According to Douglas, the De Beers experience shows that a mine's "logistics people have to recognize the challenges and be prepared to deal with weather variability."

OCCIAR is offering workshops and preparing case studies for the industry as pragmatic guides for how mining can better prepare for upcoming climate disruptions. Part of a nationwide education and resource development effort initiated by Natural Resources Canada, the program offered by OCCIAR—and by similar groups in other provinces—is in line with what the International Council on Mines and Minerals (ICMM) has identified as the way forward for its members.

In its 2012 report, *Adapting to a Changing Climate: Implications for the Mining and Metals Industry*, the ICMM urged mining companies to “forge relationships with important external actors” to expand the tools, resources and latest techniques needed to meet climate changes head-on.

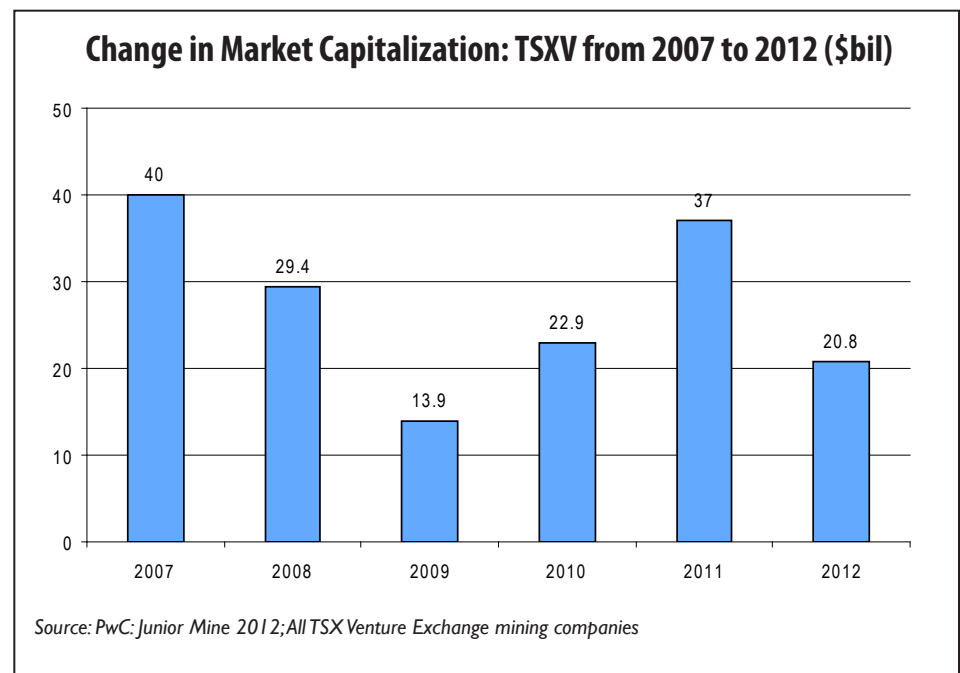
Douglas credits the ICMM, whose members include most of those in the “world’s-largest” category, for bringing “awareness to the issues, giving facts and statements about what companies are dealing with.”

“When you talk about the big companies and what they’re doing, it makes smaller operators think and talk,” said Douglas. “The ICMM can be the spark for champions [of climate change policies] within the companies themselves,” he said. “We refer to the ICMM report in our workshops and will in our upcoming case studies.”

Breaking Down Barriers

The case studies are a crucial component, in part because they are a step toward opening dialogue among the mining companies themselves. “It’s a good way to show companies what their colleagues are doing,” said Douglas. “It’s also an opportunity to express the challenges, barriers and needs ... to create an enabling environment.”

The most significant challenges for mining operations in Ontario, said Douglas, who is also director of climate



change adaptation at the applied research NGO MIRARCO, include warming temperatures and too much or too little water. The latter affects water for processing as well as tailings management while the former will require increased cooling (energy) to augment ventilation in warming mines.

“They both translate into cost,” said Douglas, noting that OCCIAR will research the relative costs and benefits of adaptation now versus climate-related disruptions in the future. “We’ll do a cost benefit analysis for adoption—future and present values, as well as mine closure value [in terms of climate] in 20 years versus the cost if they don’t” take action, he said. The goal overall is to help support climate change adaptation and that includes breaking down barriers that

are holding companies back. Among the top barriers is the lack of geographic and industrial specificity in climate projections. Currently, the projections are more regional in nature, not specific to individual industries, said Douglas.

Another roadblock: identifying the tools needed to assess climate impacts, especially the risk management frameworks. “The tools exist,” said Douglas. “The tools and guidance we used for communities and municipalities need only slight modifications for the mining industry.”

“The mining sector is engaged [in the climate discussion], but it’s at an earlier part of the continuum,” said Douglas. “We will give them the resources and information they need.” ⚙

TSXV Top 5 Mining Companies	Position in 2012's Top 100	2012 Mkt Cap \$ Millions	Position in 2011's Top 100	2011 Mkt Cap \$ Millions	% Change
Sandstorm Gold	1	582	12	382	52%
Iberian Minerals Corp	2	548	10	406	35%
Copper Fox Metals	3	450	1	790	-43%
Aurcana Corp	4	415	33	208	100%
Dia Bras Exploration	5	409	11	388	5%

Source: PwC: *Junior Mine 2012*

Newmont Mining Tackles Mitigation and Looks at Adaptation

Q&A with Omar Jabara, Newmont Mining

Ranked as the world's 18th-largest mining company in 2010, **Newmont Mining** (Greenwood Village, Colo.; 2012 revenues \$9.87 billion) is also one of the world's largest gold-mining companies, with operations in Ghana, Peru, Indonesia, Australia, New Zealand and the United States. One of its open-pit gold mines in Nevada was the first of its kind. As of 2012, Newmont had "proven and probable" gold reserves of 99.2 million ounces, according to the company.

Newmont also has a robust sustainability program outlined in its *BeyondtheMine.com* website. The company discloses its carbon emissions to the Carbon Disclosure Project (CDP) and between 2008-2012 was added to the CDP's Leadership Index. In 2007, Newmont was the first gold mining company selected for the Dow Jones Sustainability World Index.

In addition to GHG disclosures, the company is upfront about the threat of a changing climate. "Our operations could be threatened by . . . rising sea levels at our port operations and severe weather damage to site infrastructure—roads, dams, and process facilities. Floods or drought would severely impact our water balance," it writes on its website.

Newmont is already exposed to GHG mitigation policies, including the Australia Clean Energy Act, passed in 2012, that imposes a carbon tax on diesel fuel, gasoline, natural gas and purchased electricity. "Its financial impact to our Australian operations is \$30 million to more than \$50 million annually," the company said. (As noted in CCBJ's recent carbon markets edition, the future of carbon pricing in Australia is up in the air due to the election of anti-carbon tax Liberal Party leader Tony Abbott.)

Anticipating the risks posed by both climate change and carbon pricing, Newmont calls its carbon management policy "crucial" for the company's competitive position and "an essential component of our commitment to be a leader in the mining industry." Newmont spokesman Omar Jabara discusses the new reality of facing-down carbon and climate to maintain business as semi-usual in the gold mining industry.

CCBJ: Who handles your mitigation and carbon policies: A dedicated team?

Jabara: Newmont has a team dedicated to managing the risks and opportunities climate change poses for our business. We have a corporate Greenhouse Gas (GHG) Manager that establishes global policy, a regional Principal Advisor in Australia that manages climate change issues such as the Australia Carbon Tax and energy efficiency, and assigned staff that track climate change issues in Africa and Peru.

Additionally, the Sustainability & External Relations functional group chartered a Global Energy and Carbon Team (GECT) in February 2010 to provide energy and carbon management solutions as part of our business strategy to reduce Newmont's energy costs and carbon footprint. Solutions include renewable energy, energy efficiency, carbon offsets and carbon trading. The GECT consists of one or two representatives from each region, a corporate senior director, a corporate energy director and the corporate GHG Manager, who chairs the GECT. The GECT meets regularly via teleconferences, site visits and face-to-face meetings. Regional representatives of the GECT communicate GECT activities and projects to regional and site management.

CCBJ: When did your carbon management policy also begin to address a changing climate as a risk to operations and investment?

Jabara: In 2009, Newmont developed a Global Climate Change Strategic Plan to describe, communicate and implement our Climate Change strategy. Mining is an energy-intensive business, and transitioning to a carbon constrained future poses financial and regulatory risk to the minerals industry, while changing weather patterns and rising sea levels pose physical risks to Newmont's global operations.

CCBJ: What specific climate-related issues are of most concern/impact?

Jabara: The two primary climate-related issues for Newmont are financial risk of carbon taxes or Emission Trading Schemes and reputational risk of not meeting stakeholder expectations regarding greenhouse gas emissions reporting, mitigation or other perceived indifference regarding climate change.

From our 2012 annual report, "Regulations and pending legislation governing issues involving climate change could result in increased operating costs which could have a material, adverse effect on our business."

The potential physical impacts of climate change on our operations are uncertain and are dependent upon the geographic conditions of the areas in which we operate. These may include changes in rainfall, storm patterns and intensities, water shortages, sea-levels rising and changing temperatures. These impacts could adversely impact the cost, production and financial performance of our operations. However, we have not seen any unusual or adverse impacts from climate change to our operations, so far.

CCBJ: In addition to the in-house expertise that you've developed, what types of expertise related to climate change do you seek from consulting and professional service firms?

Jabara: Newmont contracted an energy consulting firm as well as a carbon services firm to develop, review and update our

Carbon Management Strategic Plan. We also enlisted Conservation International to review our Global Carbon Management Policy.

We have contracted various carbon offset experts to develop our Carbon Offset Strategy, and we worked with a carbon offset projects provider in Australia to develop two forestry projects; estimated tonnes of CO₂ to be sequestered over the life of the projects are 119,000 in the New South Wales parcel and 182,000 in the Western Australia.

For the past three years, we have contracted a third party consulting firm to verify our annual greenhouse gas emissions, and we also use energy consultants to identify energy efficiency/ GHG reduction opportunities. We are also working with a large petroleum company in Africa and Australia to provide solutions to reduce our mobile diesel consumption and our mobile GHG emissions.

CCBJ: Are you taking climate into account for planning mine closures? New or expanding a current operation?

Jabara: Engineering design for closure, expansion and new operations is based on historical climate data such as the 100-year/24-hour storm event. Our KCGM joint venture mine in Australia does have plans to construct a solar power plant on waste rock dumps after closure to provide low-emission, green power to the town of Kalgoorlie. We are also looking at installing micro hydro plants at our existing legacy sites to provide low-emission, green power required for our closure operations such as water treatment.

CCBJ: Overall, does Newmont think that a changing climate will continue to be a factor in operations in the near and distant future?

Jabara: While we have not experienced adverse impacts of physical climate change on our operations, we do recognize this as a possibility in the future and

believe that the designed safety features incorporated into our facilities could handle the physical impacts of climate change.

CCBJ: What are the primary drivers for mitigation?

Jabara: The primary drivers behind mitigation include financial risk from taxation or trading schemes, reputational risk and the need for improved energy efficiency.

CCBJ: Have you seen increased pressure from shareholders around climate issues?

Jabara: We have not.

CCBJ: Has mitigation been of value in terms of operational costs?

Jabara: Yes. Our operational cost savings are estimated to be \$15 million annually for 29 energy efficiency projects that have already been implemented and another 52 that are in progress. The percentage of our total energy spend that is used on renewables is roughly 19 percent, including hydropower, biodiesel and geothermal.

CCBJ: You were testing the feasibility of producing your own biodiesel at the Leeville site in Nevada, using a native wildflower as feedstock. What was the outcome?

Jabara: After completing biodiesel testing at Leeville in 2011, we came to the conclusion that it is much more cost efficient to purchase biodiesel versus producing it ourselves.

As such, we purchased 740,000 gallons of biodiesel in 2012 for our Nevada underground operations. In 2012, our Yanacocha, Peru, operation began using B5 (a 5 percent biodiesel/ 95 percent diesel mix) in all of our mobile equipment. In prior years, Yanacocha used B2 (a 2 percent biodiesel/98 percent diesel mix). ⚙

All that Glitters Could be Renewables

In the fall of 2012, Rio Tinto's Diavik Diamond Mine in the remote tundra of Canada's Northwest Territories flipped the switch on a \$30 million wind power generation facility, Rio Tinto's first and billed as the most northern, large-scale, wind-diesel-hybrid power facility in the world.

Located on an island in a subarctic lake, the mine—reportedly sitting on 60 million carats of diamonds—relies on diesel to power its operations and equipment. To supply fuel, an endless train of tankers maneuver the ice road—a 32-hour round trip from the nearest community on a road that is closed 10 months out of the year. And sometimes, barrels of diesel are even flown in by cargo planes.

With the wind facility, Diavik will have a year-round source of energy. Although not as reliable as diesel engines, the wind turbines will supply enough power to reduce annual fuel use by 10% and the mine's carbon footprint by 6%, according to Rio Tinto. It will also take 100 of those tanker trucks off the delicate frozen highway.

Rio Tinto is among a growing number of mining companies who are taking a second look at wind and solar energy thanks to the constantly improving economics of those technologies. "The costs for PV and wind are low enough to compete with the cost of diesel," said Andrew Slavin, director of Canada Clean Energy Conferences, which in late September 2013 hosted its first Renewable Energy and Mining Summit in Toronto.

Incorporating renewables into the diesel-dominated mining world is particularly seductive to far-flung operations like Diavik, which are too far into the wilderness to get juice from an electric grid. They build their own microgrid infrastructure and transmission systems,

Energy Costs and Carbon Risks and Mitigation Opportunities

Declining ore grade concentrations	Mining companies constantly assess ore grades. Energy cost is an important input to assessing mine feasibility. While current operational energy costs make up around 7-12% of total mining costs for different mining sub-sectors in Australia, within 10 years, energy costs could be as high as 20-30% of total operational mining costs. Energy intensive gold and copper mines are most exposed if cost effective investments are not made in more energy efficient comminution (crushing and grinding) technologies. Over the last 30 years, the average grade of mined Australian ore bodies has halved ¹⁰ leading to a 70% increase in energy consumption across mining operations. ¹¹ This is rising at around 6% annually. ¹² Once grades fall below 1%, energy requirements rise exponentially to grind ores to obtain the valuable mineral.
Short term focused capital expenditure	Energy savings of up to 50% per tonne below business as usual energy usage trends are practically feasible in the design of new Greenfield metal ore mining and minerals processing operations through implementing an integrated mine-to-mill energy efficiency strategy. ¹³ Few mining companies are realising such long term operational energy cost savings due to investors and industries focusing on minimising upfront capex costs in establishing mine site operations as quickly as possible. This may leave some mines exposed to reduced competitiveness (over the longer term) if energy costs rise while at the same time mineral prices fall.
Diesel fuel price exposure	The mining sector in Australia relies on diesel fuel to run generators and mining haul trucks. The price of diesel fuel is pegged to the oil price which the International Energy Agency (IEA) forecasts to rise significantly once the global economy returns to historic growth trends.
Reliance on diesel fuel subsidies	The Australian mining sector currently receives tax deductions for the use of diesel fuel. The G20 has committed to phasing out fossil fuel subsidies and the OECD continues to highlight Australia's subsidies for fossil fuels. Price on carbon Over 50 national or sub-national carbon price schemes are in place around the world. Many of the remaining nations have some form of climate change regulation or policy which creates a shadow carbon price on energy prices. Mining is energy intensive thus, if carbon mitigation steps are not taken, the price on carbon increases energy costs.

Source: Assessing Climate Change Risks And Opportunities For Investors: Mining and Minerals Processing Sector, Investor Group on Climate Change/Australian National University

spending prodigious amounts of money, effort and manhours.

Generally, 30% of the cost of operating a mine comes from procuring energy, and that has gone up from 23-25% a few years ago, according to Michel Carreau, director of renewable power at **Hatch**, a management, engineering and development consultancy and mining specialist, in an interview with Canada Clean Energy Conferences.

"Miners can't be profitable unless they decrease the cost of energy," said Carreau, especially under current mining conditions when the quality of ore is declining. "It now takes more effort and energy to

get the same yields as in the past."

The lure of renewables also includes their price stability. Diesel costs fluctuate. Electricity costs do, too. "Renewables are a stable resource. Twenty years from now you'll know how much your renewable energy costs. They won't change," said Slavin,

Mine Boggling Electric Costs

"Every mining company needs electricity, and the bottom line for that company is cost," said Ross Beaty, founder and chairman of **Pan American Silver Corp.**, the world's second largest silver-producing company, also interviewed by Slavin's

group as part of the case studies presented at the Toronto event.

"If you think you can provide electricity to that operation more cheaply or securely with less volatility over the long term, you simply have to make your case and put together a model, and then present that model to whoever is procuring power for that mine. ... If you can make a positive case, you will get a good reception. Everybody wants to use renewable energy if it makes economic sense."

One place where renewable power is making good economic sense is Chile. The world's largest producer of copper, Chile is also one of the most expensive places

on the globe to buy electricity. Costs there have risen 11% a year since 2000.

Blamed on delays in bringing new power capacity online, the steady increase in prices has mining firms pushing the government to make changes in its electricity market regulatory system, according to the Wall Street Journal. Mining operations there use about one-third of the country's electric output.

For many of those mining companies, a key concern is the grid that serves the rich copper region in northern Chile. Demand on the grid is expected to rise by more than 8% over the next decade, but new plants aren't anticipated until at least 2016, according to metal consultancy group CRU.

Chile's electric costs are helping spur the use of renewables—but another driver is the country's renewable energy policy. "Chile has seen our greatest investment in renewables, which is partly driven by the government's renewable energy requirement," Scott Fraser, director of Power Projects **Barrick Gold**, said in an interview with Slavin.

"When you use electricity in Chile, you either have to have a certain portion coming from renewable energy sources or you are required to purchase renewable energy credits from within the country at prices that are expected to increase in the future. So, investing in wind or other renewable energy projects meet our obligations for renewable energy and demonstrates our commitment to sustainability," Fraser said.

Big Players Are Taking the Plunge

According to **Ernst & Young**, mining companies in 2012 were investing in renewable energy "faster than other industries and will account for 1.8 percent of global clean-power spending this year, double the 0.9 percent rate in 2010."

The mining industry accounts for 2 percent of the world's energy-related GHG emissions—about the same amount

as a medium-sized developed country such as Canada, according to research by the **International Council on Mining and Metals (ICMM)**. And while renewables like solar and wind power can help achieve corporate CO2 emission-reduction targets (whether imposed by regulation or voluntary corporate goals), their adoption today is more like a mini-pilot program until the clean-energy industry catches up with needed adjunct technologies, storage in particular.

Solar and wind are variable power sources, and storage technology isn't there yet in terms of maturity and cost to satisfy large-scale users like the mining industry. But as Slavin said, "There's a lot going on in storage technology for wind and sun, using diesel. At some point, storage too will be cheaper." (See *Energy Storage II* on CCBJ's back editions page.)

Still, the examples of companies taking the renewables plunge are impressive. **Rio Tinto**, the world's second-largest mining company, powers nearly one-third of its operations with clean nuclear and hydro energy, according to the company. **Anglo American**, a British mining conglomerate and the world's largest producer of platinum, relies on clean energy for about a quarter of its energy needs, states a company report.

Barrick Gold, the world's largest gold mining company, gets about 14% of its electricity from low-carbon sources. It owns a solar farm in Nevada and a \$50 million, 36 MW wind farm in Chile. A wind pioneer, in 2007 Barrick installed the world's highest-situated wind turbine (4,200m) at its Veladero mine in Argentina.

Newmont Mining uses clean energy at 10 of its 14 gold mines and in 2011 spent \$171 million on hydropower, biodiesel and geothermal power, said spokesman Omar Jabara. Newmont says its hydro-electric facilities in Ghana are "more cost-effective than gas-fired or diesel plants."

Unearthing a Cleaner Business Model

John Drexhage, climate change director at ICMM, said such examples represent a trend that isn't about a "broader altruistic corporate motive" but one based on solid economics. While spurred in part by regulatory pressures to lower GHG emissions, adoption of renewables in the mining sector is today based on "the simple bottom line that renewables are helping to actually work as an effective means of helping to cut down both exposure and costs," he told Bloomberg News.

For Slavin, hosting the Renewable Energy and Mining Summit is not about greening the mining industry but bringing renewables into the business of mining. Slavin and partner, director Adrienne Baker, have held many events on renewable energy but only this year addressed mining. "We held off until the time was right," said Slavin. "We didn't want to be too far ahead of the curve. We're not trying to be aspirational or sell an idea. This is about renewables working on an economic level."

Renewable projects are also providing benefits to the communities that serve the mines. "The average project cycle of a mine is five years, but a solar power system can last up to 20 years. It will be there after the mine is gone, and it will help with the economic development of the community."

While many of the speakers at the event represent major mining companies based outside of Canada, Slavin said Toronto is an appropriate venue: more mining companies are listed on Toronto Stock Exchange than any other: 75 percent of the world's mining companies are headquartered in Canada, where mining accounts for about 4 percent of Canada's GDP.

It doesn't hurt the mining industry to learn more about a sector it actually supplies: photovoltaic solar panels and wind turbines use the copper, aluminum, platinum and other metals and minerals that miners unearth. ⚙

AECOM: Adapting to a Changing Climate will Become Standard Practice for Mining

Early on, “we understood what a changing climate means to mining,” said Michael Nolan, global practice leader for resilience and climate adaptation at AECOM, the \$8-billion global professional-technical and management support services company. That understanding has enabled the firm to deeply integrate climate change risk assessments and adaptation into its scope of work for the mining industry.

To create strategies for mining clients to adapt to changing climatic conditions, AECOM reaches across its divisions to include water, transport, power and environmental services for integrative solutions that often arise in the grey areas between technical, policy and advisory disciplines.

AECOM, which reported \$8.2 billion in revenue for the year ending June 30, 2013, has been building its climate-change services portfolio in Australia for more than 10 years, participating in studies on the possible impacts of climate change in the Southern Hemisphere, where the company employs about 4,000 people in nearly 25 offices across Australia and New Zealand. In 2004 AECOM joined forces with the **Commonwealth Scientific and Industrial Research Organisation** (CSIRO), Australia’s national science agency, to study the risks of a changing climate on the state of Victoria.

“We looked at the infrastructure and at climate change impacts on ports, roads, rail, industrial facilities and water supply,” said Nolan. “This study really built the awareness of how sensitive construction materials and infrastructure assets were to climatic changes. There are significant risks to mining and related infrastructure.”

“Since we completed the report, the majority of high rated climatic risks identified have already occurred,” said Nolan, “It was a valuable process,”—and one the company built upon in assessing the national climate change impacts to infrastructure across every Australian state and territory for incorporation into the 2008 Garnaut Climate Change Review.

We look at climate scenarios and design thresholds—what might be at risk and the solutions.”

Australia’s early interest in climate change impacts to assets and operations has also provided companies like AECOM an edge in assessing climatic risks and vulnerabilities there. The climate projection modeling tools used to determine those impacts are “easier to apply” in Australia, said Nolan, because there is one lead government research and industry organization—CSIRO—producing climate projections Australia-wide, while in other countries multiple universities and organizations offer climate projection products and styles.

Australia, Nolan added, has advanced the use of financial analysis of climate adaptation solutions to deliver “more robust investment decisions that factor in current and future climate conditions.”

No Climate Holiday for Christmas Island

Among AECOM’s projects was an assessment of potential climate change-related risks, vulnerabilities and impacts on the community, economy and environment of Christmas Island located in the Indian Ocean near Indonesia.

Christmas Island is basically a large rock in the ocean, extremely elevated, a focal point for sea birds and home to a phosphate mine closed by the Australia-

lian government in 1987 and reopened in 1991 by a consortium of former mine workers. The Australian Government’s Attorney General commissioned AECOM to assess the climate change risks to the island and subsequently to the mining operation.

Traditionally, cyclones formed in the area of the island but moved elsewhere before becoming cyclones. Now, with higher ocean temperatures, tropical storms are becoming cyclones closer to the island with a couple causing significant damage to mining, power and water infrastructure located there in recent years, said Nolan. Key responses included re-location of critical power supply assets underground and incorporation of increased wind intensity and debris protection into design of new assets as well as hardening of existing assets at risk.

In another example, AECOM was contracted by a resource development company to assess climatic risks on a mine tailings storage facility at a high altitude mine. Even though the mine was to have a short production run of less than 10 years, the environmental regulator required a climate risk assessment as part of environmental planning approvals, according to Nolan. The government would be responsible for maintaining the storage system after closure and was concerned about the change in rainfall and water availability required to maintain the integrity of the storage facility.

The annual rainfall has been decreasing in the region where the mine is located, and climate projections indicate a continued reduction of rainfall in the decades and century ahead. Located near the top of a mountain, the mine relied on precipitation for stream flow into the mine waste storage to provide a permanent water cover to prevent the oxygenation of the sulfur-rich tailings. Without a stable water supply, the acid rock waste was likely to actively break down the integrity of the storage facility and release toxic

materials downstream, said Nolan, posing a “significant problem” for the towns and cities in that watershed.

“We helped the company consider other design options for the storage facility to manage the risk of reduced rainfall,” said Nolan. Options included diverting water from other streams to increase reliability of water capacity to designing waterless clay capping and protective material covers for the storage facility with additional drainage capacity.

Water Central to Miners’ Climate Challenges

Elsewhere in Southeast Asia, AECOM was recently commissioned by the World Bank to provide consultancy services for climate change adaptation for water supply and sanitation sectors in Vietnam and China. And it was hired by the Asian Development Bank to help Indonesia address and strengthen climate impacts on water resources in the Citarum River basin in the West Java province.

As discussed elsewhere in this edition, the focus on water security in a changing climate is an important issue for mining globally. “The selection of new mining and metals projects will need to consider future water, snow, permafrost and glacial conditions,” noted Nolan.

The United States Agency for International Development (USAID) has awarded AECOM a four-year, \$8 million contract to assist glacier-dependent countries of the Andes, specifically Colombia, Ecuador and Peru, in adapting to climate change. While not directly related to mining, Nolan counsels: “It is important for the mining sector to be aware of these types of studies as they will provide valuable understanding of future changes to the environment that have implications for the planning and management of mining activities,” said Nolan.

In the United States, there are substantial investments in adapting to changing

climatic conditions by the agricultural, water and power industries but less investment and integration of climate science into mine design and development, according to Nolan. By contrast the activity in Canada has been significant with climate adaptation guidance developed for the mining sector particularly in the polar region where there has been rapid changes in loss of permafrost impacting pipelines, roads, airports and buildings.

“The most cost effective response mining companies can make in the short term is to integrate climate change risks into the business case for investment.”

(In 2013, Nolan was seconded to the United States and Canada to work on climate adaptation projects for cities, territories and utility infrastructure developments as well as running climate adaptation training for private and public sector clients. The demand for climate adaptation services in the North American market is expanding rapidly particularly in extractive industries, transport, water, energy and agricultural product sectors. (See CCBJ’s 2012 adaptation edition.)

30 Years Is a Trend Worthy of Attention

AECOM’s role in adaptation services is to assess historic climate data, recent trends and to help interpret climate projections for the future, said Nolan. The recent trends for example in rainfall patterns, need to show a statistically significant change over at least the last 30 years.

“In completing over 120 climate adaptation projects globally, the majority of sites demonstrated recent change in annual, maximum and minimum temperatures as well as annual and seasonal precipitation trends,” said Nolan. “The climate is

currently changing, companies can no longer design mining operations for past climate conditions. They need to integrate changing conditions into planning, design, operations, asset management and supply chain. We look at climate scenarios and design thresholds—what might be at risk and the solutions.”

“The most cost effective response mining companies can make in the short term is to integrate climate change risks into the business case for investment in new projects and throughout the design process,” said Nolan. “In helping mining companies to do this, there is clear advantage in having a screening process to determine which projects require a light touch versus a detailed climate risk analysis dependent on location, expected life of operation, water and power dependencies and the nature of potential social and environmental concerns in a region.”

Some mining companies are only tackling the climate vulnerabilities at the Environmental Impact Assessment (EIA) stage and some are individually requesting “indications” of how climate change may affect a specific site at closure for managing rehabilitation or at a port facility in response to sea level rise.

In some cases, mining companies are doing climate change analysis in response to increased incidences of extreme rainfall in recent years causing flooding of mine assets such as open cut mines and tailings dams as well as washing out rail and road assets. “We’ll see a lot more of these [water-related] impacts,” said Nolan, “which will cause downtime for mines.”

Nolan anticipates that over the next decade climate change risk analysis will be a common practice at the corporate and operations level. “For investors, it will be a box they’ll want checked, companies who do choose to adapt will prosper and recover faster than those—their competitors—who don’t.”

“The investors want to evaluate the climate resilience of all their investments, not just mining,” he said. “Industries, infrastructure assets and property developments that are located in the coastal zone or in floodplains will be scrutinized. Those that have progressed a plan to increase their resilience will be safer, more valuable investments.”

With climate change a perceived risk, and with the knowledge that investors are asking it, mining companies “know they need answers,” said Nolan. “The upside is that mining companies take mitigating risk seriously. They already have well-developed processes to deal with risk of any sort.”

One More Risk for a Risk-Hardened Industry

Thinking about climate adaptation is not a huge leap for an industry accustomed to designing operations for harsh conditions. “Mines can generally handle severe weather events,” said Nolan. “It’s those extreme weather events with high operational and financial consequences but traditionally a low probability of occurring that are an issue. These extreme events are becoming larger weather system events and more likely to occur in a changing climate.”

Of course, not everyone in the mining industry is convinced about the threat of climate change, even in Australia where epic droughts, catastrophic floods and extraordinary wildfires have occurred in the last decade. The results of the country’s September 2013 election, won by anti-carbon tax Liberal Party leader Tony Abbott, underscore the reality that short-term economic growth can still trump long-term mitigation and adaptation.

Answering critics of climate-related assessments, Nolan agrees that there are “a lot of uncertainties in using future climate projections. But there is greater certainty the weather will not remain the same as it has been. ☼

Groundwater Limits Force Miners to Seek Alternatives

Expert George W. Annandale discusses our unsustainable reliance on groundwater; the solution could lie upriver.

The Arizona desert is breaking apart. Years of extensive reliance on the state’s groundwater supplies for all uses—residential, agricultural and industrial, including mining—prior to the influx of Colorado River water created a network of earth fissures. The largest is a spider vein located almost exactly between the two largest cities, Phoenix and Tucson, along Interstate 10.

The fissures can stretch for more than a mile, measure 15 feet wide and drop hundreds of feet into the earth. Like sinkholes, they’re a potential safety menace and have now been officially designated as such by the Arizona Geological Survey, which in 2006 was authorized to assess the fissures and post the areas affected on an interactive map for public viewing.

Arizona’s cracking landscape is no surprise to George W. Annandale, an award-winning, internationally known expert on scour—the washing away of earth by swiftly moving water, which can compromise structures such as bridges and dams—and reservoir sedimentation management.

A native of South Africa, Annandale has spent much of his career applying his knowledge of water flow and management to the mining sector—including work at an Arizona mining operation. As a consultant and program leader at **Golder Associates**, the Toronto-based international construction, design and consulting company, he has consulted with mining companies in many other regions on sustainable water supplies.

Today Annandale’s driving concern is the world’s unsustainable reliance on groundwater. As he writes in his recently released book, *Quenching the Thirst*:

Sustainable Water Supply and Climate Change, “the central purpose of sustainable development is to create intergenerational equity.”

“Sustainable development is about people and how we provide [water and other resources] for future generations,” he told CCBJ. Warned Annandale, the world is using, on average, 3.5 times more groundwater than what is being replenished naturally. “It is not defensible to use groundwater for long periods of time.”

The Magic 1400

Annandale’s solution is reliance on and careful management of river water augmented by equally well-managed reservoirs—the latter in response and as a solution to the variability built into current climate change projections—and he uses a 1400-year analogy to illustrate why: “If we magically removed all fresh groundwater from the earth, it would take 1400 years to replenish it,” he said. “It would globally take rivers only 16 days to recover” from such a loss.

Underscoring Annandale’s perspective, aquifers everywhere are feeling the impact of overuse. The huge, eight-state Ogallala Aquifer serving people and farmland in the central United States is being drained at a rate nine-times greater than it can replenish itself, said Annandale.

The aquifer serving California’s vast Central Valley agricultural industry is being drained at a rate seven times greater than recovery. In northwest Mexico, groundwater is being withdrawn at a rate 27 times greater than nature’s faucet can pour it back in—and will pose “a serious problem in a few decades.”

For mining companies, “water supply is a big issue and extremely important in the extraction process” said Annandale. Yet mining, with its extract-and-exit business model, has a “short-term mindset, which is generally not concerned with the long-term sustainability of water resources.”

South Africa's Golden Witwatersand

Early in his career, Annandale worked on one such a solution in the Witwatersand region of South Africa that has proved to be ahead of its time—and supports his theory that rivers and expert management of those waterways is the sustainable alternative.

Sitting atop the region's lucrative gold reef, the Witwatersand supports numerous gold mines and for that reason represents, said Annandale, "the 'economic heartland of South Africa.'" Rich in gold, it's pressed for water, with no large rivers in the immediate vicinity.

In the 1980s, Annandale was on the team that developed a management system for delivering water to the region via an interconnected system of 38 dams and reservoirs that draw water for the area from eight different river basins. Nearly four decades later, "the management system is being used on a daily basis," said Annandale. And it continues to provide water even when the region succumbs to what is commonplace: droughts, which, he added, can last from five to seven years.

The management scheme entails storing water as high up in the system as possible for releases to reservoirs lower downstream as they empty. Developing the decision rules to accomplish this goal required extensive computer simulations, which eventually boiled down to a few graphs that can be used by operators to manage the system of reservoirs.

Of Salt and Sediment

Mining's thirst for water is making the case for desalination. BHP Billiton and Rio Tinto have embraced the solution, spending \$3.43 billion on a desalination facility to feed their Escondida copper mine in Chile's parched Atacama Desert.

"Desalination captures the imagination," said Annandale, and while it does serve the purpose, it's far from a sustainable solution. It typically costs between 80

cents and \$1.20 a cubic meter to process seawater compared to about 7 cents a cubic meter for treated water from rivers.

Then there's moving the water to its destination—building a pipeline, said Annandale, can cost between \$500,000 and \$4 million per kilometer (about \$1 million to \$7 million per mile), and depending on topography, the system requires the installation of pump and booster stations adding to the cost.

The simple solution, in Annandale's mind, is to look at the alternative, river water, and also at the bigger picture: climate change. "Mining companies have to understand what may happen, then begin building a robust infrastructure."

For Annandale, the future is about taking his knowledge of sustainable development upriver—he's working with the World Bank in Africa and with USAID in South-East Asia on massive water-infrastructure projects. In South-East Asia he works on the Mekong River that originates in Tibet, flows through China and ends up in the Lower Mekong Basin, flowing through Laos, Cambodia and Vietnam.

One the longest rivers in the world, rich with fish, it supports tens of millions of people. It has never been developed, until now. Plans call for the construction of up to 130 dams. These dams are indispensable for the development of the region, but will collect millions of tons of sediment, starving the Mekong Delta and Tonle Sap (a large inland lake) of sediment and nutrients.

The anticipated deterioration of these two natural resources is expected to impact up to 60 million people. Annandale's role is to consult on preventing deposition of prodigious amounts of sediment in reservoirs, thereby safeguarding aquatic resources. "I'm very happy about this," said Annandale of the opportunity to share his expertise. "I have the ear of the ministries and governments." ❄

Black & Veatch Forms New Mining Group as Industry Seeks Climate Solutions

Black & Veatch is no stranger to mining, having been working in the sector for more than 15 years. But two years ago the \$3-billion Overland Park, Kansas-based company noticed that interest from mining companies was heating up, particularly for three practice areas critical for the success of a mining operation: telecom, energy and water. So it established a dedicated mining group, and that turned out to be a propitious decision.

"We've grown extremely rapidly," said Jonathan Pressdee, vice president and managing director of the new mining team. "It has been robust growth, and mining has become a significant part of the business. Mines use a lot of power, a large quantity of water and need a communication system to keep it all together."

Just addressing a mining operation's water needs is an enormous opportunity. Reuters recently reported that mining companies are projected to spend \$11.9 billion on water infrastructure in 2013. As Pressdee noted, Black & Veatch's water division accounted for one-quarter of the company's overall \$3.3 billion in revenue as reported in 2012.

Mines are basically "a hole in ground with a lot of infrastructure to enable the complex operation of resource extraction," said Pressdee. "Mining is also a conservative business. They want proven solutions, a balance between appropriate innovations and robustness," including those that address adaptation.

"Mining companies are looking at climate change, especially the major companies, the global ones who are subject to regulatory and shareholder pressures in terms of the environment. The World Bank is stipulating environmental aspects for financing."

Mining operations are also looking at solutions for the cost of energy. Beyond powering the operation, it takes a lot of juice to pump the prodigious amounts of water mining requires. "It's become increasingly significant to be more energy and water efficient," said Pressdee, and to that end mining is considering a range of alternatives, from energy recovery and renewables to smart grids. Also on the mining radar—and, like smart grids, a Black & Veatch specialty—desalination systems.

Desal to Quench Escondida's Thirst

In 2008, Mining Magazine reported on a planned desalination project being developed by a consortium of three companies, including Black & Veatch, that would be "the largest privately-held desalination plant in the world when complete." In the summer of 2013, a major sea-water desalination plant was approved by the Chilean environmental authority, Corema. It will serve the world's largest copper mine in the world's largest copper-producing nation, the Escondida mine in Chile's parched Atacama Desert.

In 2012, Escondida produced about 1.1 million tons of copper, nearly one-quarter of the 5.5 million tons of copper produced in Chile, where copper accounts for one-third of government revenue.

Escondida is majority owned by the world's two largest extraction companies, **BHP Billiton**, with a 57.5 percent stake, and **Rio Tinto**, 30 percent owner; the remaining investor is Jeco of Japan, led by Mitsubishi. BHP and Rio Tinto invested \$3.8 billion (\$2.6 billion and \$1.2 billion, respectively) in 2012 to expand the mining operation, according to BHP news releases and infomine.com.

The mine is located in the hottest, driest, most formidable desert in the world, where rainfall, if it occurs, rarely exceeds a half-inch annually. That climate dictates that Escondida and other mines there scurry to find a source for the significant

quantity of water used in all phases of copper extraction and processing.

Chile's indigenous population and environmentalists are challenging the mining industry's thirst for groundwater—and they're also targeting government policies. Water in Chile is a commodity that can be bought and sold on the open market, a legacy of the Pinochet dictatorship that the government claims it can't undo.

As a result, most of the water used at Escondida is sourced from the ocean, far to the west of Atacama at the concentrate-shipping port of Coloso, where Suez Environment's Degrémont subsidiary built a reverse osmosis desalination plant for BHP in 2005, according to Degrémont. BHP is investing \$2 billion in the new desalination system will be six-times the size of the current system, according to Reuters, and will be carried to the mine—180 kilometers away and 3,100 meters above sea level—through two parallel aqueducts and pump stations.

The production goal is 180 million gallons a day, which would require an intake of 7,700 l/s (liters-per-second) of seawater, of which 4,500 l/s of saltwater would be left over and redistributed to the ocean.

Of Commodities and Stern Stakeholders

Mining is a commodity-driven industry, which basically means that mining companies are only as valuable as the market prices of the commodities they produce. "That means they have to be on their game all the time."

Mining is also a cyclical business; it follows the ups and downs of the market as it reacts to whatever stirs the pot—most recently the source of growth in demand has been "a huge expansion of projects" driven by the lure of boom times in China, said Pressdee. As the Chinese boom slowed down, slackening demand "suppressed prices and caused [project] cancellations."

As a result, companies like BHP and Rio Tinto took big stock hits, with investors also complaining that mining companies played hard and fast with the money they enjoyed when gold soared to \$2,000 an ounce and copper ticked up to \$4, from its normal mid-\$2 range.

According to the New York Times, the "central complaint [by investors] is that the big companies, during a period of high metals prices and strong profit from 2009 to 2011, spent too much money building mines instead of returning money to shareholders." The chief executives of BHP, Rio Tinto, Anglo American and Barrick Gold—the four largest multinational operators—have all been replaced.

Another external and costly impact: increased production of waste tailings. "It is taking more and more effort to get a quality end product," said Pressdee. Gold mines in South Africa are "going deeper and deeper" to find quality veins, he said, adding that the quality of copper ore is also degrading.

Deeper gold mining means more water to discharge, adding energy costs to the budget. Digging deeper to find quality copper ore generates more waste, which takes more water to maintain the tailings storage ponds. And more tailings also require larger storage facilities.

Mining represents "a complex picture," said Pressdee, "We go into these details at Black & Veatch. We help them find economic ways of dealing with these challenges," including technologies that prevent over-pumping when moving water around or designing efficient recovery systems for waste streams.

"We look at a more predictive management of resources, at cost savings and sustainability," he added. Mining operations, said Pressdee, are under "an increasing onus from shareholders to be more flexible, to bring innovations more quickly. There are a lot of opportunities for companies that can adapt to change." ⚙

Golder Quantifies Climate Impacts on Mining Industry

Like other consulting and engineering (C&E) firms interviewed by CCBJ, \$1-billion international construction, design and consulting company **Golder Associates** identified adaptation in the mining sector as a growing market. But according to Sean Capstick, principal in Golder's Mississauga, Ont., office, "Some companies are embracing the challenge. Other aren't. And a lot of the action is happening behind the scenes."

One behind-the-scenes project at Golder has now come into the light: the conclusion of an 18-month climate change vulnerability assessment for **Xstrata Nickel Sudbury Operations**, a nickel, copper and assorted precious metals mining facility in mineral-rich northern Ontario. As of May 2, 2013, Xstrata became part of **Glencore Xstrata**, a \$90 billion natural resources group created by the merger of the two mining companies.

A component of Xstrata's corporate sustainability initiative, the assessment used Xstrata's established risk management framework and followed the climate specific guidance in the Public Infrastructure Engineering Vulnerability Committee (PIEVC) Protocol, developed by **Engineers Canada**, a professional and regulatory organization that also licenses Canada's engineers. The vulnerabilities identified over the span of the project, said Capstick, have now been incorporated into the company's corporate risk register. The next step is to follow up on what Golder and the company identified as possible threats to business-as-usual at the century-old mine and to its adjacent smelter, which has been in operation for more than 60 years.

Calling on projections from global circulation models (GCM), which simulate, in numerical terms, possible changes in climate, the assessment weighed cur-

rent vulnerabilities against future climate risks to establish a climate infrastructure matrix. "We looked at severity and probability," said Capstick, "We looked at what was vulnerable, then [asked] if those vulnerabilities could increase over time" with changes in climate.

"A number of items rose to the top," said Capstick of the climate component, among them variations in precipitation, increases in temperature and erratic winds. All would create challenges for the Xstrata mining site and its infrastructure.

Climate models for the Xstrata operation—located in an area that experiences warm, hot summers and long, cold, snowy winters—called for warmer temperatures overall and a shift in precipitation patterns. "Too much water in the spring and not enough in the summer," said Capstick. "The highest risk that came out of the assessment," said Capstick, "was the water balance."

Workshop attendees were at first skeptical [but] "We put climate change into the risk vocabulary and that allowed for project team member buy-in."

Rainfall variations will affect water movement around the site, and in particular threaten to negatively impact maintenance of the tailings (rock waste) that have increased in quantity over the decades. Tailings require water to guard against acid generation and to keep down dust.

But there were also concerns about the increases in average temperature. Nickel is an underground mining operation; the deeper the mines, the hotter the rocks. "Now, the mines operate on air that is brought in from the surface," said Capstick. But if surface temperatures heat up, a trend that will also increase the temperature inside the mine shafts, it

could mean an increase in the number of work stoppages in summer particularly in deeper mines.

Another possible challenge: which way will the wind blow? Projections suggest a change in winds at the smelter, which emits sulfur dioxide. If the wind patterns change then additional curtailment (production slowdowns to control emissions) may be necessary in the future.

Risk Is a Four-Letter Word

"It's about the economy of the mine," said Capstick of the risk assessment and the challenges it identified, which is also related to questions of production and expansion. For example, would it be more cost effective to open a new mine or expand the old one.

Creating the vulnerability assessment was half the battle, as Capstick explains. The other was convincing the entire project team that "it's necessary to face these challenges." Golder did so through a series of workshops (a key recommendation in the International Council on Mining and Minerals' March 2013 guidebook on climate change adaptation; see story on page 6.). It was in these workshops "that the light went on," said Capstick.

Workshop attendees who were at first skeptical, asking, as Capstick puts it, "Why am I here," came around when asked, "Does weather affect your operation?" Heads were also turned when the conversation included phrases like "extreme weather" and "weather vulnerability." The deal was sealed when the discussion was illustrated with heat maps that indicate projections of temperature changes globally. "Everyone understood that," said Capstick. "We were talking about risk; we put climate change into the risk vocabulary and that allowed for project team member buy-in."

The task ahead is to apply the assessment findings to the areas identified as posing the greatest risk to the business

Potential Risks of Climate Change for Xstrata Nickel

Reputation

- Health and Safety

Regulation

- Ability to meet air quality limits

Physical

- Mine closure water balance

Marketplace

- Curtailment hours & transportation

Climate Change Commitments: Energy Efficiency and GHG Reductions

- Innovative technology; fuel switching; seek carbon sinks;
- Reduce scope 3 or indirect GHG emissions
- Commodity business to build integrated climate change strategies

and its investment. The Xstrata operation is not closing down anytime soon; it sits on a world-class nickel deposit—Canada produces 9% of the world's total supply of the refined product—and it recently opened a new mine on the property.

"We will quantify [the data] and move forward," said Capstick, providing the company not with "an abstract challenge but one that allows Xstrata to understand what needs to be done next."

"It is a challenge and it cascades across the operation," said Capstick of both the assessment and the newness of identifying and accepting climate-related risks, which, in the mining industry, touch on natural resources as well as operations.

Golder, said Capstick, can help assuage that confusion due to its multi-disciplinary approach: divisions within the employee-owned company, founded in 1960 and reporting \$1 billion in annual revenue, are well-versed in the range of impacts a company like Xstrata can face, whether specific to mining or to sectors mining calls on. Golder's range of services cover water resources and infrastructure, power generation and transmission, transportation and waste management, all of

which touch on the needs of the mining industry.

"We talk to each other," said Capstick of Golder's knowledge-sharing culture. Cross-divisional expertise aids in what is at the heart of smoothing out the rough spots that any new vulnerability poses to an industry as broad and mature as mining.

"Some people may see climate change adaptation as contrived, or too big to tackle. But we break it up into bite-sized pieces. That makes the risks more meaningful."

"It's a challenge," Capstick said of recognizing and accepting that climate change will have deep impacts on business-as-usual. "Some people may see climate change adaptation as contrived, or too big to tackle. But we break it up into bite-sized pieces. That makes the risks more meaningful [across the operation]. Then we can move from one solution to another. It makes it more palatable." ☼

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Arizona Miners Grapple with Water Challenge

Without its booming silver mine that brought in about \$85 million back in the late 1880s, there would have been no legendary Tombstone, Arizona; no Earp brothers and stagecoach robbers to make movies about; no shoot-out at the OK Corral. And without copper, Arizona's economy over the past century would have been as flat as a rattlesnake stretched out under a cool rock in the heat of a summer day.

Mining has been big business in the state for most of its European history—and even before: turquoise and silver were prized among the native population. The Copper State has been a top producer of copper since the 19th century, today producing about two-thirds of U.S.-mined copper. The Morenci mine near New Mexico is the largest open-pit copper mine in the United States.

Recent years have been good for copper miners: as the Arizona Mining Commission reports, U.S. producer prices have quadrupled over the past decade, from \$1.12 per pound in 2000 to \$4.05 in 2011. In Q3 2013, prices traded between \$3 and \$3.40, according to infomine.com.

More than 10,000 people work in the state's copper industry, which is dominated by three companies: **Freeport-McMoRan**, which acquired Phelps Dodge; ASARCO, now a subsidiary of **Grupo Mexico**; and Australia's **BHP Billiton**, the world's largest mining and minerals concern.

While copper is king, other minerals like silver, also reign in Arizona. A Canadian mining company, **Wildcat Silver**, is in the permitting process to drill exploratory holes on 9.2 acres of U.S. Forest Service land in mountains south of Tucson. The prize is an estimated 271 million ounces of silver, 12.6 million pounds of zinc, 670,000 pounds of copper and

84.4 million pounds of manganese (the metal alloy used in stainless steel) over the mine's 13.5-year lifespan. Wildcat expects to earn \$99 million on a \$377 million investment.

Arizona has coal and uranium. When uranium prices shot up in 2005–2006, thousands rushed in to file claims, according to Michael Conway, chief of the Geologic Extension Service at the **Arizona Geological Survey**. To protect the Grand Canyon watershed, then Secretary of Interior Ken Salazar withdrew about 1 million acres from new mining claims in January 2012.

While copper is king, other minerals like silver, also reign in Arizona... Wildcat expects to earn \$99 million on a \$377 million investment.

According to a DOI news release, the decision “will provide adequate time for monitoring to inform future land use decisions in this treasured area, while allowing currently approved mining operations to continue as well as new operations on valid existing mining claims.” Up to 11 uranium mines could still be developed, but without the withdrawal, “there could be 30 uranium mines in the area over the next 20 years.”

Also hot in Arizona, potash, a potassium compound used in fertilizer. Over the past two years, 120 exploratory wells have been drilled in the Holbrook Basin on the northeast side of the state to gauge potash deposits. “They like what they see,” said Conway.

Proposed Copper Mine Risks Assessed

The economic benefits of mining notwithstanding, controversy is dogging a proposed \$1.2 billion open-pit copper, molybdenum and silver mining opera-

tion in the Santa Rita Mountains south of Tucson, not far from one of the oldest open-pit mines in the state, Silver Bell, owned by ASARCO—and in the vicinity of the Wildcat silver lode.

Rosemont Copper Remains in Review Process After Seven Years

Still in the review process seven years after the 995 acre-property was purchased for \$20.8 million by parent company **Augusta Resource**, Rosemont Copper would be the third-largest open-pit mine in the United States—measuring up to 6,500 feet in diameter and up to 2,900 feet deep at the end of its mining cycle.

According to the draft Environmental Impact Statement (DEIS)—principally authored by **SWCA Environmental Consultants** with contributions from **Applied Environmental Consultants**, **Dark Sky Partners**, **Golder Associates**, **Horst Schor**, **Loftus Landscape Studios**, **Montgomery and Associates**, **MWH Global**, **SRK Consulting** and **Tetra Tech**—the mine would account for about 10% of U.S. copper production.

Augusta, headquartered in Vancouver, B.C., says its explorations indicate that Rosemont sits atop a reserve of 5.9 billion pounds of copper and 194 million pounds of molybdenum, a metal used in alloys and for compounds in chemical applications. (A byproduct of copper mining, Arizona is the second-largest producer of molybdenum in the United States.)

With estimates that Rosemont will be a producing mine for approximately 21 years, Augusta plans to extract 243 million pounds of copper and 5.4 million pounds of molybdenum annually.

In Dry-Country Mining Sites, Be Prepared for a Water Fight

The process for any project of the size and scale of Rosemont is a complicated, detailed, public display of good impacts and bad. In this case, the complications

are multiplied due to the number of stakeholders. In addition to the land the mine owns, Rosemont's operation includes 3,670 acres of National Forest System land, 15 acres of Bureau of Land Management-administered land and 75 acres of Arizona State Land Department land administered as a State Trust.

Its detractors include environmentalists, but state and federal agencies are also questioning Rosemont's impact and mitigation plans. They include Pima County, in which the mine is located; the Arizona Game & Fish Department; the Arizona Department of Environmental Quality; the U.S. Environmental Protection Agency; and the Bureau of Land Management.

Supporting Rosemont, the Tucson Metropolitan Chamber of Commerce, the Southern Arizona Leadership Council and the U.S. Forest Service. Still to weigh in, the Army Corps of Engineers, which will rule on the mine's federal permit.

Debate over the Rosemont project touches on a range of environmental issues, but the primary concern is water use. Before anything is built, Rosemont must address its water-impact mitigation measures to obtain a federal Clean Water Act permit. Copper mining requires a lot of water, not only for ore processing but also to keep the dust down. At nearby Silver Bell mine, the roads winding up and down the pit are constantly sprayed with water carried in 10,000-gallon trucks. It also uses water jets in crusher equipment and conveyor belts to keep dust to a minimum during processing.

Rosemont says it will use 5,000 acre-feet of fresh water a year, or approximately 125,000 acre-feet over the lifetime of the mine—less than that used at the smaller-producing Silver Bell mine, adding that it will also “employ water conservation and recycling techniques never before implemented at an Arizona copper mining facility.” (One acre-foot is approximately

the amount of water used annually by a suburban household).

Rosemont's water will primarily come from Southern Arizona's aquifer and be pumped from nearby wells to the mine. According to the DEIS, “groundwater levels could decrease up to an additional 70 feet from the pumping, declining at a rate of up to 3.5 feet per year above and beyond existing groundwater declines.”

***Before anything is built,
Rosemont must address
its water-impact mitigation
measures to obtain a federal
Clean Water Act permit.***

It also notes that Rosemont's water needs could result in a 6 to 7% increase in groundwater pumping from a sub-basin within the Tucson groundwater region, and a 2 percent increase in overall groundwater pumping from the entire Tucson Active Management Area, the regional portion of the state's groundwater usage and all of it governed by the Arizona Department of Water Resources.

Residential and agricultural users in Tucson use Colorado River water from the Central Arizona Project (CAP) while mines operate exclusively on groundwater, which in 2003 accounted for about 57% of total industrial water demand, according to the state water resources department.

Rosemont has been purchasing and storing CAP water for operational use and has signed a letter of intent to fund a seven-mile CAP pipeline extension for communities in the area, which will, it writes, provide “much-needed recharge of CAP water into [the communities'] service area many years sooner than would have otherwise been possible.” It also plans to buy 4,500 acres and 1,700 acre-feet of water rights on properties

adjoining the mine site to help mitigate its usage.

Environmental Impact Statement the Focus of Intense Scrutiny

Environmentalists like Paul Green, executive director, **Tucson Audubon**, aren't convinced that Rosemont can successfully address the potential water losses. In an opinion piece in the *Star*, Green questioned Rosemont's ability to mitigate impacts on two waterways that are part of the watershed that provides “one-fifth of the groundwater recharged to the Tucson basin,” Green wrote.

Also troubling, he said, is a model that suggests the pit itself will drain water from beneath the area, causing the water depth to drop by between 600 and 900 feet below its current level. Toxins from the estimated 1 billion tons of tailings are another major concern.

To date, Rosemont has spent, or is proposing to spend, \$75 million above the \$25 million it cost to buy the mine site. This investment includes about \$25 million worth of real estate and water rights, a \$25 million community and social endowment trust fund and \$25 million to build a recharge pipeline for CAP water, according to a spokesman.

Rosemont appears to be getting impatient with the process. A link on its website takes viewers to a Facebook page that blares, “Isn't seven years of study enough?” The answer appears to be, Apparently not. The final release of the EIS was postponed by the U.S. Forest Service from late September 2013 to March 2014, “to resolve controversy” over issues including water resources.

While this may not get settled in a shoot-out on main street, controversy over the environmental impacts of mining in the Copper State—especially the water impact—are sure to increase as the state contends with the challenges of climate change. ⚙

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