CHAPTER FOUR

SUSTAINABLE DEVELOPMENT, TECHNOLOGY, AND A LOOK TO THE FUTURE

DECISION-MAKERS
FIELD CONFERENCE 2005
Taos Region

Photo not available online

Valle Vidal, Sangre de Cristo Mountains, Carson National Forest.

Photo not available online

Sustainable Development and Mining Communities

Dirk van Zyl, *Mackay School of Earth Sciences and Engineering University of Nevada*

The term *sustainable development* has been around since the early 1970s. However, it became firmly established in 1987 as a result of the report of the United Nations Committee on Development and Environment, where the concept was described as follows:

> *Humanity has the ability to make development sustainable-to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs.*

The accepted pillars or elements of sustainable development are economic, environmental, and social/community. These often are used with a modifier, such as economic equity, environmental well being, and social/community well being. Other terms that have been used to provide an image of sustainable development are the three-legged stool and triple bottom line. The former refers to maintaining a balance between the three components (the three legs of a stool), whereas the latter refers to an accounting sheet providing bottom lines (profit/loss) not only on economic activity but also on environmental and social/community well being.

Other aspects are also very important in defining sustainable development, including:

- Governance (of countries and companies)—often considered a fourth element or leg of the stool; the term governance refers to the laws and regulations of different levels of government as well as the capacity to implement and enforce those laws, however, it also refers to the policies, culture, and management of mining companies and their capacity to interpret and live by the applicable laws and regulations
- Technology—as technology changes so does our ability to change the contributions to technology
- Scale—sustainable development can have different meaning at the local, regional, national, and global scales

Ultimately sustainable development is a concept of needs, an idea of limitations, a future-oriented paradigm, and a process of change. In contributing to sustainable development, mining companies will have to consider the needs of communities, the limitations of their own resources, and often the limitations of the communities to participate in the technical discussions that are part of the permitting process. All of this must be done with a clear view of the future and will most definitely require changes in thinking and culture.

MINING AND SUSTAINABLE DEVELOPMENT

Society depends on many materials to maintain a specific standard of living or to improve its standard of living. There must be a sustainable supply of these materials to maintain economic activity and supply the needs of society. Mining is one way of supplying these materials; recycling and re-use are other options. However, for most materials the present international society is dependent on primary supplies from mining. At this time we cannot supply all the materials required by society from other sources without including mining.

Mines are developed where ore is found. Site, climate, topography, and other physical conditions determine the potential for positive or negative environmental impacts from the mine during the mining life cycle.

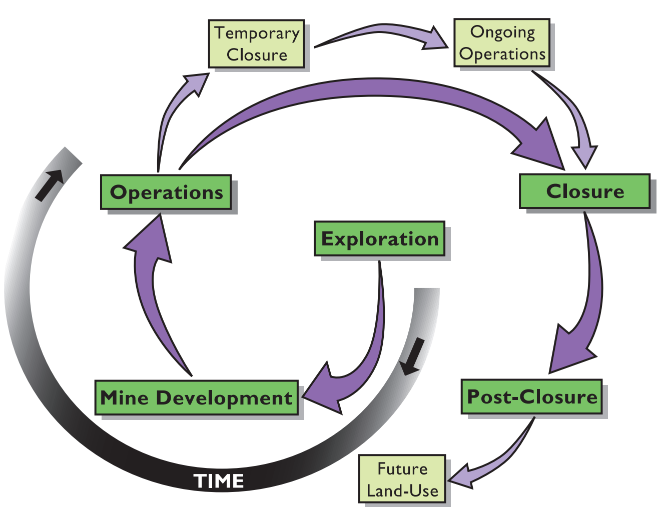
Mining and sustainable development does not refer to sustainability of the industry, a company, or a mine; sustainable mining is clearly an oxymoron, as all ore bodies will be depleted over time. However, the concept as applied to mining refers to a culture that addresses in very clear and practical terms how mining can contribute to sustainable development. Supplying the materials that society needs is one contribution, protecting or improving the well being of the environment is another, providing for the long-term well being of communities is yet another.

THE MINING LIFE CYCLE

Every mine follows the same life-cycle stages. However, the site-specific characteristics are different. The major life-cycle stages are exploration, mine development, operations, closure, and post-closure. The mine may also close temporarily because of low commodity prices, labor disputes, etc. The mine may also re-open when new technologies or higher metal prices make it possible again to have a profitable operation. Future land use for the mine site may include economic activities other than mining, such as solid waste disposal in the mine pit, construction of homes on waste rock disposal facilities or other mine property, renewable energy development, etc.

The timelines associated with each of the stages of the mine life cycle vary from site to site. There are mines with operating stages as short as three to five years, whereas others have operating lives of more than one hundred years. The mine life cycle is not a linear process; many things can happen during the various stages that change the outcomes in terms of longevity, environmental impacts, and future land use. It may be more appropriate to refer to the "mine life spiral." The intent of the "mine life spiral" is to improve the environmental and social/community well being through the development of a mine.

Past mining activities have left many legacies. These legacies include positive aspects such as long-term economic development of a region, as well as negative aspects such as environment degradation and communities subject to boom and bust economic activity. Negative legacies can jeopardize the development of new mines, and it is essential that these past legacies be addressed. A coordinated effort is required to accomplish the reclamation of mine sites, in addressing both safety concerns and negative environmental impacts. A number of agencies in the U.S. are active in the remediation of previous mine sites. However, more funding and coordination is necessary. Such a coordinated effort has been established in Canada between the federal and provincial governments.



Mine life cycle stages. Future land use can include further exploration and ongoing mining, other economic uses such as renewable energy or grazing, and wildlife habitat.

There has been a remarkable evolution in the approach of mining companies to the mining life cycle. Until the 1960s it was common to leave a mine site as is when the project stopped returning a profit. The actions at that time did not include closure activities such as reclamation and site remediation. In many cases these mines were abandoned, and the associated communities became ghost towns. In the 1980s mining companies actively implemented reclamation at mine sites, and the philosophy of designing and operating for closure took hold in the 1990s. Much attention is currently paid to this stage of the mining life cycle. Extensive regulatory requirements are also in place in the U.S. for the closure of mines.

Examples of mines that have or are contributing to the sustainable development of communities and ecosystems are becoming more common. A recent paper by Kennecott Minerals describes the positive contributions of two projects: the Flambeau project near Ladysmith, Wisconsin, and the Ridgeway project near Columbia, South Carolina.

THE SEVEN QUESTIONS OF SUSTAINABILITY

One of the activities of the Mining, Minerals and Sustainable Development Project in North America was to develop an approach to measure the contributions that mining makes to sustainable development. The outcome of this project, with contributions from about forty individuals with widely varying backgrounds and interests from the U.S. and Canada, was a set of seven questions that can be asked about any mining (or other development) project. The questions must be customized to fit the specific interests and needs of a local community. So, although the questions may be universal in their application, they very much relate to the needs and interests of each community. The seven questions are:

1—*Engagement.* Are engagement processes in place and working effectively? The term engagement is used to describe a process of active listening and participation in discussions by both the mining company and the communities that are impacted.

2—***People (human well being).*** Will people's well being be maintained or improved during and after the project or operation?

3—***Environment (ecological well being).*** Will the integrity of the environment be taken care of in the long term?

4—***Economy (market economy).*** Is the economic viability of the company assured; is the community and regional economy better off not only during operation but into post-closure?

5—***Traditional and Non-Market Activities (non-market economy).*** Is the viability of traditional and non-market activities in the community and surrounding area maintained or improved with the project or operation?

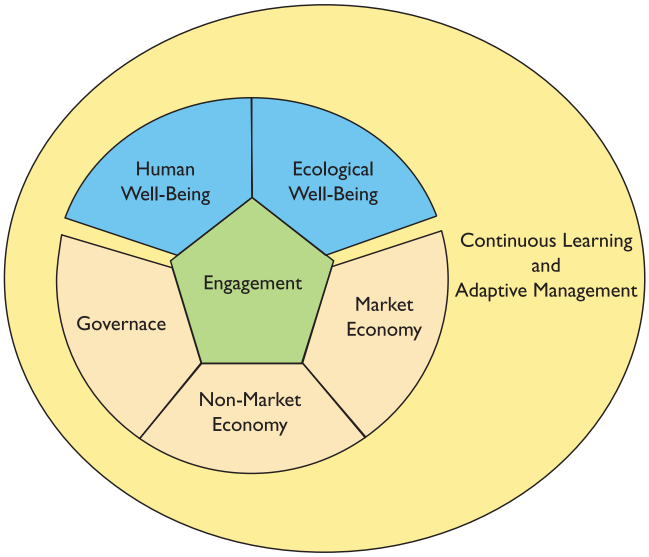
6—***Institutional Arrangements and Governance.*** Are the rules, incentives, and capacities in place now and as long as required to address project or operational consequences?

7—***Synthesis and Continuous Learning (Continuous Learning and Adaptive Management).*** Does a synthesis show the project to be net positive or negative for people and ecosystems; is the system in place to repeat the assessment from time to time? A synthesis is required to combine answers from all six previous questions in making the determination of the contributions of the project to the well being of both people and ecosystem.

Methodologies have been proposed to implement these seven questions at the local level, and they provide a very powerful platform for evaluating the contributions of single or multiple projects to the sustainability of a community or an area.

An important realization during the development of the Seven Questions project was that a mine provides a bridge between the pre-mining and post-mining environment (nature and humans). This creates a significant opportunity to consider how the resources from the mining and other economic activity can be used to maintain or improve the well being of the environment and communities (in other words, how the mine can contribute to sustainable development).

Many mining projects contribute much to the communities where they are located. These contributions take place during the operating life of the mine, and it is challenging to find ways to expand these contributions so that future generations can also benefit from



The schematic of the seven questions in this figure clearly emphasizes the centrality of engagement, ecological (environmental) well-being, and human-well being to the contributions of mining to sustainable development. Much of the focus must be on these issues. Schematic of Seven Questions (after Ian Thomson, On Common Ground Consultant, Vancouver, B.C.)

the mining activity. Active engagement of communities and mining companies is essential for this to occur. This can only be done if there is trust and respect between the different groups. Communities may not have the capacity to perform the long-term planning that is necessary to develop a sustainable development plan. Governments and companies must become partners of the communities to accomplish this.

HURDLES TO IMPLEMENTATION

There are hurdles that must be overcome to maximize the contributions of mining to sustainable development. Our laws and regulations have not been developed with sustainable development as a foundation, and they may contain aspects that make it difficult to fully implement the laws and to contribute to sustainable development. One such hurdle is related to regulations that govern federal land use and post-mining economic activities on the land. It could be very beneficial for some communities to have full access to the facilities at a mine site so that they can be used for other economic activities—e.g., renewable energy, engine rebuilding, etc.

Another hurdle is the capacity of communities to fully implement sustainable development concepts and the associated activities. Coordination between companies, government, and educational institutions is necessary to keep that process going. Resources will have to be available to coordinate all these efforts. Such resources will have to come from a number of sources, including federal and state funding, private enterprises, and the mining companies. It is clearly unrealistic to expect that mining companies should carry the full load for such support.

A third hurdle is related to mining legacy issues. These are not always clearly understood or appreciated by industry, government, and civil society. Although coordination between federal, state, and local governments can do much to correct safety and environmental issues, mining companies must also understand the social legacy issues. These are not always the same for all communities; it is only with active engagement that they can be identified and addressed.

Mining contributes significantly to sustainable development of societies. However, ongoing efforts are required to expand these contributions and make them work in the long term.

Suggested Reading

Our Common Future: The World Commission on Environment and Development. Oxford University Press, 1987.

www.abandoned-mines.org This Web site provides information about the activities in Canada to address the issues related to abandoned mines on a national scale.

Breaking New Ground: Mining, Mineral and Sustainable Development. International Institute for Environment and Development, London, UK, 2002 (**www.iied.org/mmsd**).

Seven Questions to Sustainability: How to Assess the Contribution of Mining and Minerals Activities. International Institute of Sustainable Development, Winnipeg, Manitoba, 2002 (**www.iisd.org/mmsd**).

Fox, F.D., 2003, Mining and Sustainable Development: Flambeau and Ridgeway Mines—Lessons Learned; Kennecott Minerals Company, Salt Lake City, Utah, Paper presented at the Society of Mining, Metallurgy and Exploration Annual Meeting, Cincinnati, OH.

Shields, Deborah J. and Solar, Slavko V., 2000, Challenges to Sustainable Development in the Mining Sector, UNEP Industry and Environment, Volume 23, Special Issue, Mining and Sustainable Development II—Challenges and Perspectives.

Sustainable Aggregate Resource Management

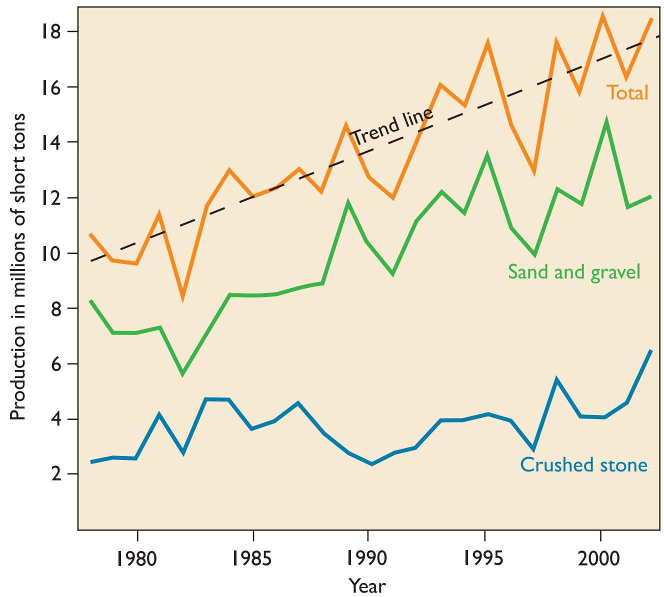
William H. Langer, *U.S. Geological Survey*

The two main sources of aggregate, an essential commodity in our modern world, are crushed stone and sand and gravel. Buildings, roads, highways, bridges, railroads, airports, seaports, water and waste treatment facilities, and energy generation facilities all require large amounts of aggregate. Aggregate in one form or another is also used in many industrial, agricultural, pharmaceutical, and environmental applications.

About 16.8 million tons of aggregate worth about $94.5 million was produced in New Mexico in 2002. Sand and gravel was about 65 percent of the total; crushed stone was about 35 percent of the total. Although there are increases and decreases in annual aggregate production, during the last twenty-five years aggregate production in New Mexico has increased by about 73 percent. During the same period of time population has increased from about 1 million to about 1.8 million. Per capita consumption of aggregate has decreased slightly from about 9.5 tons per year to about 9.4 tons per year. New Mexico's population is expected to reach nearly 2.45 million by 2020. Based on those predictions, New Mexico will consume over 330 million tons of aggregate between 2005 and 2020.

Geology determines the location of an aggregate resource; location and inherent physical and chemical properties are non-negotiable. Although sources of aggregate are widely distributed throughout the world, there are large regions where aggregate is non-existent. Even if sources of aggregate are present, they must meet certain quality parameters before they can be used. There are large regions where chemical or physical properties of local aggregate render them useless for many applications. New Mexico is fortunate in having quality aggregate deposits scattered throughout the state.

Potential environmental impacts associated with aggregate extraction include the conversion of land use, changes to the landscape, loss of habitat, noise, dust, vibrations, erosion, and sedimentation, as well as impacts from the truck traffic that normally accompanies aggregate operations. Most of the environmental impacts associated with aggregate mining are relatively benign. By employing best management practices, most environmental impacts can be controlled, mitigated, or kept at tolerable levels and can be restricted to the immediate vicinity of the aggregate operation. Some otherwise high-quality aggregate resources may not be developed because of environmental reasons.



New Mexico aggregate production, 1978–2002.

Aggregate is a high-bulk, low unit-value commodity that derives much of its value from being near markets. Thus, it is said to have a high "place value." Transporting aggregate long distances can add significantly to the overall price of the product, and in some situations can be the major component of the final delivered cost. Therefore, many aggregate operations are located near population centers and other market areas.

This juxtaposition of aggregate operations and population centers may result in conflicting land uses that prevent development of otherwise suitable resources. "Resource sterilization" occurs when the development of a resource is precluded by another existing land use. For example, aggregate commonly cannot be extracted from underneath a housing development or shopping center.

Despite society's dependence on aggregate, citizens may demand that crushed stone and sand and gravel not be mined nearby. To protect citizens from the impacts of mining, governments may require permits or impose regulations to control aggregate development, thus further restricting aggregate availability. This type of conflict, referred to as the "Dispersed Benefits Riddle," occurs because the negative impacts from aggregate resource development are usually located near the site of extraction, whereas the benefits from resource extraction are dispersed throughout an entire region. These dispersed benefits are not commonly considered in the local permitting process. But when aggregate resource extraction is denied because of opposition by the local community, other costs arise. Longer haul routes result in more traffic, more accidents, more fuel consumption, generation of more greenhouse gases, greater wear and tear on vehicles, and higher vehicle replacement rates. In such cases, gains by the local community may come at the expense of the greater public, the greater environment, and some other local area where extraction ultimately takes place. Instead of reducing impacts, they may simply be exacerbated and transferred elsewhere.

The reality is that every land use decision has both costs and benefits. The answer to the riddle is finding a means to ensure that the dispersed benefits of aggregate use are adequately weighed in resource development decisions. Sustainable aggregate resource management (SARM) might be the solution.

WHAT IS SUSTAINABLE RESOURCE MANAGEMENT?

The term sustainability dates back to the 1980 World Conservation Strategy, and was given prominence in *Our Common Future* (1987), otherwise known as the "Brundtland Commission Report." That report states that the purpose of sustainable development is to ensure that development meets the needs of the present without compromising the ability of future generations to meet their own needs. At a minimum, sustainable development must not endanger the natural systems that support life on our planet: the atmosphere, the waters, and the soils.

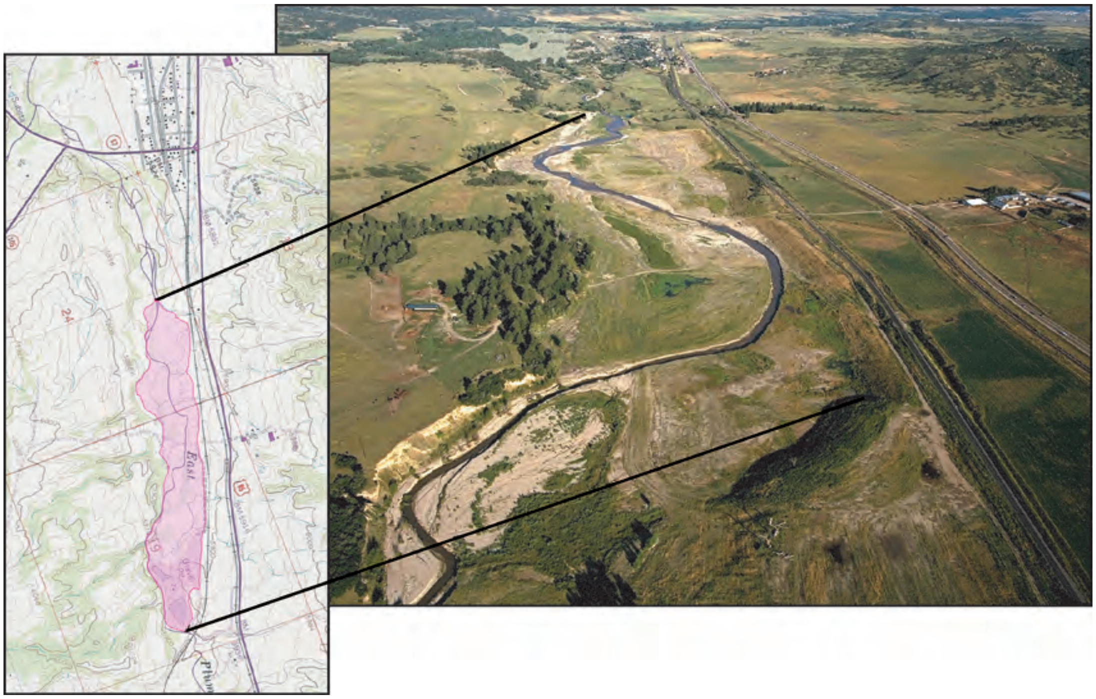
In the simplest sense, the "manufactured capital" and "natural capital" (natural resources) that one generation passes on to the next must be maintained or enhanced in order to achieve sustainable development. This philosophy gets somewhat confusing when dealing with a non-renewable resource such as natural aggregate (in contrast to a renewable resource such as forestry products). Aggregate resources, like all non-renewable resources, are indeed finite, and society technically cannot pass on the same amount of aggregate to its progeny.

However, unlike many non-renewable resources, the potential supply of aggregate resources on a worldwide scale is so large that "finite" has no practical meaning. Consequently, on a world scale, there is no real concern about running out of aggregate resources, and sustainability does not need to be invoked to ensure adequate future supplies of aggregate. But natural aggregate of suitable quality for an intended use can be in short or non-existent supply on a regional or local scale, and in the realm of sustainability, having an accessible local supply of aggregate resources takes on great significance because, as described above, transporting aggregate long distances adds to the overall cost of the product and to the overall cost to the environment.

An equally important goal of sustainability is to protect or enhance the environment. The aggregate industry manages a large amount of land and can promote sustainability by employing operational practices that minimize adverse effects on the environment and maximize the benefits from reclamation.

Sustainable aggregate resource management requires developing aggregate resources in an environmentally responsible manner that does not result in long-term environmental harm, even if short-term environmental impacts are unavoidable. There are many regulatory and voluntary tools that can be used to identify, reduce, and control negative environmental impacts, including best management practices, environmental impact assessments, environmental management systems, environmental accounting and reporting, and ISO 14000 standards. These tools can be applied both on site (quarry and processing facility) and to transportation routes.

SARM, however, is not just about protecting the environment from the potential negative impacts of aggregate extraction. Reclaiming aggregate operations or abandoned sites has tremendous potential to improve our quality of life, create additional wealth, restore the environment, and increase biodiversity. In today's expanding suburban areas, mined-out aggregate pits and quarries are converted into second uses that range from home sites to wildlife refuges, from golf courses to watercourses, and from botanical gardens to natural wetlands. Reclamation can be a major element of sustaining the environment and creating biodiversity.



Topographic map showing approximate location of gravel extraction near Sedalia, Colorado. The photo shows this same area following reclamation.

HOW DO WE APPLY SUSTAINABLE AGGREGATE RESOURCE MANAGEMENT?

To be effective, SARM must be a pragmatic pursuit, not an ideological exercise. It is an ongoing process among stakeholders, so government, citizens, and industry should all be involved in the pursuit. The process consists of a number of steps, including issuance of *policy statements*, elaboration of *objectives*, establishment of *actions*, identification of *indicators*, and *monitoring*.

Policy statements issued by governments commonly identify the aggregate industry as a key industry contributing to jobs, wealth, and a high quality of life for its citizens, and commit the government to the protection of critical aggregate resources and the protection of citizens from unwanted impacts of aggregate extraction. Industry policy statements commonly identify environmental and societal concerns and commit the company to environmental stewardship and interaction with the community. *Objectives* describe what is intended to be accomplished. *Actions* are associated with each objective and describe the approach needed to reach the objective. Examples of paired objectives (in italics) and actions include:

- ***Maximize availability of, and access to, aggregate*** by forward planning that protects important resources from urban encroachment; by extracting as much aggregate as possible from an area that has to be disturbed and using it for the most economically valuable application appropriate for the aggregate quality; by avoiding high grading (picking the best parts of the resource and limiting the ability to use the remainder); by finding uses and markets for all of the material disturbed (e.g., turning crusher fines into "manufactured sand" thus taking the pressure off natural sand sources in more environmentally sensitive areas); and by encouraging use of recycled aggregate.

- ***Minimize societal impacts*** by forward planning that protects communities from the nuisance impacts of poorly designed, poorly located, and poorly managed aggregate operations; by using best management practice designs and operations to control blasting, noise, dust, sediment erosion, and visual scarring in extractive and transport operations; and by involving the local community in planning activities. Community involvement may lead to a measure of community acceptance and an unofficial "social license to operate," which can be just as important as the official, legal permits.

- ***Minimize environmental impacts*** by providing for conservation of natural surroundings with buffer areas that maintain or enhance vegetation and wildlife habitats and corridors; by using best management practice designs and operations.

- ***Maximize rehabilitation of disturbed areas*** by allowing for reclamation as an integral part of the quarry/pit design process before extraction begins; by starting rehabilitation from day one; and by being flexible enough to allow for advances in technology and changing local needs.

MONITORING SUCCESS

Indicators measure progress toward reaching objectives as well as the effects of actions to protect and enhance natural and human systems. Indicators are specific to the target and actions but tend to be similar in many situations. Example indicators include:

- Proportion of aggregate coming from areas preferred for extraction

- Proportion of natural aggregates compared to recycled material

- Proportion of sites covered by modern operating conditions

- Proportion of aggregate coming from environmentally sensitive areas

- Area of land restored compared to area of land undergoing extraction

Monitoring, feedback, and the regular reconsideration of requirements as events develop all help to refine the SARM process. Establishment of a joint monitoring process presents an excellent opportunity to forge partnerships with communities and involve citizen groups.

To ensure the sustainability of aggregate resources, each of the primary stakeholders must accept certain responsibilities:

- The government is responsible for developing the policies, regulatory framework, and economic climate that provide conditions for success.

- The industry must work to be recognized as a responsible corporate and environmental member of the community.

- The public and non-governmental organizations have the responsibility to become informed about natural resource management issues and to contribute constructively to a decision-making process that addresses not only their own, but also a wide range of objectives and interests.

- All stakeholders have the responsibility to identify and resolve legitimate concerns; government, industry, and the public must cooperate at regional and local levels in planning for sustainable aggregate extraction.

Sustainable aggregate resource management, and finding an answer to the "Dispersed Benefit Riddle," would be less difficult if all conflicts between regional aggregate resource needs and local impacts had solutions that would leave everyone better off. This is seldom the case, and there are usually winners and losers. But as the amount of accessible land that is underlain with suitable aggregate resources diminishes, inequalities will increase. The longer we wait to implement sustainable resource management principles, the more difficult it becomes to implement sustainable resource management.

Surface and Ground Water Management Practices at Mining Operations

R. David Williams, *Bureau of Land Management*

Many of the challenges facing the minerals industry in the twenty-first century, a century that must focus on sustainable development, center on the development of technologies and practices that can help to eliminate or limit long-term environmental liabilities during mining and following closure of mining and processing facilities. Often the issues surrounding mine operations and closure focus on the control, management, and treatment of surface and ground waters, and on the disruption of ground and surface water flow paths during excavation of large surface mine open pits. Most agencies and companies try to follow a fairly standard set of procedures to minimize long-term environmental risks to ground and surface waters, including *avoidance, isolation,* and *treatment*.

Avoidance can be accomplished either by not disturbing or exposing problematic waste units (i.e., tailings and waste rock piles) encountered during mining operations, or by avoiding specific mineral processing technologies that may create these problems. These choices affect the project economics, so in many cases avoidance is simply not a practical alternative. In this case, the next alternative is to isolate problematic waste from air and water that can create and transport contaminants off site. *Isolation* can incorporate several alternative strategies and technologies. Problematic waste can sometimes be minimized through selective mining or handling, or operational changes in milling processes. Waste can sometimes be treated in place through addition of amendments. Isolation by treatment in place is an attempt to avoid the final alternative: *treatment*. Long-term treatment is the least desirable alternative, because it generally requires a continued infrastructure for treatment in addition to the treatment itself, and is generally the most expensive alternative.

SURFACE WATER CONTROL AND MANAGEMENT

Surface water control can be an important aspect of a sustainable development program. A poorly designed surface water control program will result in long-term maintenance issues, and may result in additional waters needing treatment, or in violations of water quality standards. Because modern mine sites are typically large-scale disturbances of the existing environment, drainages and streams may be disturbed or eliminated, and replaced with constructed drainageways that must be designed to accommodate the large storm flows that will occur intermittently for many years to come. Current mine reclamation practices tend to include the construction of extensive areas of uniform slopes, broken by benches and drainageways that effectively transport rainfall and snowmelt off reclaimed slopes. However, they do not mimic the natural environment. They are essentially engineered terrains and, like all engineered features, require routine periodic maintenance to remove debris and repair damage from unanticipated events.

This catchment pond at the Ortiz mine in northern New Mexico was built to prevent mine drainage from entering surface streams.

A developing technology involves the shaping of waste dumps using drainage patterns and slope forms that mimic the surrounding terrain, typically including complex slopes and dendritic drainage patterns. Global positioning system technology is very helpful in the application of this new reclamation technique because it allows earth-moving equipment to achieve far greater accuracy when creating specific slope angles and elevations. BHP Billiton is currently using this technique at coal mines in New Mexico, and the Montana Department of Environmental Quality and the federal Bureau of Land Management are actively

Modern mine reclamation often includes extensive areas of uniform slopes, with slope breaks/benches and constructed drainageways.

encouraging its use in future mining proposals in Montana. The goal is to help limit long-term maintenance requirements by developing reclaimed environments that more closely mimic the appearance and function of the natural environment. This technique has been used extensively on many smaller-scale abandoned mine reclamation projects.

GROUND WATER CONTROL AND MANAGEMENT

The first step in a ground water control program is an effective surface water control program, because the two are related. A ground water control program for reclamation generally is distinct and separate from the ground water control program for active mining. Active mining programs focus on removing water from the mine in order to conduct operations in a relatively dry environment. Following the completion of mining, the program objectives will likely shift to either avoid ground water interaction with problematic waste material, or to collect and control contaminated waters. Ground water control is an art unto itself, and techniques vary from site to site. Ground water controls at mine sites can include sheet piles, grout curtains and clay cutoff walls that seek to isolate a project area from outside ground water. However, most mines rely on well systems that intercept the ground water and pump it away from the project area. The other technologies mentioned tend to be much more complex and are generally better suited to smaller-scale projects.

As most mine pits are below the water table, the ground water will reestablish its approximate original elevation in the area once pumping stops. If the pit is not backfilled, a pit lake will result. Pit lakes have been proposed at many mine sites. They may be an acceptable closure strategy if the pit lake water quality issues can be satisfactorily resolved. There is considerable ongoing research into the use of pit lakes as water treatment facilities relying on in-pit processes to treat the water. Research has focused on how mixing and stratification of pit waters can be used to enhance or limit chemical processes to improve water quality.

Although it is appealing to think that backfilling pits with mine waste will resolve environmental issues, success depends on site-specific conditions. If the waste does not have the potential to become acidic and does not contain contaminants, this can be an excellent reclamation strategy that eliminates the waste rock and the pit. However, if the pit is backfilled with acidic mine waste, ground water may interact with the backfilled material, forming contaminants

Reclamation and slope stabilization on tailings at the Miami mine in Arizona. The cows are grazing on the newly reclaimed slope to the right.

that will adversely impact water quality. In this case, the resulting poor-quality water would have to be collected and treated or isolated in place, and both of these options are expensive and difficult to achieve. Therefore, not backfilling the pit and dealing with the resulting pit lake may be less costly and have fewer ground water contamination problems in the long run.

TREATMENT OF MINE IMPACTED WATERS

Mine impacted waters (MIW) may need to be treated in order to meet water quality standards. This may be done as a last resort after other control methods have proven inadequate, or generation of MIW may be an unavoidable impact of mining even though proper surface and ground water control programs can help to limit the amount of MIW needing treatment. The types of treatment for MIW include (in order of relative cost) passive, semi-passive, and active. Passive treatment technologies rely on natural chemical or biological processes to precipitate or remove metals and other contaminants from the MIW. They do not require continual intervention, though they do require ongoing monitoring and maintenance. Typical passive systems include constructed aerobic and anaerobic wetlands, anoxic limestone drains, vertical flow systems, and open limestone channels. Active treatment technologies require a regular staff and infrastructure, relying on a continuous source of power and materials to maintain the treatment system. Active treatment is generally considered to be a safe and effective technology and operates at a large number of mine sites. The most common types of active treatment include chemical or biological addition, filtration, and ion exchange. Semi-passive treatment often consists of an active treatment with a passive treatment as a finishing step in order to meet water quality standards.

The most common form of treatment for MIW is chemical addition of alkali, usually limestone, to raise the pH (lower the acidity) of the solution and precipitate the metals out of solution. Filtration is generally used for the removal of particulates, though the filtering media can be used for some limited chemical reactions if concentrations are low. Ion exchange is also most suitable for relatively low concentrations of metals. A variety of natural and artificial products can be used to remove metals from MIW through cation exchange. As with the other processes noted above, the materials used must be replenished as they are consumed. Such treatment may be necessary for many years or in perpetuity. Active processes also result in the production of a waste product, generally a sludge that must be disposed of appropriately. Because of the expense associated with active treatment, there is considerable research focusing on new technologies that reduce treatment costs. Much of this research involves the use of biological processes to reduce either the cost or quantity of reagents and materials needed.

Pit lake at the Ortiz mine in northern New Mexico.

New and Evolving Technology in Mining and Mineral Processing

Douglas Bland
New Mexico Bureau of Geology and Mineral Resources

Mining companies are continually looking for innovative ways to reduce operational costs, increase mineral recovery, improve working conditions, and minimize negative impacts on the public and the environment. Research in the pursuit of new technologies that help to achieve this goal is ongoing. Large corporations have their own research and development (R&D) programs, and much of the work underway in this setting is proprietary and may not be available to the public.

Other R&D efforts are undertaken by companies that provide specific products or services. One example of this is a new technology using microbes to recover metals from acid mine waters. BioteQ Environmental Technologies, Inc., a Canadian industrial process technology company, has developed and the patented BioSulphide Process® for treatment of acid mine drainage that is being used by the Phelps Dodge Mining Company in Bisbee, Arizona, for the recovery of copper. BioteQ's process is relatively inexpensive compared to conventional ion exchange processes, allowing economic recovery of marketable metals from low-grade solutions.

At Bisbee, acid drainage is collected at a water plant and pumped to the BioteQ facility. A sulfur-reducing anaerobic bacteria culture is used in a bioreactor where it plays a key role in producing hydrogen sulfide gas. The acidic drainage, which contains dissolved copper and other metals, is mixed with the hydrogen sulfide gas. Copper then precipitates out as a sulfide concentrate and is shipped to a smelter for further refining. The process water is pumped back to the stockpile where it is re-applied to continue leaching copper. The bacteria never enter the water and are contained in the bioreactor. Other metals, such as nickel, cadmium, zinc, and iron, can also be precipitated from acid mine drainage by adjusting the pH to near neutral.

Another example was developed by an Australian company, Virotec International, Ltd., that created a series of reagents or substances that alter the chemical nature of problematic materials. These reagents are applied at mine sites in powder, pellet, or liquid slurry form directly onto existing acid-generating rock and leach piles, acid tailings ponds, other contaminated waters, and soils where they neutralize acid materials and remove excess metals without generating toxic waste products. These reagents have been used successfully at a number of mines around the world.

Other R&D programs are partnerships between mining or service companies, the government, and research facilities. For example, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy manages the Industrial Technologies Program (ITP), whose mission is to improve industrial energy efficiency and environmental performance through projects involving partnerships with industry, national laboratories and other research institutions, and stakeholders.

One project the ITP saw through to fruition was implemented at the smelter associated with the Bingham Canyon copper mine near Salt Lake City, Utah. Kennecott recently installed new burners in the smelter that use a new technology called dilute oxygen combustion, which incorporates high velocity fuel and oxygen jets that produce increased combustion in the furnace. Use of this technology has increased efficiency, reduced fuel needs, and reduced nitrogen air contaminants (NOx) by 80%.

Other ITP projects that have completed their R&D or are underway include:

- Robotics for improving mining productivity
- Projectile-based excavation
- Treatment of cyanide solutions and slurries using air-sparged hydrocyclone
- Robot-human control interactions in mining operations
- Development of new geophysical techniques for mineral exploration and mineral discrimination based on electromagnetic methods
- Investigation of a combined GPS and inertial measurement unit positioning system for mining equipment
- Imaging ahead of mining
- Drilling and blasting optimization
- Mining byproduct recovery

There is no guarantee that all of these projects ultimately will achieve success and be incorporated into industry practices, but many others will be investigated and adopted, changing the way mining and the environment are managed in the future.

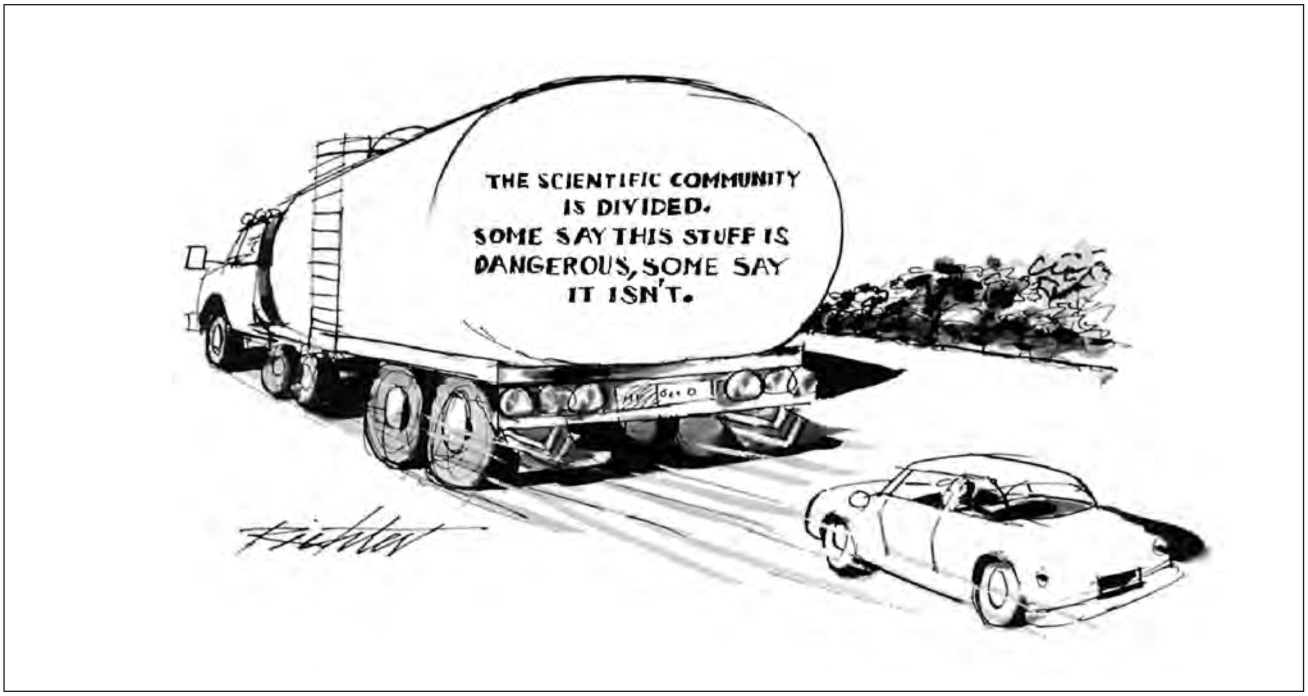
How Science Can Aid in the Decision-Making Process—Translating Science into Legislation

Peter A. Scholle, *New Mexico Bureau of Geology and Mineral Resources*

Science, like most fields of inquiry, represents a search for complete understanding or "truth." But scientists are no more or less infallible than others in our society. They can be unintentionally biased; they can be (one hopes only in very rare instances) intentionally biased (remember the American Tobacco Institute?); they often work with incomplete data sets making it difficult to get reliable conclusions; and they can draw incorrect conclusions even from fairly complete data sets. But the process of science is one of constant questioning and testing of one's own work and the work of others. That jousting and sparring between scientists, no less than the competition between animals in the wild, leads to the survival of the fittest—the fittest ideas and conclusions in the case of scientists. The process of intellectual competition can be a long and slow one. Indeed, it is really a never-ending process as new data are gained, and old ideas are reexamined. Thus, scientific inquiry is basically a process of successive approximation in which we draw ever closer to the truth, but perhaps never completely reach it. That is no less true in economics, history, political science, or any other field of inquiry (think of polling results both before and after the last election, for example), but common public expectations are that scientific inquiry should rise above such data uncertainties to yield definitive answers.

For decision makers in particular, dealing with scientific uncertainty can be a very frustrating and even disillusioning process, especially as they listen to scientists debate their individual perspectives on technical issues that may have significant social implications. That frustration, in turn, often results in legislative gridlock, in calls for more research to resolve the conflicts (thereby sometimes providing political cover for inaction on the real problem), or in the waste of funds expended for actions that later prove to be ineffective or useless.

The global warming/climate change issue provides a good example of such controversy within the scientific communities and the struggles of decision makers throughout the world to deal with the associated scien-



FROM *THE NEW YORKER*. USED WITH PERMISSION.

tific uncertainties. It may help us to understand the differences between measurable, predictable, or modelable information in an exceedingly complex system. Let's start with the simplest question—is the earth's surface warming? Simple—we just stick the thermometer in … where? Well, even that is complex. It is a big planet, and we have a limited number of accurate ground-based weather stations, most of which are located in North America and Europe. So we send up expensive satellites that scan the earth as they orbit around it, and we compile global temperature information. But how do we compare that modern information with ground-based temperature data from 100 years ago to see when warming began and how far it may have progressed? This remains an area of conflicting opinion among scientists, but an overwhelming majority of reputable (and who decides that?) scientists now agree—warming of the order of 1° C has occurred over the past 100 years. But that just takes us on to the harder questions with less easily measurable answers: have we caused such warming through human industrial and agricultural activities (deforestation and burning of fossil fuels, for example), or is it part of a natural climate cyclicity that geologists have deduced to have occurred over the past billions of years of earth history? If we caused the changes, how can we model how quickly warming is proceeding and predict what the consequences will be? Are other things we are doing (pumping sulfur dioxide and particulates into the atmosphere, among others) offsetting all or part of the effects of greenhouse gases?

Clearly, the answers to these questions are difficult to obtain and may never be known with full certainty. The United States has responded to the crisis with a call for more research before taking any action. Much of the rest of the world has responded with a desire to immediately start to reduce greenhouse gas emissions. These completely different legislative responses to the same data and interpretive models highlight the difficulties of dealing with uncertainty—we will know the right answer in 100 to 200 years, but by then it may be too late to change our choices.

So how can science aid in the decision-making process? What can decision makers do to deal with such uncertainties? The first step is to stop thinking just about right and wrong and think instead about probabilities. There is virtually nothing we ever know with 100% certainty. We all make decisions in our private lives based on probability. You probably do not believe you are going to get sick or die this year, yet you most likely do have medical and life insurance. Why?—Because the consequences of being wrong are significant enough and the possibility of getting ill or dying is great enough that you take prudent steps to deal with the problem. The same insurance-oriented, probability-based, decision-making principles should be applied to water, climate, pollution, and other issues that have potentially drastic societal consequences.

A second step is for decision makers to take a more direct role in some aspects of science management. I am not advocating that legislators, for example, decide how fundamental science is done or interfere with the generally impartial peer review of technical proposals that forms the foundation of how science is done in most developed nations. But at the same time, it is unrealistic to expect that fundamental societal questions will be adequately addressed in the absence of guidance from the people who have to make the final decisions. Legislators and legislative staffers need to educate themselves on issues sufficiently to pose the questions that they feel need to be answered (in part by attending conferences such as this one). Then they need to ensure that funding is available to address those questions. Where funding is provided through agencies that put out topically specific requests for proposals (RFPs), rather than passively reviewing independently conceived and submitted proposals, research can be directed to targeted goals. Again, I want to emphasize that there is great value to independently conceived research, and we should continue to support it as well. But if you want answers for your questions, you should frame the questions and fund the search for answers directly.

In that same context, where legislators are authorizing and funding recurring large-scale, but still experimental work that has substantial scientific uncertainties—something like salt cedar eradication, for example—why not include a requirement (and funding) for independent scientific monitoring at the same time? That would assure that adequate data are available to judge the efficacy of such programs when subsequent requests come before the legislature.

Three other methodologies also can be recommended to deal with uncertainties and help translate scientific knowledge into better legislation. Two of these approaches shift the responsibilities of evaluating conflicting scientific opinions to other, potentially more knowledgeable groups. At the federal level, the National Academy of Sciences (NAS) acts as an organization that sets up specific, theoretically impartial review boards consisting of nationally known scientific and technical experts to review questions of complexity and importance (such as global warming). Although the process is not without its flaws, the consensus reports of these review boards carry considerable weight and commonly offer excellent guidance to legislators and the public. The effectiveness of this process depends substantially on how the reports are funded, how the panels are selected and chaired, and how the study questions are posed. The NAS will work, in some cases, on state problems, especially if the problems carry over into a number of states (that really means they prefer to work on regional or national issues). However, NAS reports are expensive; generally too expensive for individual states.

Independent, non-regulatory state agencies—people like the New Mexico Bureau of Geology and Mineral Resources—can sometimes act in a manner comparable to the NAS in order to deal with complex issues. The agencies can assemble panels of capable scientists, chair the meetings, and take on the responsibility of producing the final report authored by the full and diverse panel. It is not, however, realistic to expect that any state agency will take on the role of sole arbiter of complex technical and scientific questions. No single agency has the breadth of in-house expertise and perspective to compete with a broadly chosen board, and no state agency will eagerly (or should) take on the responsibility and potential liability of providing a definitive recommendation on complex issues of major social and financial import.

A final suggestion for the future of legislative decision making is the development of computer-based modeling tools specifically designed for legislators. Modeling tools, if properly designed, allow one to see the consequences of actions before they are taken. Well-designed models can also combine specific technical strategies with economic prognostication, allowing decision makers to understand the economic consequences of specific actions or the lack of any action. To go back to our climate change question: a well-designed model should allow one to predict the costs of doing nothing to curb greenhouse gas emissions (costs related to rising sea levels, changing ecosystems, higher temperatures, more extreme storms, and other effects) versus the costs of reducing emissions (costs such as building infrastructure for alternative energy sources, increasing efficiency of energy use, carbon dioxide sequestration programs, and others). Models can be graphic and effective tools for prediction, but models are no better that the programming and data that go into them. If the linkages and feedbacks in a system are not well understood, if data for one or more of the variables are not available or have large uncertainties, then the effectiveness of the model is greatly reduced. Small changes in climate models, for example, often produce large variations in their predictions. The world is complex, and in systems with many variables, the number of potential interactions between variables grows exponentially. Good examples of this are drug interactions in humans or the interactions of combinations of chemicals released into the environment. We need to test not only if a drug or chemical is safe and effective taken or used by itself, but we also must test how it might interact with the thousands of other drugs on the market or other chemicals already found in surface or ground waters.

We have learned much about the world around us, but there is, oh so much more to learn. In the mining area, as well as in most other fields of environmental interest, we know the basics and need much additional information before we can understand the details. But all this should inspire you to fund more scientific investigations, not to give up on science in decision making. Science will not provide the answer to what are basically social choices but it can inform those decisions. Scientific information will never be complete, but using scientific input, no matter how incomplete, is better than ignoring the existing body of scientific data. The final decisions involving major human issues are always based primarily on social and/or economic considerations, but scientific input has a valuable place in narrowing the debate to focus on the most acceptable choices.

Incorporating Science and Stakeholder Values in the Decision-Making Process

Andrew MacG. Robertson and Shannon Shaw
Robertson GeoConsultants, Inc.

Planning, constructing, operating, and reclaiming a mine in today's world involves many specialized disciplines, some technical and scientific, and others related to public needs and values. All these factors must be considered to make the best choices that meet the needs of the mining company, regulators, and the public, yet it is not feasible for decision makers themselves to become well versed in all of these disciplines.

One fundamental problem that has plagued everyone concerned with these issues is how to combine quantifiable scientific data and qualitative social desires in one unified evaluation process that identifies the best solution, considering all these factors and giving appropriate weights for each. With the push for sustainable development across the industrial sector, a number of tools are evolving in order to do just this. Two tools that are becoming more prevalent in the mining industry are the *Failure Modes and Effects Analysis* (FMEA) for risk evaluation, and the *Multiple Accounts Analysis* (MAA). The latter is used for evaluating the impacts of various mining and reclamation options, and then identifying the most desirable options that minimize negative impacts and risks and maximize benefits, while considering the level of uncertainty. Both tools provide a means by which experts can convey their science-based assessments of various impacts and risks to other decision makers and other interested parties.

Multiple Accounts Analysis allows decision makers to select the most suitable choice from a list of options by weighing the relative positive and negative impacts of each. Issues used to develop options are grouped into four categories called accounts: technical, environmental, socio-economic, and project economics. Each issue is defined by indicators, some of which are straightforward and quantitative (costs, for example). However, many indicators, particularly environmental and socio-economic factors, are difficult to describe or quantify. Expert judgment is needed to assign relative levels of desirability (values) for certain indicators, based on scientific testing, modeling and analyses, precedents, and experience. Having participants who are experienced with similar projects and dedicated to understanding and learning the benefits and limitations of certain indicators is critical to the success of these evaluations. For example, the issue of water quality impacts is nearly always included in the evaluations of mining projects. Although a great deal of science is involved, the predictive values for long-term water quality are often difficult to quantify, so the ultimate evaluation ends up being qualitative.

Once the list of issues (accounts) is complete, the options are scored through a numerical process, and a matrix is developed that identifies the most favorable option. (Use Robertson Figure 2a to illustrate?) The MAA format serves to translate detailed scientific evaluations into justifications for each option that can be readily explained to decision makers, who can then defend their decisions using the expert evaluations in the MAA matrix.

The *Failure Modes and Effects Analysis* (FMEA) is another tool being used widely in the mining industry for assessing the risks associated with a preferred option. Risk is a combination of the likelihood of an event or failure and the consequence if it occurs. Often the effects of a failure can have impacts of different severity with respect to the economy, the environment, land use or biota, health and safety of humans, and regulatory compliance issues. Descriptions of likelihood and consequences are usually quantitative (science based) but occasionally qualitative (experience based, from an appropriately experienced scientist).

The FMEA allows decision makers to perform a systematic and comprehensive evaluation of the potential failure modes of an option in order to identify potential hazards. For example, the FMEA can be used to evaluate the collapse of a collection pond dam (failure) causing a discharge of water. While the likelihood of this in a semi-arid environment may be considered *moderate* (0.1 to 1% chance of occurrence in any one year), the consequences on the environment may be different for different circumstances. Depending on the quality of the discharged water and the type of environment into which it flows, the consequence could be *moderate* (science based and quantitative) with respect to the biological and land use impacts; the regulatory and public image consequences could be expected to be *high* (qualitative); and the cost consequences (science-based cost calculation) to repair the pond could be relatively *low*. Typically the FMEA work sheet and results are both developed as a matrix.

There is a difference between the risk of a failure and uncertainty in the estimate of that risk. There are also uncertainties associated with the potential frequency of failure and expected consequences. Quantifying the uncertainties provides decision makers with an understanding of the analyst's opinion in terms they know and understand.

Finding Solutions—Collaborative Processes and Issues Resolution

Julia Hosford Barnes and Mary Uhl, *New Mexico Environment Department*

Given the complexities of environmental problems today, governors, state agencies, legislators, and scientists are looking for long-lasting solutions that navigate political minefields. The converging worlds of science, government, and politics pose fascinating and extraordinary challenges to environmental public policy issues. Scientific information is technical, complex, and difficult to translate into the language of the layperson. Health and environmental issues often fall within the jurisdiction of different federal, state, and local governing bodies, and the issues can be politically heated when the goals of the stakeholders are diametrically opposed. Success in finding consensus or concurrence in these converging worlds is a large achievement.

The mining industry in New Mexico faces all of these challenges today. Most mining issues are related to: (1) siting—should a mine be located here; (2) impact on the local community; and (3) environmental protection and reclamation after mine closure. Identifying solutions acceptable to all stakeholders is complex and time-consuming, but often avoids protracted and costly litigation later on.

To improve the chances of long-term resolution, leaders are using the power of assembly to resolve complex environmental issues in mining and other sectors. In a collaborative process, community groups, the environmental community, industry, and government officials come together to:

- Develop a common understanding of the factual and scientific issues presented
- Design a process that identifies the goals and how to reach these goals
- Discuss and come to consensus on key issues
- Determine the steps to implement the decisions made

The work is typically done with a facilitator who helps to manage the process and a project manager who understands the technical and scientific issues involved. This team assists the convener to work toward completion of the project. (The team of convener, facilitator, and project manager are referred to collectively as "convener" here.)

Through our work at the New Mexico Environment Department in convening community groups to address local environmental issues, we have identified four key leadership goals and four key science goals that can improve the chances of a positive outcome.

LEADERSHIP GOALS

When a leader uses the power to convene a community group to work on a local issue, there are four areas that warrant special attention:

1—Manage carefully the initial design of the collaborative process. Two points in a process provide times when decision making is key: at the beginning and the end of a process. First, how you are going to work together and, at the end, how you are going to implement the agreements after the process concludes? The convener has several important initial decisions to make. Among these decisions are:

- Is the leader or the lead organization neutral and viewed as neutral? If not, can they still convene the process?
- What parties are important to bring to the table?
- What is the goal of bringing the group together?
- What are you trying to achieve and why?
- Do others involved agree with your process design?
- What does a successful outcome look like?

When the process is fully designed, the convener should be able to answer *Who? What? Where? When? How?* and, most importantly, *Why?* Clear goals at the beginning of a process can set up good decision making at the end of the process.

2—Manage the expectations of all involved. It is important to articulate goals regarding the process—both *what* you want the group to accomplish (e.g., to provide input on a health risk assessment) and *why* this is important (e.g., to have a better overall picture of the affected area or to work with industry to make safety improvements). The process differs depending on the outcome you seek. If you do not have clear goals, you run the risk of having various groups expecting various outcomes, and inevitably some of these expectations will never be met. For example, if your goal is to make safety improvements in targeted industries, industry must understand and support the desired outcome. If your goal is to help the community understand the overall environmental picture in the affected area, you will focus more on uncovering all sources of pollution in the area. If community groups expect industry to change its safety requirements, but the agency goal is only to understand the environmental impacts in the area, the community groups will be frustrated with the ultimate outcome.

When these goals are determined, it is essential to communicate the goals to the stakeholders and to those watching the process so that all are clear on what to expect from the process. Some projects are high profile and may be covered by the media. Typically, the upper echelons of government and industry are watching the process. New leaders can come in during the process, through elections or otherwise. It is important to be able to communicate effectively the project goals to new leadership, and to get the support of the new leaders. Clear goals and clear articulation of these goals can ensure that everyone expects the same things from the process.

One area of common confusion is the extent of power a governmental agency has under its regulatory authority. Whereas regulatory agencies understand how they are limited by laws under which they operate, the public commonly does not. The convener should ensure that everyone understands the limitation of the laws and what constraints that puts on the process.

We urge leaders to consider one note of caution: Public policy collaboration is sometimes suggested because nothing else has worked, and the situation has hit "rock bottom." Collaborative processes in these situations often achieve only modest results and may not achieve anything at all. It is difficult in these situations to come to consensus regarding every step in the process, from who is at the table to what you are trying to achieve. If a group is convened over a long-term dispute, it is best to set small clear goals and take the project one step at a time. Expecting a ten-year dispute to be resolved because a task force is convened is typically an unreasonable and unachievable expectation.

3—Manage the bureaucracy. Bringing a group together can be a cumbersome process. When a governmental agency acts as a convener, it necessarily has to work within the bureaucratic structure of government. If not managed carefully, the group process can be substantially less efficient due to the constraints of governmental bureaucracy.

The convener should anticipate the bureaucratic difficulties and then concentrate as many of the bureaucratic requirements into one time period, if possible. For example, if several contractors are needed, the community group could meet to decide the scope of work for all contractors. The group could then recess during the time needed for the agency to go through the process of selecting contractors. Once the contracts are in place, the group can then meet again to move forward. Bureaucracies tend not to move faster when pushed, so it is best to plan around these requirements.

4—Manage the process "All the world loves a stage." Group collaborations, by definition, bring people together. If forums are not managed appropriately, it provides an opportunity for all types of grandstanding by divergent groups. Decision making in the spotlight can be explosive and ineffective. It is important to manage the process to minimize the abuse of the public forum.

At the same time, the public forum can bring about good results. Statements made and decisions announced in public can make people more accountable. Agreements made by groups in a public manner are frequently honored. The convener can work to set ground rules for conduct at the meetings and can capture the decisions of the group so that the process moves forward.

SCIENCE GOALS

When groups are convened to look at scientific information, special challenges arise. The convener should ensure that scientific information is conveyed in a manner that can be understood by the non-scientists who are at the table. We suggest four areas on which to focus attention:

1—Provide baseline information on the relevant science so there is a common understanding in the group. In order to ensure that the scientific presentations are comprehensible, it is important to discuss the baseline scientific information at the beginning of the project. At this time, you can ensure that all members of the group understand the scientific concepts involved, understand how science might answer the questions asked, and understand the possible limitations to the answers. The baseline scientific discussion can also identify areas in which there is conflicting scientific information or protocol. These are areas that can be discussed later.

2—Provide understandable scientific information presented by scientists who can clearly deliver the information. Environmental issues can require many complex scientific components to be examined and discussed within a public forum. Some group members are able to understand complex scientific issues, and some may not. Scientific information should be presented without scientific jargon following the suggestions below:

- Choose a charismatic speaker who likes to present to the public. The speaker must listen to questions and respond both to the precise question asked and must address the underlying, unasked question. If English is the second language of the presenter, make sure that language or the presenter's accent does not make communication more difficult.
- Present the results of the research *first*, rather than beginning with the basis for the results. The technical basis for the results is important in the scientific world, but will not be followed easily by a layperson.
- Put the results into context for the public. The public needs to understand *why* a result is important.
- Make the presentation to a technical group *before* making the presentation to the larger public group and make necessary changes. A peer review committee of scientists is recommended. This can substantially improve the presentation to the public.

3—Provide a reality check for the public. Scientific studies can be very expensive, and they sometimes provide limited and conflicting answers. Most members of the public do not understand or appreciate how complex it can be to determine the scientific answers to questions asked. The convener should ensure that the members of the group understand the work necessary to obtain the requested scientific information, the limitations of the budget, and the possibility of limited or inconclusive results.

4—Provide a common agreement within the group about what to do with the dilemmas of misinformation, conflicting information, and perceived information. The convener should discuss ground rules with the group regarding how to handle misinformation, conflicting information, and perceived misinformation. This can be a very difficult problem because groups in conflict tend to question the “facts” presented by the other side, and it is time consuming to research each questioned “fact.” These problems can quickly derail a group. On the other hand, if misinformation is not addressed, the group might act upon bad information. One possible solution is to set aside a portion of the budget to investigate factual disputes or form a technical peer-review committee that will look into factual issues.

Collaboration can result in new ways of working on troubled issues that concludes with a solution that is more palatable to the local community. It can provide long-term solutions to problems that affect entire communities. Although the process may be challenging, it can provide results that surpass any alternative. There is a great deal of information available regarding public policy collaborations. One excellent resource established to support governmental public policy projects is the Policy Consensus Initiative (http://www.policyconsensus.org). This is important, challenging, and exciting work. We wish you luck.

The Role of Non-Government Organizations

Brian Shields, *Amigos Bravos*

The current NGO policy issue centers on creating an enabling environment for NGOs to play equal roles in the development of the society especially when the government is withdrawing from the social delivery processes. —Tanzania Gender Networking Programme

The World Bank defines non-government organizations (NGOs) as "private organizations that pursue activities to relieve suffering, promote the interests of the poor, protect the environment, provide basic social services, or undertake community development." Although the World Bank's definition of an NGO may be an accurate portrayal of public interest organizations, it does not take into account that there are now a number of corporate-backed NGOs, such as the New Mexico Mining Association, promoting industry's agenda. I will limit my comments to the role of the community-based, environmental and social justice NGO as exemplified by Amigos Bravos. In exploring the role the NGO plays as it becomes increasingly invested in a community, I will draw on my experience working with Amigos Bravos to address the contamination of the Red River from mine-generated waste at the Molycorp mine in Questa, New Mexico.

The primary role of the environmental and social justice NGO is to be a voice for the long-term health and well-being of individuals, communities, and the natural environment. It is the NGO's responsibility to help identify and define the problems and issues that impact the health of the community and its environment, to advocate for policies and actions that promote a healthy and sustainable existence, to hold government, industry, and polluters accountable for actions that are detrimental to a healthy life, and to help develop solutions and resources that will address these problems. Most importantly, it is the NGO's role to question the dominant social paradigm and to work toward creating a just, equitable, and sustainable society. Strengths generally associated with the NGO sector include:

- Strong grassroots links
- Field-based development expertise
- Ability to innovate and adapt
- Process-oriented approach to development
- Participatory methodologies and tools
- Long-term commitment and emphasis on sustainability
- Cost-effectiveness

Each NGO is an entity unto itself, with its own mission, style of leadership, and unique operating culture, and each adopts strategies based on those factors. Every community-based NGO would like nothing better than to accomplish its mission and thus work itself out of a job.

Successful NGOs know that they have three overarching ethical responsibilities to the communities they represent. They must maintain credibility by always speaking the truth; they must be fully accountable for their actions; and they must build the infrastructure to maintain the organization for the life of the issues they choose to address. Without fulfilling all three of these responsibilities, NGOs are subject to criticism and failure.

Ideally, given the needed resources, the NGO will take on various roles including that of educator, government and industry watchdog, community organizer, political activist, litigator, researcher, or even investor in a beneficial project—all roles that Amigos Bravos has played in efforts to clean up the Red River. More often than not, successful campaigns to address complex, chronic pollution issues—such as ones presented by the Molycorp mine—require multiple skills and knowledge that no single community-based organization can possess. In those instances, a number of NGOs with specialized skills will come together in a concerted campaign.

In New Mexico, where communities are spread over vast distances, rural populations are small, and financial resources are scarce, local NGOs have had to take on the critical role of protecting the communities' interests by focusing on one specific part of an issue, and letting other NGOs—often within the same community—take on other aspects of the issue. For instance, in Questa the Río Colorado Reclamation Committee has taken on oversight of the Superfund process, Concerned Citizens of Questa continues its forty-year effort to hold Molycorp accountable for contamination, Artesanos de Questa is creating sustainable economic development alternatives to mining, the Questa Environment and Health Coalition is helping to determine impacts of tailings and water contamination on residents' health, and Amigos Bravos is focused on restoring the Red River.

WHY ARE THERE SO MANY NGOS IN NEW MEXICO?

The answer lies in the fact that despite progressive advances in the protection of health, the environment, and social welfare by the passage of many federal and state laws, the government has produced regulations that often have been written with industry at the table. These regulations are complex and hard to enforce and often depend on the good will of industry. Some of the regulations take several years to implement. The ground water discharge permits required under the New Mexico Water Quality Act of the early 1970s are one good example. The regulations requiring discharge permits were adopted in 1978, yet Molycorp did not receive a ground water discharge permit for its mining operations until 1999.

Many regulations depend on voluntary compliance by industry. An example of this is the way permits are written and non-point source pollution is controlled. In New Mexico it is common practice for industry to suggest permit language that is then reviewed by the agency. Because of this, it falls on the NGO's shoulders to see that regulations ultimately include conditions that address community concerns. Molycorp's mining permit, in which Amigos Bravos played a key role, contains no fewer than sixty-four conditions. Similarly, New Mexico depends on voluntary compliance, through the development of best management practices (BMPs), to control acid rock drainage and other non-point sources of water contamination. Because BMPs can fall short of controlling pollution, it may fall to the community-based NGO to apply political pressure to ensure that the issues are addressed.

At the same time, the mining industry has been known to challenge the government's authority to enforce certain regulations. A prime example of this attitude is Molycorp's 1989 proposal for the Guadalupe Mountain tailings facility, in which the mine challenged the Bureau of Land Management's authority to require the mine to look at alternatives during the NEPA (National Environmental Protection Act) analysis. More recent examples include Molycorp's 1999 and Phelps Dodge's 2003 challenges before the New Mexico Water Quality Control Commission regarding how the state should regulate ground water at mining operations.

A further complicating factor for communities is the lack of consistency and continuity in government funding and policy implementation. As administrations change, so do policy and funding priorities, with the result that some initiatives are discontinued or left with greatly reduced funding. The present funding crisis for clean-up at Superfund sites is a prime example. All of these factors have fostered an increasing need for community stewardship of its resources—and hence a growth in the number of NGOs. The fact that there are so many NGOs working on mining issues points to a basic societal problem: Mines continue to produce waste, and, despite excellent laws and regulations, pollution continues to threaten public health and the environment.

To reverse this problem, NGOs must find ways of empowering regulators to claim the authority to hold the mining industry accountable to the communities where these natural resources are located. NGOs can bring a broad array of resources to the table that would otherwise not be available to regulators and industry. Besides monitoring data, scientific analysis, on-the-ground restoration efforts, and problem-solving expertise, NGOs often engage people from a broad spectrum of society who, though impacted by mining practices, would normally not be part of a mine-related, decision-making process—including people involved in the arts, human health, financing, etc. In order for NGOs to be effective voices for the concerns of their communities, and for society to benefit from an NGO's expertise, the NGO should be empowered to sit at the decision-making table whenever industry is present—especially when addressing environmental issues.

A CASE STUDY: AMIGOS BRAVOS

Incorporated in 1988, Amigos Bravos, Inc. is a statewide environmental NGO guided by social justice principles, with offices in Taos and Albuquerque, a staff of seven, and a membership of 1,500 individuals, families, and businesses. Because rivers are the lifeblood of New Mexico's communities, human and natural, Amigos Bravos works to protect both the ecological and cultural richness engendered by rivers. Amigos Bravos accomplishes its mission through direct advocacy and by empowering individuals and communities to protect local water resources.

It is the mission of Amigos Bravos to:

- Return New Mexico's rivers and the Río Grande watershed to drinkable quality wherever possible, and to contact quality everywhere else
- Ensure that natural flows are maintained and, where those flows have been disrupted by human intervention, to advocate that they be regulated to protect and reclaim the river ecosystem by approximating natural flows
- Preserve and restore the native riparian and riverine biodiversity
- Support the environmentally sound, sustainable, traditional ways of life of indigenous cultures
- Ensure that environmental justice and social justice go hand in hand

Amigos Bravos uses all advocacy tools including educating the public through the media and other venues; offering opportunities for volunteer action; working with policymakers to enforce environmental laws and to adopt progressive policies; participating in complex administrative and regulatory processes including standard-setting, rulemaking, and permitting; and undertaking protection and restoration efforts.

At its inception, Amigos Bravos became active on mining issues in response to the pollution of the Red River from many tailings pipeline spills, and the consequences of operations at the Molycorp mine. Subsequently, when Molycorp proposed to build a tailings facility on the saddle of Guadalupe Mountain, adjacent to the Wild Rivers Recreation Area, Amigos Bravos joined many other NGOs in opposing the construction of the tailings facility. Since then Amigos Bravos has been involved in many mining-related issues and campaigns dealing with both acute and chronic situations.

THE ROLE OF THE NGO IN ACUTE VS. CHRONIC SITUATIONS

The proposal to develop a new tailings facility and the ongoing contamination of the Red River represent two very different situations requiring different NGO roles, strategies, and attributes. Whereas a proposed new tailings facility in an unsuitable location presents an acute problem requiring a fast and immediate response with maximum public input, the contamination of the Red River represents a chronic problem requiring a long-term clean-up strategy that may go on beyond the lifetime of the individuals involved at the beginning.

In response to the acute problem, NGOs abide by the belief that decision makers have to respond to public outcry—although this may not be what actually happens, because of legal, political, and/or security and safety reasons. Existing NGOs, within and outside of the community, mobilize their membership and dedicate resources in order to achieve a quick resolution. Newly formed NGOs may have to respond to the various elements and/or requirements of the crisis. Once the issue has been resolved, the newly formed NGOs often go dormant until a similar issue arises again. Local NGOs will go back to their ongoing work, and regional and national NGOs will go on to the next acute battleground challenge.

Dealing with chronic pollution situations requires a much broader combination of roles and challenges for the NGO. Chronic situations usually involve large quantities of toxic substances, and a complex set of physical and legal circumstances. All too often politicians and the public grow tired of dealing with long-term problems and, because of the complexity of the issues, feel powerless to do anything about them. In those situations the NGO has to develop and maintain community support; credibility with the media, the public, and the regulators; staying power for the long haul; technical expertise to provide solutions; a place at the negotiation table; and a role in the implementation and enforcement of cleanup plans. For Amigos Bravos, each of these attributes has represented a new stage in the development of the organization—and to a great extent has required that the organization take on new roles and new challenges.

I will conclude with some personal observations and recommendations regarding the role that NGOs should be able to exercise in the decision-making process.

The NGO should be recognized as a legitimate voice for concerns, and a valuable asset to the decision-making process. Too often, I have come away from meetings with decision makers feeling ignored and discounted. I have heard the retort that NGOs do not represent communities—that only elected officials hold that privilege. Decision makers should recognize that NGOs speak from convictions that transcend political agendas. NGOs raise concerns of individuals, species, and natural systems that often do not have a voice at the table. In many instances NGOs are the canaries in the mineshaft.

Moreover, some NGOs are perceived as troublemakers or obstructionists. The responsible NGO is interested in finding sustainable solutions to acute and chronic problems. NGOs will often propose creative solutions well in advance of industry and government —who are constrained by their own culture and perceptions. It is the decision-makers' responsibility to explore NGO alternatives.

NGOs need the necessary resources to fully participate in the decision-making process. NGOs provide a tremendous range of expertise, experience, and information that would not otherwise be available to the decision maker. It often falls upon NGOs to demand accountability, bring to the discussion sensitive community information, propose alternatives, and/or counter industry's experts. NGOs add value to the regulatory process that should be recognized, and the added costs accepted as part of doing business. It is in the long-term interest of industry and government to ensure that NGOs in the affected communities are able to participate fully in the decision-making process. Society as a whole—regulators and industry included—will harvest great benefits from NGO participation.

NGOs should be invited into the decision-making process. This requires that regulators exert their authority to provide adequate notification to the communities affected by mining. Notices in newspapers and radio are not enough, especially in low-income and minority communities where personal contact is the primary way of engaging residents. In those situations, regulators and industry should contract with community organizers to engage key community representation and expertise. In the interest of creating a healthy and sustainable future, it behooves decision makers to create opportunities for NGOs to be at the decision-making table.

A Partial List of Public Interest NGOs Working on Mining Issues in New Mexico

Amigos Bravos
Big Mountain
Black Mesa Trust
Black Mesa Water Coalition
Carson Forest Watch
Center for Biological Diversity
Center for Science in Public Participation
Citizens Coal Council
Coalition for Clean Affordable Energy
Concerned Citizens of Questa
Diné Care
Diné Mining Action Center
EARTHWORKS
Eastern Navajo Uranium Workers
ENDAUM—Eastern Navajo Diné Against Uranium Mining
Friends of Santa Fe County
Forest Guardians
Gente del Río Pecos
Gila Resources Information Center
Laguna-Acoma Coalition for a Safe Environment
Mining Impacts Communications Alliance
Moquino Domestic Water Users Association
New Mexico Citizens for Clean Air & Water
New Mexico Conservation Voters
New Mexico Environmental Law Center
New Mexico Mining Act Network
New Mexico Public Interest Research Group
Questa Environment and Health Coalition
Río Colorado Reclamation Committee
San Juan Citizens Alliance
Sierra Club
Southwest Research and Information Center
Trout Unlimited
Vecinos del Río
Water Information Network
Western Environmental Law Center
Western Mining Activists Network
Westerners for Responsible Mining
The Wilderness Society
Zuni Salt Lake Coalition

The Future of Mining in New Mexico

The mining industry has played and continues to play an important role in the economic prosperity of New Mexico. In 2003 there were 225 active mining operations in the state, employing more than 5,000 people, with an annual payroll of $229 million. That same year the industry generated over $27 million in revenues to the state of New Mexico. But what of the future of mining in New Mexico? We as a nation continue to rely upon a viable mining industry to support a quality of life that we take for granted. But that future, here and elsewhere, will rely on achieving a balance between our needs and desires, the changing economy, and our growing concern over environmental and social issues that face all of us (many of which are not unique to the mining industry). We cannot predict what role mining will play in the future, but we can state very clearly that it will depend upon our ability to face a number of very specific challenges down the line.

THE REMAINING RESOURCE POTENTIAL IN NEW MEXICO

The single most important factor that will determine the future of mining in New Mexico is the presence of economic mineral deposits in the state. New Mexico is at the eastern edge of one of the world's great metal-bearing provinces. New Mexico (and the neighboring states of Utah and Arizona) are host to significant, even world-class copper deposits. The potential for discovery of additional metals in New Mexico is good.

Yet, despite the recent increase in commodity prices, exploration and production of mineral deposits in New Mexico are at an all time low. Most known mineral deposits in New Mexico are currently being mined or are not economic at present, because they are either too small, too low grade, too deep, or are in areas where it would be difficult to mine. The Jones Hill project north of Pecos in the Santa Fe National Forest is one of several small, medium-grade mineral deposits containing gold, silver, lead, zinc, and copper. But a permitted mine there would require the costly construction of haul roads through forested mountains that are popular recreational areas, and it could have environmental impacts on the Pecos River. Similar deposits in the area are even less likely candidates for mining because they are in rugged, undeveloped canyons. Some of the known mineral deposits that might be considered favorable exploration targets are found in or near Wilderness or Wilderness Study Areas (such as deposits in the Nogal area in Lincoln County), on restricted lands, or on land withdrawn from mineral entry (such as deposits in the Elizabethtown–Baldy district in Colfax County).

Economically it will be very difficult to mine at this time the lead and zinc that exist in New Mexico. Vast reserves of high-grade, near-surface lead and zinc ore exist in other states (Cominco's Red Dog deposit in Alaska and Doe Run Company's deposits in the Viburnum Trend in Missouri are two examples). New Mexico's lead and zinc deposits are low grade, small tonnage, deep, and costly to mine and process. Existing lead and zinc smelters are far from New Mexico. Anyone wanting to mine lead and zinc in New Mexico would have a difficult time finding a buyer for the concentrate.

The closure of the Hurley (Grant County), Hidalgo (Playas, Hidalgo County), and ASARCO (El Paso) smelters has prevented some small metal mines from operating. Several small mines in the Lordsburg, Steeple Rock, Mogollon, and Hillsboro districts have operated in the past twenty years only by producing silica-fluxing ores containing gold, silver, and copper. These mines did not need mills but depended upon the smelters purchasing their crushed, unprocessed ores. These small metal mines are typically too small and low grade to finance the construction of a mill, and without a ready market they cannot exist strictly as metal mines.

Potential exists for finding economic gold deposits in several areas in New Mexico. However, some of the highest-grade deposits are at Ortiz in Santa Fe County, and a number of environmental factors have prevented any mining there in recent years. Remaining gold deposits in New Mexico would be classified as exploration targets rather than ore deposits.

New Mexico is second only to Wyoming in uranium reserves in this country. It will be difficult to mine uranium by conventional methods in New Mexico because in-state deposits currently have difficulty competing with production from Canada and Australia, and there are no processing facilities in New Mexico at this time. At the same time, there are several companies actively exploring for uranium in New Mexico today. The industry is exploring the possibility of mining existing reserves in place through the use of in situ leaching techniques. Whatever the outcome, it is very likely that there will be renewed interest in the state's uranium resources in the future.

New Mexico is third in the nation in terms of coal reserves, and industrial minerals are an increasingly significant commodity in the state. New Mexico is first in the nation in the production of potash, perlite, and zeolite. Both limestone and aggregate are available in abundance. Yet 20 percent of the cement we use in the U.S. is currently imported, and in New Mexico there remains only one active cement plant. There are concerns today regarding pressures to impose new regulations on the sand and gravel industry. The primary concern is over the lack of a statewide reclamation requirement for sand and gravel operations. Regardless of the outcome, regulation will likely affect the future of the sand and gravel industry in New Mexico.

Virtually all mineral deposits are mined only when a mining company believes that the operation will make a profit under prevailing market conditions. One exception to this is strategic minerals, which are those minerals deemed critical to military, industrial, or civilian needs during a national emergency. Under such conditions, some minerals could become economically viable overnight. The sources upon which the U.S. relies for many strategic minerals are often found in politically unstable countries. Over 90 percent of the world's platinum, manganese, and chromium deposits are found in the former Soviet Union and South Africa. During World War II, deposits such as those at the Harding mine were developed for this purpose.

Although strategic minerals are not mined today in New Mexico, there is the potential for these deposits to be tapped in the future. For example, manganese production from New Mexico until 1981 amounted to 1,750,096 long tons, and remaining reserves in small, low-grade deposits are abundant in some districts including Luis Lopez, Deming, and Boston Hill. The Taylor Creek district is one of the few areas where tin (used in bronze and brass) is found in the United States. Other small, low-grade deposits of strategic mineral materials including beryllium, iron, nickel, cobalt, titanium, tungsten, barite, and tantalum are found throughout the state. They are available for production if and when they are needed, should foreign sources become unreliable.

THE INFLUENCE OF THE REGULATORY FRAMEWORK

The citizens of New Mexico play an important part in deciding how or if mining is conducted here in the future. They do this by supporting the passage and enforcement of laws and regulations designed to control where, how, when, and ultimately if mines go into operation. The tide of public opinion can (and does) change, and lawmakers follow suit.

Laws are passed to address or prevent specific negative impacts from mining such as water or air contamination, but in the end they have more far-reaching consequences. If the costs a mining company must incur to comply with regulations make the operation unprofitable, then the regulations have prevented the mine from going into operation. The negative environmental and social impacts are avoided, but the minerals, jobs, revenues, and other economic benefits that would have accompanied them are lost. The current trend in public policy and regulation is toward allowing mining only if it can be done in an environmentally responsible manner that limits factors such as visual impact, truck traffic, noise, dust, and other health, safety, and environmental impacts. Perhaps the three most significant elements that have been incorporated in recent laws are increased public involvement, requirements to reclaim mines to other beneficial land uses after closure, and financial assurance requirements to ensure permit requirements are met.

Mining companies weigh the regulatory burden that applies to potential mines in different states and countries along with many other factors when deciding which options to pursue. Where does New Mexico stand compared with other states? In 2004 the Fraser Institute, an independent Canadian economic and social research organization, published a report that summarizes the opinions of many mining company executives and compares certain states and countries in terms of several factors related to mining today. This report places New Mexico fourth out of fourteen western states in terms of which state's environmental regulations are favorable to exploration investment, ranking ahead of states like Arizona and Alaska. Only Nevada, Utah, and Wyoming were considered more favorable. New Mexico ranked somewhere in the middle for most regulatory and public policy-related factors. When other countries are included in the mix, our state still ranked in the middle. Nevada consistently ranked as the most desirable state in the U.S., whereas Wisconsin and California consistently ranked as the least desirable. The methodologies and accuracy of the Fraser Institute report are not without controversy, but it is one way of taking a broad look at the industry worldwide. Although individual companies' opinions vary considerably, in general the current regulatory framework does not seem to strongly dissuade companies from coming to New Mexico. Other factors such as mineral resource potential play a larger role.

Ultimately the consumer pays for the added costs associated with complying with regulations, because these costs are included as a part of doing business. If the citizens of New Mexico wish to encourage mining, steps can be taken within the regulatory process to facilitate such development. For example, it can take many years to obtain all necessary federal and state permits to open a major mine today. This is one of the problems most commonly cited by mining companies operating in New Mexico. If this process can be streamlined and multiple agency requirements coordinated, this time period could be substantially reduced. Resource protection and land-management obligations could be simplified and consolidated into fewer programs without weakening the provisions. Through legislation and regulation, tax burdens could be cut, development incentives initiated, and infrastructure assistance provided.

Conversely, if our populace decides mining is not in the best interest of New Mexico, it can deter or effectively eliminate active mining through passage of more stringent laws, or by placing a moratorium on mining that will send mining companies to more receptive locations. Perhaps more likely than either of these two extremes is a scenario where laws and regulations are refined to reduce environmental degradation and provide citizen protections, while not preventing mining altogether. Other states and countries are likely to do the same.

ECONOMICS

Geology determines where a deposit occurs and what methods must be used for extraction. The transportation network connecting the buyer with the seller finally determines the delivered price. Beyond these basics, mining is a very competitive, worldwide, cyclic business characterized by low return on equity and long lead times to first production.

The current high mineral prices are based primarily on the rapid increase in demand, as a result of the high annual economic growth that has occurred in China, India, and other countries over the past several years, as well as a decline in the value of the U.S. dollar. China has traditionally been an exporter of many minerals, offering high grade and low price, which drove many operations out of business worldwide. China now uses much of its production internally, and is importing as well. This decrease in mineral supply and increase in demand has caused prices to increase worldwide. Increased prices bring former operations back into production, which ultimately increases supply and lowers price—perpetuating the classic boom-bust cycle of the mineral business.

In the U.S., most deposits are developed over a period of ten to twelve years, due mainly to the permitting process. This period is far longer than the mineral supply/demand cycle. Predicting mineral price and demand that far in advance is difficult, so developing a mineral deposit is financially risky. Coming online in a down cycle can seriously hamper or doom an operation. Risk is inherent in the exploration process, because only a few of the deposits evaluated are developed, and most exploration funds are spent on undeveloped prospects.

About $1.2 billion was spent worldwide in 2004 for mineral exploration. Overall mining capitalization (investments) is about $390 billion, largely controlled by international companies that are based mostly in Europe. The return on equity for U.S. mining was 10 percent in 2004. This return is up from many years of 6–7 percent, which is close to the return on equity that can be realized without such risk. This low return is similar to railroads (8.54 percent in 2004, a banner year), which have been in financial difficulties for decades. By comparison, the return for U.S. industry as a whole in 2004 was about 12 percent.

Given the narrow margins under which these companies operate, the cost of complying with financial assurance and bonding requirements severely affects the ability of these companies to see a return on their investment. Financial assurance requirements have risen dramatically in recent years and have a significant effect on the willingness of companies to do business here. New Mexico has imposed financial assurance requirements on several mining operations in the state that are among the highest in the world.

Regionally, New Mexico is in a similar situation for mineral exploitation as surrounding states. Although New Mexico has somewhat higher taxes, most western states are viewed as relatively unattractive exploration targets by mining executives, as expressed in the 2004 Fraser Institute study. The transportation network in New Mexico has pluses and minuses. On the plus side, trucking backhauls are abundant and inexpensive because New Mexico is not a manufacturing state, so more truckloads arrive than depart. The rail network is adequate, but a spur line into the northwestern coal fields would benefit New Mexico greatly. On the negative side, many areas with mineral potential are served only by gravel roads, which must be upgraded, adding significantly to the cost of mine development. Access to shipping by water is primarily through the ports of Los Angeles and Houston but requires truck or rail haul to those cities, which partly eliminates the savings associated with water transport. Overall, New Mexico mines serving local markets are partially protected from outside competition by the transport network, so the relative remoteness of the state works both ways. But mineral sales to distant markets are easily lost to competitors who have easier access to lower-cost transportation.

THE CHALLENGES OF THE FUTURE

What would it take to breathe new life into the mining industry in New Mexico, or even to maintain the status quo? Clearly a lot will depend upon increasing demand, streamlining the regulatory framework, and a favorable economic environment. Yet it is clear that the mining industry must be accountable to growing concerns over environmental issues. It is difficult to predict how all of these challenges will resolve themselves, but ultimately the future will depend upon the following:

- Water. There is not a single industry in New Mexico whose future does not depend upon both access to water and the ability to guarantee protection of the quality of the state's water resources.
- Environmental concerns. There must, indeed, be a way to do it right, and the public increasingly demands this.
- A willingness on the part of the population to say, "Yes, in my back yard, if our economic well-being and way of life depend upon it. But with a few caveats."
- The mining companies must be good neighbors. And this has to do both with perception and with reality.
- The issue of sustainable development. The mining industry must find a way to fit into this developing model, which has more to do with *how* the industry does its business than *where*, and for *how long*.
- The nature of the regulatory framework. Although laws are sometimes designed to be obstructive, the process itself should not be.

Many of these challenges are not unique to this industry; they reflect the realities of our time. Facing these challenges successfully will depend upon a willingness to communicate and collaborate, a reliance on the best that science can offer, and an inherent concern with both the environment and our quality of life.

—*The Editors*