Proceedings of the 15th Annual British Columbia Mine Reclamation Symposium in Kamloops, BC, 1991.
The Technical and Research Committee on Reclamation

MINE RECLAMATION AND SUSTAINABLE DEVELOPMENT

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Sustainable development has become a common phrase in today's language, much like the term ecology was in the 1960s. The concept of sustainable development appears to be simple, yet its definition as applied to real issues is elusive. The questions raised include: is mining sustainable? what is sustainable development with respect to mine reclamation? sustainable on regional or global dimensions? sustainable over what period of time? The concept of sustainable development as applied to mining must develop a meaningful working definition that incorporates non-renewable resource management within the economic realities of society and the desires of preservation and conservation. Much attention has been given to planning for exploration, pre-mining extraction and active mine operations, without concern of sustainable development or sustainability. Even less attention has been devoted to the concept of sustainability following the active phase of a mining operation. The additional question to be addressed is what does sustainability or sustainable development mean in the context of mine reclamation?

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La réhabilitation des sites miniers et le développement soutenable

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Le développement soutenable est devenu une expression courante dans le langage d'aujourd'hui, un peu comme le mot écologie dans les années 60.

Le concept de développement soutenable semble simple, et pourtant, sa définition, lorsqu'appliquée à des questions réelles, reste plutôt evasive.

Les questions qui se posent sont: est-ce que l'exploitation minière est soutenable? que signifie "développement soutenable" dans un contexte de réhabilitation de sites miniers? est-il question de développement soutenable dans une perspective globale ou régionale? soutenable dans le cadre de quel échéancier?

Le concept de développement soutenable, tel qu'appliqué à l'exploitation minière, doit pouvoir se définir dans un contexte de travail qui englobe la gestion des ressources non-renouvelables, dans le cadre des réalités économiques de la société et des volontés de préservation et de conservation. On a accordé beaucoup d'importance à la planification de l'exploration, de l'extraction pré-minière et des travaux d'exploitation, sans se préoccuper du développement soutenable ou de la soutenabilité. On a accordé encore moins d'attention au concept de soutenabilité après la phase active d'une exploitation minière. La question additionnelle qui doit être posée est la suivante: que signifie la soutenabilité ou le développement soutenable dans un contexte de réhabilitation de sites miniers?

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The title of this presentation may appear contradictory as why should reclamation be necessary if we have achieved sustainable development? This apparent contradiction results from the common evolution of word usage from the specific to the popular, just as has occurred with countless other words and concepts, like ecology. The publication by the World Commission on Environment and Development (WCED, 1987) or the Brundtland Report, Our Common Future, brought the phrase "sustainable development" into the public arena just as The Club of Rome's Project on the Predicament of Mankind (1972), The Limits to Growth, made "ecology" a household word.

Neither concept is new! Both philosophies have been recognized for millenia by the Greek's belief of Gaia (Goddess of Earth) and by Native People's myths and legends. Both reflect comparable ideals of the interrelationships between humans and the Earth. Both reflect a change of philosophy and attitude of humans from one of conquering nature to serve our needs to one of being an integral part of nature. Ecology of the past was identified as a hierarchy of organisms (animals and plants) and environmental units, each maintaining structure and functional identity, while evolving (development) as a whole and affecting the constituent parts. This was an organismic concept that led to great public concern about the fate of Earth's organisms and human extravagance. Odum's treatise "Environment, Power and Society" (1971) extended this view of the Earth to large patterns, interrelated constituents and hybridized science, biology and engineering to systems ecology. Similarly the concepts of conservation brought forth the familiar principles of sustainable utilization of renewable resources.

The transition from ecology (organisms and their environment) to systems ecology (interaction among organisms and their environment) to sustainable development is a logical evolution of human concern. This sequence parallels human behaviour moving from the individual, to the family, to the community, and the globe. The transition also reflects the concept that the human species is an intergral part of the whole and that the common good of society (social, economic, and spirtual) depends on this recognition. The question of survival of the human species is not new. The rate at which the question being asked has accelerated. Sustainable development attempts to address the

issues that must be faced for the existence and persistence of the human species.

Why has the rate at which the question about gloom and doom accelerated? The Earth is finite as are its resources - sun, air, land, water, and minerals. Biological organisms are not finite, unless a vital resource becomes limiting. Human populations took several 10s of thousands of years to reach a global world population of 700 million by the 170Os, in the next 150 years this figure doubled. By 1950 global human population doubled once again to 2.5 billion. Or from 1700 to 1750, 90 million people were added to global numbers, while from between 1900 and 1950, ten times as many were added, in spite of two world wars, disease, epidemics, and a global economic crisis.

Consumption of food, energy, minerals, *etc.*, has grown parallel to this exponential population growth, as has waste and garbage. The total amounts of sun, air, land, water, and minerals on the Earth have not been lost. They have been made less usable (polluted), they have been redistributed (mines to households), they have been transformed (iron, carbon, and chromium to stainless steel), they have been diluted (gold nuggets to tooth fillings), and they are becoming more scarce per person. All at the price of increasing energy inputs, largely from fossil fuels (coal and oil). It is this exponential demand for resources that has more rapidly brought attention to predictions of gloom and doom and the concern about human existence and persistence (sustainable development).

Resources have been arbitrarily categorized as renewable (air and water) and non-renewable (minerals). The distinction is one of scale (time) and kind (reuse). All resources are renewable over a geologic time scale of billions of years, and reusable. This of course is unacceptable!

Along with the exponential growth of human populations and the demand for resources, society has also changed profoundly in structure and function. Communications among peoples of the globe are today almost instantaneous. The Persian Gulf War in early 1991 was watched as it happened in our own homes. The increase in population has increased human intellect and complexity of the structure of society. The public today is informed, albeit some may argue, poorly! If this be so, we are all at fault. As individuals, groups or organizations, we believe in what we are doing, be it as advocates of industrial development or that society is on an accelerating treadmill, destined to doom. We can believe that future technology will solve our problems (i.e., our children) or that we must conserve and preserve for future generations at all cost.

There are problems. We must learn to be in touch with the functions and processes of the natural world and those of

society. There must be better communication between the goal and problem definers. The actions taken to address these defined goals must strive for a balance between social policy and the mix of economic and environmental factors.

In North America, most individuals living today can trace their ancestry to a rural life style. Today, over one-half of the world's population lives in cities. The desires of this urban population have changed the concept of natural resources to concepts involving monetary value. This global urban public, technologically sophisticated, has developed an intricate infrastructure of social, economic and political institutions that control human activity. The public are greatly aware of things about them. This awareness has profound effects on public concerns about their environment. To respond to these public concerns, governments increase authoritative regulation on industrial activity and on market adjustments on commodities demanded by society. The structure is so complex that branches of the same organization, even within government, promote the very thing that the other attempts to regulate. The influence of the global public must be recognized. Recent events are clear evidence. The abandonment of the seal-fur trade in Canada, the potential loss of 100,000 jobs in the Pacific Northwest of the United States to create a 5 million hectare forest to help save the northern spotted owl, the news film report in western Europe on forest "destruction" in British Columbia, the "atom bomb devastation" of the British Columbia wilderness by the proposed copper mine from Windy Craggy Mountain on the Tatshenshini River, etc., are today's realities.

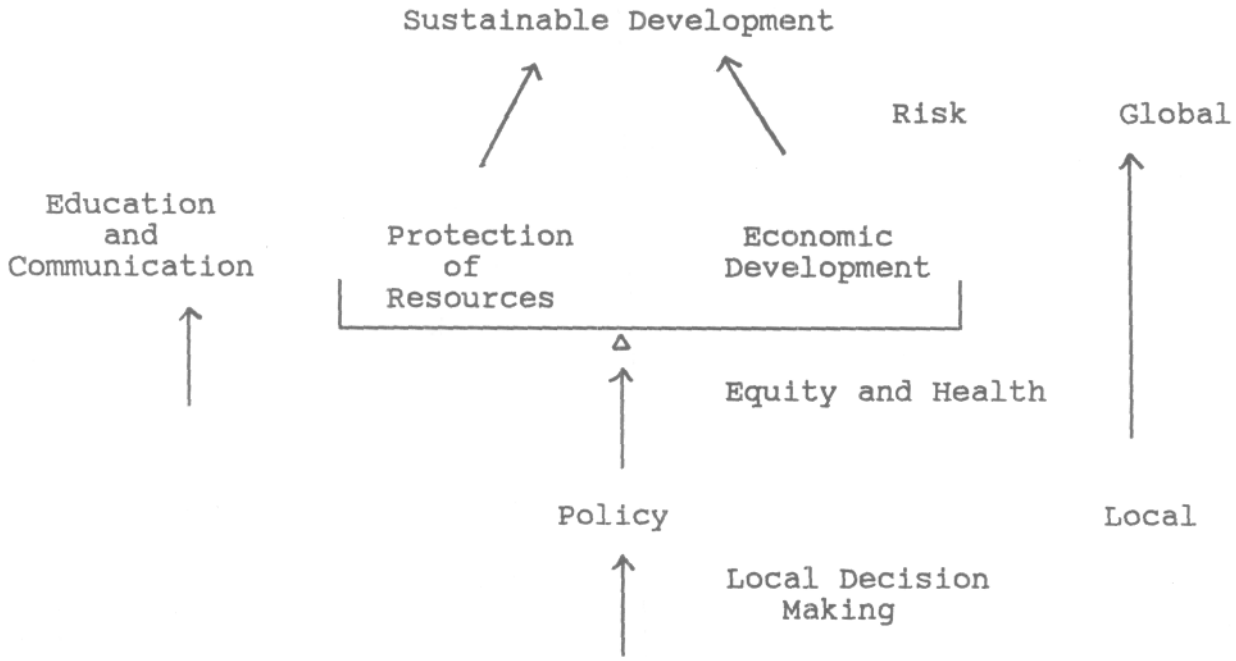
What is Sustainable Development?

Sustainable development as defined by the WCED is a "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987) and concludes that "(w)hat is needed now is a new era of economic growth - growth that is forceful and at the same time socially and environmentally sustainable". The definition leaves much room for interpretation.

In the debates that the Brundtland report stimulated, different ideas on sustainable development have emerged, (Barbier, 1987). These perceptions reflect the interpretations or emphasis given to economic, environmental and social systems and values. Some people choose to use the Brundtland report to reinforce their traditional views of increased economic development or increased environmental protection or increased social well being. Others interpret the report as emphasis on the need and interdependence of each of the objectives but apply varying priorities among the components of economic growth, social acceptance and environmental sustainability. For example, some advocate that only through economic development can humans

afford measures that conserve the environment or reduce social inequalities. To convince the public, advocates of sustainable development have coined qualifying terminology, e.g., environmentally sustainable socioeconomic development.

The common elements of the WCED report may be summarized as maintaining environmental integrity while meeting human needs, keeping social options open, and increasing global preception and awareness. The report recognizes the need for food, employment, and health in the context of less intensive need for energy and materials (resource base), reorientation of technology, bridging environment and economics in decision-making, and learning to manage risk. Or, schematically:



Sustainable development is not the new saviour of the world, just like ecology and integrated resource management did not eliminate resource concerns in the 1960s to 1980s. We must be precise in the utilization of the concept. Various interest groups use sustainable development to justify their own objectives, such as forest policy of sustained yield or the mining industry's claim that it means every proposed mine will go forward vs the avid environmentalists' claim that it means no more clear cutting or new mines.

The Path to Sustainable Development

In order to achieve the ideals of sustainable development, each individual, organization, or government has to address

three fundamental issues; namely goals, objectives, and evaluation. Too often the three issues become blurred and the failure to recognize the nature of any one of them is used as cause to diminish the others.

Goals are defined as (a) a well developed statement of the quality of life that society wants from its environment (ecosystem); (b) a description of the form or forms of production required from that environment in order to achieve the quality of life sought (this may be profit, recreation, culture, or some other product); (c) a description of the landscape and process functions in order to sustain indefinitely the production to sustain that quality of life. Goal setting is dynamic and must be under constant review and subject to alteration.

Objectives are subsets of goals and are descriptions of directions that should be followed to attempt to achieve the goals that have been set. These may be called the procedures that one sets upon to work towards the three part goal of quality of life, production, and landscape.

The third category of developing sustainable development is that of setting guidelines and problem evaluation (risk). This entails the choice of procedures to follow in meeting some of the objectives identified that move us towards reaching our goals.

The above discussion may appear foreign, altruistic, or naive. Yet when one considers the simplicity of the statements, it makes sense! The difficulty is clearly stating our goals, objectives, and problem solving procedures or guidelines. In the sustainable development concept, not only the owner or proponent or the individual sets the goals. These are stated in broad terms by local decision makers and are often not narrowly focused. This is to allow the evaluation of alternatives and maintain social policy flexibility.

Our goal could be to reclaim a mine site so that the site will maintain a productive environment not too different from other sites found naturally in the region, one that is non-polluting (risk evaluation) arid blends into the geographic setting. A rather vague yet achievable goal. The objectives to achieve this goal focuses on developing a sustainable water cycle, mineral (nutrient) cycle, energy flow, and promoting biological succession. In this sense, there is no quick fix and the objectives involve inputs from outside (seed, fertilizer, labour, etc.) and the application of knowledge of the natural system and how it functions. Without due attention to water, minerals (nutrients), and energy, there will be no biological life and thus no succession.

Everywhere on the plant Earth, there is a balanced system of energy flow, a water cycle, a mineral (nutrient) cycle and a succession of biological life forms - a living soil. The soil in

the pedological sense, does not consist of only two or three components of, say, energy (sun) and mineral and/or water, but an intricate balance among the four components of energy, mineral, water, and biological succession. It is this phenomenon of Nature that allows soil to support living ecosystems on rock, on vegetative material, in water and everywhere from the Arctic to the tropics. The systems consists of the same components, or parts, yet is different; just like human beings consist of the same parts yet each individual is different! It is the "magic" of Nature that balances these components and allows soil not only to be life, but to sustain life. *If* humans wish to sustain reclamation, then our actions should mimic Nature's successful processes. To obtain the goals of sustainable development, our actions should enhance and quicken the rate of natural processes.

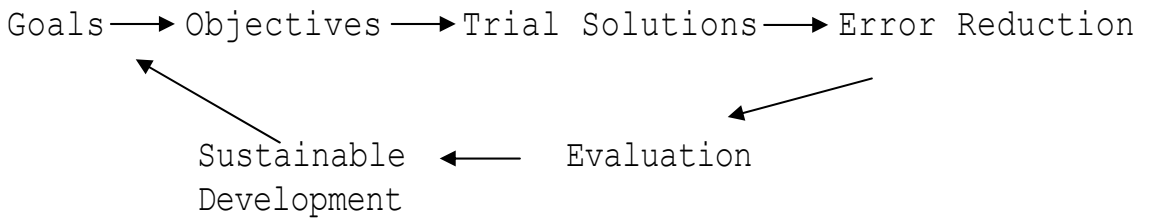
The reader will note that the objectives are not oriented to making the landscape "natural" as before the mining activity. Rather it focuses on those actions that allow humans to hasten the natural processes to make the landscape sustainable unto itself, just as Nature does. Humans do not understand Nature completely. Thus, there is a risk or probability that even with our best efforts, we may not be able to attain self perpetuating water and mineral cycles, energy flow, and succession. If so, we then reevaluate our goals and objectives and employ new techniques to move towards attaining them. This works in Nature and with Earth's processes. We should not attempt to force processes on Nature that will not work.

The setting of goals and objectives involves people and society's perception of the quality of life. If people are not involved we end up with the all too familiar proponent-opponent confrontational approach to economic development. Just as one cannot force Nature to do what is not natural, one cannot force people to accept what they believe is not right.

Some will say the procedure outlined is naive, too expensive, will take too long, and will not work. What is the alternative? To solve the problem of establishing vegetation on mine wastes, so that the site is aesthetically acceptable, and to minimize erosion. A solution could be to spread fertilizer and seed as science tells us this should make the site green. Vegetation success is found to be only partially successful, so (a) add more seed and fertilizer, (b) apply some overburden or topsoil (to decrease doughtiness), or (c) irrigate. The vegetation succeeds, only as long as irrigation is continued. Once stopped, all vegetation with high water demand dies. We have not initiated biological succession for we have not worked towards establishing the water and mineral (nutrient) cycle within the energy flow of that system. In addition, the application of irrigation water has accelerated chemical weathering of the mine waste beyond the natural rate for the system resulting in increased production of available heavy metals and acid mine

drainage. Again we have not achieved a balance between mineral (nutrient) cycles and energy flow. We have also created new problems by trying to "quick-fix" our original problem of greening-up. We now have a new borrow-pit from which we obtained our topsoil, we have altered the natural water cycle, we have an expensive irrigation system that is not working, etc. This is communicated to elected officials resulting in penalties and more restrictive regulations.

The goal setting approach, working with Nature, is not a panacea, it has risks. Can we afford not to take this risk?



Establishing goals, identification of objectives and formulating alternatives demands collaboration among managers, scientists, sociologists, economists, legal experts, health authorities and the public. The essence is communication as a continuing process. The question may be raised that this approach takes too long. Does it? Let us consider the resources and time expended over the past fifty years in attempts to "green-up" mining sites. How many sustainable reclamation projects do we have in British Columbia or Canada? That is, reclamation projects that sustain themselves, just like Nature does, having inherent in them the requisite biological balances. From our own experience, at Carbon Creek, we have documented a largely self-sustaining vegetative cover at an abandoned mine site about fifty years old. To the best of our information, Nature alone did the reclamation.

There are still problems that cannot be left to Nature alone because of the different time scales used by human beings and by Nature. Here is where we must use our understanding of natural processes to our advantage. We know, for example, Nature can produce a self-sustaining system at pH 3.5 as well as pH 8.5. When humans try we usually meet with failure, because we try the "quick-fix" approach.

Another question that may be posed is at what cost? I pose another question; can we afford not to attempt alternative paths? We do not like to believe that mining activities are subsidized by governments and therefore society. As mineral deposits become scarcer, more remote, and of lower quality, costs of mining increase. Once a mine is placed into production, (say at no cost to the public or government), who pays for the transportation network that supports the activity, the energy that powers the machinery, plants, and homes, the schools and

hospitals that are provided, the communication systems, etc? What about the environmental costs? In the United States, it is estimated that current and abandoned mines cover an estimated nine million hectares. Over 16,000 kilometers of streams in the western United States alone have been affected by off-site drainage of acid toxic wastes. This does not include estimates of air pollution, the growing evidence of human health problems or the one billion tons of mine wastes (overburden, tailings, and slag) that were produced in one year from non-fuel mining activities (Young, 1990).

It is estimated that in the United States, mine wastes exceed municipal wastes by six to seven times. It is not surprising that the increasingly popular publication, "WorldWatch" (a reference adopted for use in 1,106 courses in some 584 colleges and universities in the United States and now also available in Spanish, Portuguese, Arabic, Chinese, Japanese, Indonesian, German, Italian, French, Russian, Norwegian, Dutch, Thai, Malay and Korean - more languages than "Reader's Digest"), is influencing global social awareness and policy. The 1991 edition of State of the World - A WorldWatch Institute Report makes the following statement: "Mining ... is one of the most damaging human activities and unfortunately one of the most poorly documented. Private companies, governments, and international organizations collect and publish exhaustive statistics on mineral production, but information on its environmental cost is usually fragmented and out of date".

A more "scientific" publication, The Earth as Transformed by Human Action, (1990) published by Cambridge University Press contains the following passage (page 60): "In many places, mining is an "enclave" economy - creating towns, railways, and harbours that were more closely connected to distant markets than to the surrounding countryside. When the minerals were exhausted, only ghost towns and open pits remained".

Let me go back to my question, can we afford not to attempt new paths?

As an earth scientist, I do not even pretend to give answers and remedies, I am suggesting alternative approaches. No one discipline or profession has the answer, yet each can contribute to it.

Risk Estimation and Evaluation

I would like to address the issue of risk estimation and evaluation in the context of the probability of the occurrence of an event and its estimated consequences. This usually implies an event the consequences of which are identified by value judgment to be undesirable. Obviously the appreciation of risk can be

very different from community to community, organization to organization, and from event to event according to the base line from which it is judged.

Decisions always involve risk. There are a number of ways to estimate risk: extrapolation, reverse extrapolation, and analogue methods.

The most common is extrapolation from experience (maybe intuition). This is commonly used to project past events into the future to estimate the liklihood of the continuance of the event. For example, estimates of change in mine waste characteristics over time.

Reverse extrapolation traces backward from expected events and consequences, reducing the risks to a series of components for which experience (research) exists. For example, generation of acid mine wastes and release of toxic elements.

The third, is to extrapolate by analogue, in which experience is transferred from a different but not too dissimilar situation. For example, the probable amount of overburden and tailings produced from a variable ore deposit during active mining.

Risk evaluation transfers estimates into the social context. These may be expressed in economics or in effects. The approaches can be total avoidance or minimization of effects, such as the setting of standards and regulations; or balanced risk where some value greater than zero is accepted because of other considerations that may balance the negative effect; or cost-effective evaluation where costs are allocated to preventing injury or contamination. This is a relatively new area of endeavour in attempts to assess environmental risks, but one that is receiving greater attention.

Scientists have a major role to play in risk estimation and evaluation and in general have done very poorly. The structure of risk assessment is given below:

	Identification	Estimation	Evaluation
Methods	Testing	Intuition	Minimization
	Research	Monitoring	Balanced
	Monitoring	Extrapolation	Benefit-Risk
	Diagnosis	Analogue Transfer	
		Modeling	

The complexity of the research process involved in risk assessment, estimation, and evaluation arises from communicating the information content of research results to policy makers and the general public.

Scientific reports often identify possible existence of an environmental issue deserving more research and precautionary action. Because of the poor communication skills of the scientist, the warning or issue may be passed over or ignored by policy makers. However, the message may be modified or exaggerated in communications and a great deal of public concern may be generated. The policy maker listens and acts. At this point, scientific evidence loses credibility and emotional reactions become the norm. The suspected event or issue becomes a reality irrespective of its nature.

Response to scientific information varies with the situation of the recipient of that information. Frequently, the recipient is not in the position to understand and to act accordingly, especially to perceived and not understood environmental threats which may be subtle. Thus anxiety is generated without any information about risk or risk alleviation.

Societal concern is the result of frightening global issues (acid rain, climate change, depletion of the ozone layer). Nature's resilience may be overcome, if human beings persist long enough. This brings into question traditional economics and planning. If follows that the relationship between the human species and the environment need not be "right" economically or ethically, but must be "right" for the continuation of the human species.

To illustrate the concerns Canadians have regarding the environment, let me give an illustration of a recent poll by Environics (1989) regarding forests in Canada. To the question "what is the most important use of Canada's forests", 27% responded wildlife protection, 25% wilderness protection, and 12% logging. Regarding the question, "is it important to preserve special forest areas or ensure jobs", the reply was; 64% preserve forests and 23% preserve jobs. The response to the question, "what is the most important consideration in forest land use decisions", was 63% stating potential environmental impact, 11% potential economic value, and 9% job creation. The credibility of industry and government, according to recent polls, is at an all-time low when environmental issues are raised.

The whole process of scientific information and communication in the context of decision-making and government policy in relation to public awareness needs immediate attention. This is of utmost importance in consideration of the altruistic concept of sustainable development.

Summary

The concept of sustainable development rose from an evolution of concern by society for the world about them. Concern about the state of the Earth is not new, but the rate at which

concern is expressed has increased exponentially congruent with population growth and the demand for goods and services. The original concept of sustainable development, as with the concept of ecology, will evolve and be changed to suit individual objectives. The phrase may lose its meaning; its impact will remain. One of the major impacts of the concept is the integration of science, economics, and social values. This has *a* tremendous impact on all resource activities, including mining and reclamation.

Reclamation usually has been carried out after an operation ceases to be active. Acceptance of the concept of sustainable development will no longer permit the continuance of this procedure. The communication process, social awareness, and the demand for a quality of life in an acceptable landscape have irreversibly changed the way we do things.

Goal setting is necessary. Goal setting that involves specialists and the public are essential in order for economic development to occur in an atmosphere of minimum confrontation and of realistic guidelines set by policy makers. The objectives to meet these goals must be in harmony with natural processes and concentrate on those processes that have been successful in nature for millions of years; namely a balance of energy flow, water cycles, nutrient cycles, and biological succession. Efforts in reclamation should be geared toward working with and enhancing natural functions and processes. To do otherwise, exacerbates problems and usually meets with failure.

Communication is an essential ingredient for the achievement of sustainable development. This must take place among specialists, administrators, and the public at large, so that policy makers and regulators are in concert with social values. In order to even approach global sustainable development, local development must be economically and environmentally acceptable. No activity, including mining or even mine reclamation, is isolated from the rest of the planet. Even if we try to isolate our activity, society will not let us. Thus, to work toward mine reclamation and sustainable development we must have a system of risk evaluation that will allow the establishment to standards and guidelines that will ensure sustainable development.

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