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SCIENCE AS THE BASIS FOR LOCAL AND REGIONAL WATER POLICY
Essential Ground Water Education For Decision-Makers

Keynote Presentation

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ABSTRACT

Throughout the world, and particularly in South Africa, the sub-surface part of the hydrologic system is playing an increasingly significant role for utility supply and as an ingredient in the local and regional economy. Ground water connections to surface water are now recognized as crucial to maintain aquatic and riparian ecosystems. With finite (although renewable) resources, there is a challenge to develop equable and acceptable water policy and to implement effective management strategies based on the concept of sustainability. Water resources are subject to increasing demands but uncertain hydrologic input. The need to find policy solutions, that the hydrologic system is capable of delivering, provides a powerful impetus to develop education strategies that will communicate scientific reality for citizens, communities and decision-makers. Investment in education and training is as important as investment in supply infrastructure. People at all levels of formal education often have mistaken ideas about ground water. Scientific literacy about basic hydrologic relationships, even at an elementary level, can help local administrators and managers ensure sustained resource delivery and protection. Water education is a critical adjunct to successful implementation of water policy.

RESOURCE PRESSURES

Two thousand years ago, the world's total human population was less than 3% of the present total. In 1900 the world population was 1 billion. Currently world population is increasing by approximately 150 people per minute and now exceeds 6 billion, with absolute numbers increasing by 80 million people per year. According to the United Nations, over one billion people do not have access to a water supply and close to three billion do not have adequate sanitation (UN, 2002). Predictions for water supply for the decades ahead are speculative, especially with the uncertainties of climatic change, but most pundits believe the disparities between demand and supply will continue on a global basis. South Africa is one of the few countries with the political will, the technical know-how, administrative systems in place and the economic basis to transform its water supply infrastructure. The target is supply to all citizens by 2008 (Sonjica, 2004). Based on the last ten years of achievement, this target does not appear to be unrealistic. Since 1994, the South African population not served by water supply has been reduced from 14 million to 5 million, and the population without access to adequate sanitation has dropped from 21 million to 16 million (Kasrils, 2004).

Eighty percent of all disease in the world can be traced to drinking and washing with unsafe water supplies. Even with low per capita water use (20-40 liters minimum for drinking and sanitation), lack of water limits community health, economic progress, and food production. Ground water sources are the only supply option in most rural areas.

Globally, 80 million hectares of farmland have been degraded by a combination of salinization and waterlogging (Hinrichsen, et.al., 1998). World food production will require a two to threefold increase per hectare to meet 2025 projected minimum food requirements. Irrigation accounts for 67% of global water use, with industry using 19% and utility & residential 9%. Overall efficiency of irrigation worldwide is estimated at around 40%, and it is increasing efficiencies of agricultural water use that will allow for some of the increased demands for water for industrial and utility supply. One of the solutions to solving resource pressures is to use more sophisticated measures in water management. Where conditions allow, aquifer recharge, ground water banking and conjunctively managed surface and ground water will assist with balancing compromises among food production, industrial development and improvements in utility supply infrastructure.

When aquifers are exploited in excess of natural recharge or become contaminated, there is real risk of environmental, economic and social crisis. In addition to direct health risks and economic upheaval, contamination of aquifers usually results in a permanent net loss to the national resource inventory. The challenge is to meet growing needs from finite resources, allow for development of industry and settlement while maintaining (and restoring) the planet's life support system.

SUSTAINABILITY

The "Dublin Principles" established by the International Conference on Water and the Environment in January 1992, recognized that water resources are finite and vulnerable and that sustainability should be a management objective. Sustainability is a logical basis for ground water management and protection policy. Sustainable water use supports the ability of human society to endure and flourish into the indefinite future without undermining the integrity of the hydrological cycle or the ecological systems that depend on it (Gleick et al., 1995). Conservation is often perceived as the solution to resource scarcity. It can certainly help with sharing the resource at a particular time. However, because the hydrological system is dynamic, water not used may not necessarily be available for a later time.

Implicit in the word sustainability is a defined a level of water use over a certain time period. In reality, supply at a certain level may only be sustainable within "risk boundaries" based on the vagaries of hydrologic input. Understanding risks, and the statistical realities of hydrology, needs to be a specific education target for water managers and users. In semi-arid areas, drought contingency for agriculture may simply be a subsidy and a wait for the rain. For domestic supply purposes, where even a day without water is unacceptable, there should be a conservative approach to "risk" when assessing supply potential.

As a resource with great economic, environmental and political significance, ground water is of interest and concern to a wide number of constituents. The determinations of water allocations move beyond hydrology and encompass economics and political decisions. In reality, ground water policy may be a hybrid artifact occurring as a by-product of policies developed for areas such as economic development, public health, endangered species or agriculture (Stone, 2003)

SCIENCE

The public and non-scientists should not be frightened by the words *science* and *technology*. Science is around us every day and is not (as is the perception of some people) the exclusive domain of nerds in white coats closeted with their experiments in laboratories. In the world of cell-phones, satellite TV and I-Pods, virtually the whole world is now linked and connected with the products of science and technology. The education of 21st Century citizens (and their communities) about the occurrence and management of water should provide a basis for recognizing the basic building blocks of scientific learning. Education has the overarching objective of helping people lead fulfilling and responsible lives. Water, is a, if not the, most basic and critical ingredient of life support. At a fundamental level, science explains the interdependency of all living things and their dependence on the environment. Science should foster an intelligent respect for nature, the basics of sustainability concepts and an understanding of the impacts that technology and land use decisions can have on natural resources.

Trained ground water specialists use "science" as the basis for their work in characterizing ground water and devising schemes to access, deliver and manage the resource. If ground water scientists do a good education job in explaining what they do and how they do it, they will be spreading the fundamental basics of science as a subliminal ingredient of their outreach. Science involves the systematic application of highly regarded human values such as integrity, diligence, fairness, curiosity, and openness to ideas, skepticism and imagination. The rigor of the scientists' work, and awareness of the principles of scientific methods can help citizens learn to detect the symptoms of doubtful assertions and arguments. Scientific habits of mind can help people deal with issues involving evidence, quantitative considerations, logical arguments and uncertainty (Rutherford, 1994).

Mathematics, closely linked to science, is a process of building and applying abstract logically connected networks of ideas. The mathematics of geometric relationships is particularly important in describing, explaining and predicting ground water movement and storage. Technology is an outgrowth from science. Engineering can be considered as is the systematic application of scientific knowledge in developing and applying technology. Engineers devise strategies of design to solve practical problems. Applications of technology in engineering devices to move and store water can have a direct impact on the hydrologic system. Scientific research should be an integral part of the basis for aquifer development designs and operation procedures.

Water policy, developed at the political level, needs objective information and considered opinions from the verifiable data sets, testable hypotheses and predictive models of water scientists. In the case of ground water, the subsurface part of the hydrologic system, a combination of geologic and hydrologic expertise will typically form the basis of informed input, with additional scientific input from specialists such as chemists, mathematicians or microbiologists. The key to putting science into ground water management policy is to make the science of the sub-surface hydrologic system understandable to the policy-makers and the citizens whose interests they have been elected to serve. The challenge of creating some basic scientific literacy for non-experts, and for training new inexperienced employees entering the workforce with resource related responsibilities, is a major responsibility for those who are already qualified and experienced in ground water science.

POLICY

It is important to integrate hydrologic information, economic forecasting and social planning into resource policy decisions. Information and informed explanation (education) are important for policy, particularly because many issues are complex. There can be a disconnect between scientists, policy makers and the public because technical, academic and engineering professionals may not be adequately integrated into the political decision-making process. An additional reality is that science may be neutral but scientists are not necessarily neutral (Walker & Mairs, 1999). Data sets do not in themselves provide answers. Education of the constituent groups that can influence policy makers can reduce the effects of misinformation from exaggerated "spin" of hired-gun experts, or misinformed (but plausible) interest groups seeking to influence policy.

Agency authority can provide regulations but regulations should follow policy; policy should not be formed by regulation. Acceptance by the regulated that there is a rational need for regulations is an important prerequisite to making rules workable. Education needs to be a key element of regulation in order to achieve cooperation and compliance. Voluntary self-policing is important for many aspects of ground water protection.

In educating the public, the messenger can be as least as important as the message. There is an inherent tendency to disbelieve information from parties with a vested interest in a policy decision. One of the most important aspects of water resources policy is to ensure that those affected have an opportunity to participate. The earlier on in the process that citizens are involved, the more likely they are to cooperate. Ideally the whole community should be involved in decision-making to balance the risks, costs and benefits of water development/ protection/ allocation policy. Policy makers want to have the support of the people they serve, and policy with public support is more likely to work! (Stone 2003, 2004)

MANAGEMENT

A management process is required to implement water policy. Guidelines for policy and for management are somewhat similar because of the critical importance of feedback reports of implementation success or failure that can help to refine or redefine policy objectives. Management of resources and resource use can occur at many different scales and involve many different jurisdictions. Managers of ground water at the local level will be more effective as stewards, data collectors and as feed-back reporters, when they understand the whole hydrologic system of which their specific responsibility is a part. There are several key elements involved in developing management strategies:

COMPREHENSIVE APPROACH

The sustainability paradigm implies a long time frame for ground water management. Changing social demographics, evolving regional economics and potential technological innovations are ingredients that require some planning flexibility. Water management strategies should involve the interests of current and potential users. Including a broad base of technical experts can avoid professional bias in decisions, and collaborative agency oversight can preclude overarching claims of a single decision-making jurisdiction.

GROUND WATER A COMMODITY

The policy of providing "free" water to citizens does not mean that ground water in not a commodity. The value of ground water includes its environmental/ecological values in addition to the direct benefits derived by private sector enterprise and the local, regional and national economy. There are some key economic questions that require assessment, such as: who benefits from the current use of water? What is the value of water if used for some other purpose? Will a particular water management decision benefit one group more than another? Who has rights to the water? Who has the rights to allocate the water? Carving up the water pie presupposes that someone knows the size of the pie? Mother Nature may unpredictably provide annual water pies of different sizes. In an arena of shortage, the calculation and prediction of pie-size puts the ground water scientists' work under close public scrutiny.

MANAGEMENT TIME FRAME

Water policy should address more than the short-term benefits that accrue to the direct user. If the policy includes built-in over-exploitation, then social costs of non-sustainability should be factored in, and the price of the "exit strategy" from an over-exploitive or contamination related development should be borne by the beneficiaries. Enlightened policies provide management frameworks to equably reconcile water availability and needs. Good science, informed citizens, and a long-term perspective of economic development priorities are essential ingredients to avert the social and economic consequences of over use. Sustainability has moved from a scientific exercise to political reality because of stress between human population and natural resources. The resource management principle is changing from, how much water is needed and where do we get it? to how much is there and how can it best be used? Management objectives are set by policy. Education can powerfully influence policy decisions.

HYDROLOGIC SYSTEM

There is a logical reason to consider all water, surface water or sub-surface water as a single resource. In the integrated resource concept, one person's down-stream is another person's up-stream; one community's wastewater is another community's source water and today's ground water is tomorrow's river base flow. The drainage basin (watershed) has long been recommended as an ideal unit for water management, for example in the classic work by Richard Chorley, (Chorley, 1969). It is a fundamental prerequisite of ground water management that policy be based on an understanding of the local hydrologic conditions. A regional perspective is needed in cases where the groundwater occurs as part of a wider geologic system of recharge and storage. There may be strong jurisdictional precedent for separate surface water/ ground water management strategies but it is likely that an integrated approach will become even more prevalent. As watershed focused management becomes more established and more data are shared there should be less "turf wars" among overlapping jurisdictions.

SOCIAL COSTS

Legal ownership of ground water varies considerably among and within countries. The uniqueness of water as a basic human need elevates the resource to a high plane of consideration in terms of equable allocation decisions. State by state in the US and throughout the world, there is a sad litany of instances of ground water resources being degraded by contamination. The concept of environmental justice has been applied to management decisions relating to environmental impacts as well as to resource allocation such as deepening large wells for "big-users" at the hydrologic (and social) expense of "little users." At the 2002 Earth Summit in Johannesburg, Nelson Mandela said that it was the absence of access to clean water that was most stark in the widespread impoverishment of the natural environment.

PUBLIC AND STAKEHOLDERS

Decisions about water resources are usually too important to be made by a single group of specialists. Education can broaden the boundaries of inclusion. The challenge for the groundwater-educated super-elite (hydrogeologists & engineers) is to explain ground water's scientific "mysteries" to a range of constituencies so that the resource may be appropriately valued, cherished, protected and managed. Sharing in decision-making provides a wider sense of ownership and creates greater understanding of the supply allocation challenges faced by politicians.

EDUCATION STRATEGIES

VESTED INTERESTS

The role of the media in highlighting local environmental issues and the ease of communication via the Internet has made it difficult for environmental issues to remain hidden. There is a growing recognition among the public of wider societal concerns for health, the environment and the quality of life. With demand greater than supply, overall public awareness and concern about ground water issues is also influenced by a greater recognition of vested interests (I want it for my water utility, I want it for my trout stream, I want to irrigate my crops, Its mine by right, I want it, I want it….). There are very strong territorial and possessive emotions concerning ground water that are particularly apparent when there are private sector proposals to develop resources, or if regional water plans involve water transfers. The possessive psychology with regard to water is particularly manifested if a development proposal involves transfer across political boundaries. The response of communities can generate great need for education strategies to educate the community about the value (scarcity) of its resources.

TOP DOWN

Many excellent ground water education programs are tactical elements of a public policy strategy, and are typically related to public health issues and often funded by government. Targets of such programs include informing the public about hazardous waste collection, creating homeowner awareness about the importance of testing private wells, encouraging riparian buffers and providing information about benign alternates to lawn & garden chemicals. An extension of this form of ground water education outreach extends to agricultural and construction practices where education is seen as a critical adjunct to regulation. Education is especially relevant in areas where individual behavior can have an impact.

Working for Water is a South African program to prevent or manage alien plant species. "WeedBuster Week" was a top down initiative in 2004 to create local awareness of the problem and to strengthen the public's attitude and behavior. In nine years over one million ha. of invasive alien plants have been cleared with annual water savings estimated at 50 million cubic meters (DWA, 2004). This type of top down public education program can create local awareness and learning that can stimulate continued grass-roots concern and eventually the potential for bottom-up initiatives about local water issues.

The relative role of government and independent NGO groups in environmental education varies considerably. The ground water education programs of independent education groups may be funded from tax-based revenues, often on the basis of competitive grants. There can also be inter-government department funding of education programs that usually involves an agency transferring funds to a local unit of government for a specific education purpose.

BOTTOM UP

Citizen groups, usually self-financed or with private sector funding, may use ground water education as a tactical element to influence public policy or proposed local water management strategies. Examples of citizen concerns are; local opposition to planned industrial development near a local aquifer or a local campaign for government funding for a regional wastewater disposal system. In such cases, education endeavors are often directed at fellow citizens with the intent of influencing ballots for specific legislation or management proposals. Many citizen concerns relate to land use proposals. The concern for water is often the most potent card to play in influencing opinion, but there may well be other issues such as increased traffic, opposition to low-income housing development, pressure on schools etc. which are the main underlying reasons for an awareness and information campaign in the name of ground water.

TRAINING

While much public education is aimed at non-experts, there is an important element of public education in many of the training programs for people directly or indirectly involved in water supply. This is particularly the case with development projects involving ground water. Developing countries may not have an experienced workforce pool, resulting in appointments to the responsibilities of a job title that are not justified by the individual's exposure to training. Community education is often an essential project element for ground water based supply infrastructure improvements. Community buy-in and acceptance of new water supply sources is essential for behavior changes needed to protect resources from contamination or overuse (Stone, 2000).

In all countries there are professions such as health workers, sanitarians, building inspectors, realtors, and septic system designers that are peripherally involved with ground water issues. Basic ground water education can greatly enhance their capability to "speak-up" for ground water as they go about their daily work. For example, when a realtor (estate agent) lists a property with a well, knowledge of the significance of basic well construction, well performance and local ground water conditions can allow for a more accurate description. A sanitarian may be highly trained about the biology of organisms, but without some geologic and well construction education would have an imperfect understanding about potential contamination vectors.

One arena for training need is for new irrigation farmers, recently allocated agricultural land, who often lack experience in agricultural practices and who may have an imperfect understanding of "cause and effect" with regard to water use and protection of aquifers.

STAKEHOLDERS

There is every reason to inform the public about the scientific, technical and economic aspects of water problems so that citizens can be involved in helping to formulate policy options. The concept of stakeholders is based on the notion that many different groups may have an interest in being involved with policy decisions An important element of ground water education is to create forums for stakeholders to voice opinions and to support or challenge the scientific and economic basis for water policy. Framing the issues in an objective scientific context is important when creating a forum that has the intent of influencing public policy. Such forums or meetings should be seen to be balanced, collaborative and inclusive and not proscriptive or one-sided. There may be suspicion if one agency or entity dominates the process of selecting and promoting education forums or meetings. Water Users Associations in South Africa could provide a valuable focus for stakeholder education.

ROLES FOR GROUND WATER PROFESSIONALS

Ground water scientists can play an important education role in selling their science to the public and hence serve as a link between science and decision-making. An important strategy of ground water educators is to mobilize small armies of foot-soldier volunteers to carry the messages to their targets. Enthusiasm is a most critical element for a successful volunteer. A professional background in the arena of ground water, when appropriately channeled, can be a very powerful adjunct to enthusiasm for the resource. There are several obvious ways in which ground water specialists, in a volunteer role, can help bridge some of the "us and them" attitudes among, the public, interest groups, regulators and decision-makers. For example; by volunteering to support local education programs as a presenter; by offering to talk to school students; by encouraging clients to include a line-item for ground water education in contract budgets, and by promoting active education outreach as an objective for professional associations.

A recent partnership initiative between SRK Consulting and Ukhahlamba District Municipality in the Eastern Cape has begun a pilot program to stimulate the interest of local schools in ground water. This type of cooperation can provide valuable input to help de-mystify ground water – and additionally stimulate interest in water related work opportunities. Volunteer public education assistance can be particularly effective from academics, most of whom have teaching material that can be adapted for citizen audiences. Ivory towers can serve as lighthouses to illuminate ground water issues, and hence lead to enlightened management decisions. Providing objective information without bias is a prerequisite for effectively communicating with the public and local communities. Citizens generally view universities and their academics as sources of unbiased information.

JARGON & EDUCATION TOOLS

Awareness, information, training, teaching, public relations and outreach are words often used indiscriminately under a broad umbrella of education. They are all important! Choosing the best teachable moment can have a positive impact on the effectiveness of the message. Targeting education information by rifle-shot may achieve more results than making a lot of education noise by a shotgun approach. South African initiatives such as the Women in Water, and Youth in Water Awards programs help focus attention on water issues. Workshops, water festivals, site visits, development of school curriculum materials, interactive simulation programs, videos, teacher training, posters, pamphlets, informational press releases, etc. are a few examples of the potential educational tools that can be used. In all cases, the objective of a proposed education initiative needs to be clearly stated in order to prepare the best strategy. Almost any initiative can incrementally add to overall understanding of the importance of ground water management and protection. One of the greatest problems in helping people understand the issues is to "educate" those people who think that they understand!

EDUCATION RESOURCES

The development of education programs can benefit from professional input. Just as experts are needed to advise on technical aspects of water science and engineering, so too should community education experts be consulted to help choose among the huge arsenal of potential techniques. The constant need for promoting awareness can be compared with the annual advertising campaigns of multi-national companies. Everybody knows that the particular products or services exist – but constant reminders, via a variety of media stimuli are judged to be important for sales. Educators are sales-people too, and an effective education campaign will benefit from a level of attention, planning and investment similar to a major commercial marketing campaign.

CONCLUSION

"South Africa is a water scarce country. We know we must be circumspect in the way we use water, that we must conserve it and instill in our fellows and children a respect for its value to all things living. Yet for all our awareness, we are not close to solving our water problem. There is just not enough of the stuff. …..this is a dry country are if we are to survive we must find the solutions to optimize what we have." (Business Day, Jan 6th, 2005).

"We need to learn how to value water. While in some instances that may mean making users pay a realistic price, it must never mean depriving already marginalized people of this resource. It is one of the crueler

ironies of today's world water situation that those with the lowest income generally pay the most for their water." (Kofi Annan, UN Secretary General, June, 2003 UN Environment Program Report.)

Solutions to problems, and recognition of water's value are key ingredients of ground water education. The achievement of a basic understanding of ground water science by decision-makers helps the successful transition from awareness to concern, and from concern to action. The key to long-term education success is teaching decision makers how science works, not simply what science has discovered. Citizens made more aware of their local aquifers will feel connected in a way that enhances a feeling of natural synergy between people and their resource base. There is an important resource stewardship role for "ground water literate" stakeholders at all levels of decision-making. Ground water educators speak for the water molecules in all the world's aquifers. Like evangelical preachers – ground water's cadre of educators is convinced that the environment, the economy and quality of life are enhanced by their work. The need is for more converts!

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Some of the content and structure of this paper has drawn from two recent unpublished presentations by the author on the subject of science, education and ground water policy. These presentations are referenced above as (Stone, A.W., 2003) and (Stone A.W., 2004).