The 10 -Year Agenda For Protecting Minnesota's Waters

Working Paper

EQB Water Resources Committee
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Summary

Our Vision

The future of Minnesota depends in large part upon the future of its water resources. This future is influenced by the demands we place upon water as a result of population increases and economic growth, and through the associated waste disposal, land use, and water use practices. In order to protect the resource, we must understand how these activities taken together may affect it. We must also take the necessary steps to prevent damage to water and the people who use or are affected by it. Striving toward a holistic or integrated management of our water resources must be our emphasis.

The Agenda

The EQB Water Resources Committee identified six priority areas for water resource protection: 1. water supply protection, 2. infrastructure, 3. information, monitoring and assessment, 4. reduction of environmental pollutants, 5. managing the use of land and water, and 6. communication and education. Major issues which must be addressed were then identified within each area.

Each issue under a priority area is presented in three parts: title with brief description, ten-year objective, and major actions required. Research needs within the priority area are also presented. These were identified by WRC with the assistance of the Water Resources Research Center and the Water Resources Coordinating Committee of the University of Minnesota.

1. Water Supply Protection. Ample supplies of high quality waters are, and will continue to be, important to Minnesota for domestic, recreational, commerical, industrial, agricultural, and fish and wildlife uses. Future threats to these supplies can be anticipated from droughts, demands from other less water-rich regions, contamination emergencies, over use, and population growth. Possible impacts from global warming must also be considered. Actions to deal with these threats are needed to ensure our supplies.

- Well Protection.
- Standards.
- Water Availability.
- Global Warming.

2. Infrastructure. Minnesota's water resources infrastructure, including water and wastewater treatment systems and dams, has current needs which will increase in the future as these systems age. At the same time, government funds for infrastructure improvements are decreasing, and were never intended for replacement, repair or maintenance of previously funded systems. The ability to pay for system improvements will be of even greater concern in small communities and as the proportion of those on fixed incomes increases. Increased pressure from lakeshore and exurban development must also be addressed.

- Wastewater Collection and Treatment Systems.
- Water System Distribution and Treatment (including individual wells.)

3. Information, Monitoring And Assessments. There is an urgent need to organize information so that it is readily available. In addition, we lack much baseline information about our water-related resources and about the impacts of pollution on fish and wildlife. Finally, compatibility issues must be addressed due to the growing number of data automation systems.

- Water Resources Trends Monitoring and Reporting.
- Data Automation and Integration.
- Hydrogeologic Atlas/Regional. Assessments/Sensitive Areas.
- Monitoring Contamination Effects on Various Populations.

4. Reduction Of Environmental Pollutants. Minnesota has made major strides in reduction of primary or traditional pollutants from point sources. However, water quality problems still exist in both surface and ground waters from nonpoint sources and toxics. Issues include products such as pesticides which are used on the land, pollutants transported in the air, and biotechnology which offers both threats and opportunities for water quality improvements. Sources must be reduced and cleanup methods must be found. Approaches must be holistic, so that we do not trade one problem for another.

- Toxic Pollutants.
- Other Potential Problems and Opportunities.

5. Managing The Use Of Land And Water. Future increases in population will lead to increased pressure on land and water. Threats include increased development pressure on shoreland and sensitive and unique areas, such as wetlands, steep areas and rural lands. Pressures for economic development and increased returns will also threaten agricultural land, urban land and forests. Recreational pressures on lakes and rivers will also increase. An integrated approach is needed to resolve and eliminate conflicts.

- Holistic Management of Land and Water
- Sustainable Development.
- Strengthen Integrated Management Capabilities.

6. Communication And Education. Citizens, local governments, and others need to understand how they can obtain information or provide information to the state. Training is also needed to assure a broad understanding and provide needed skills. Issues, programs, and research results must be communicated with a view toward total environmental effects.

- Develop and Implement a Communication and Education Plan.
- Training About Range of Water Issues and Programs.
- Refining the State's Public Participation Process.

Priority Area 1
Water Supply Protection

Ample supplies of high quality waters are, and will continue to be, important to Minnesota for domestic, recreational, commerical, industrial, agricultural, and fish and wildlife uses. Future threats to these supplies can be anticipated from droughts, demands from other less water-rich regions, contamination, over use, and population growth. Possible impacts from global warming must also be considered. Actions to deal with these threats are needed to ensure our supplies.

ISSUE: Well Protection

Statewide, 75 percent of all Minnesotans receive their drinking water from wells. In addition, 93 percent of the state's municipal water supplies use wells, and wells are also important to irrigation and other commerical/industrial uses. Clearly, protecting wells, and the ground waters that feed them, is of vital importance to the state.

To protect wells we must: 1. contruct and maintain them properly, 2. seal them when they are no longer in use or pose pollution problems, 3. protect the wellhead area, that is the surface and subsurface areas that supply water to the well, from contamination, and 4. monitor the quality of the water in the wells.

The requirements for well construction and sealing were strengthened through the Ground Water Protection Act of 1989, and some moneys for well sealing were made available. However, additional efforts are necessary to deal with the estimated 1,500,000 abandoned wells in the state. Finally, the number of public (17,000) and private wells in the state make both enforcement, wellhead protection and monitoring difficult.

Ten-Year Objectives: To have effective Well Management and Wellhead Protection Programs for the state such that: 1. wells are constructed in accordance with well code requirements; 2. newly abandoned wells are sealed on a routine bases; 3. existing priority abandoned wells are sealed; and, 4. wellhead protection controls are in place for existing municipal and all new community wells and are proceeding for all public wells, and guidance is in place for private well users.

Major Actions Required During The Decade

- Locate abandoned wells, establish priorities for sealing, and develop and implement methods and funding for sealing priority wells.
- Increase delegation of well program to local units of government and strengthen enforcement efforts.
- Implement a continuing education program for well industry.
- Conduct studies to support development of wellhead protection policies, including determining local governments' legal and financial needs and resources to implement controls and develop necessary responses.
- Develop guidelines for public wells for defining wellhead protection areas and preparing management plans, and generic guidelines for private wells.
- Coordinate federal and state control efforts in wellhead protection areas.
- Develop and institute monitoring options for private wells.
- Computerize well management and monitoring data systems.
- Monitoring to ensure program effectiveness.

ISSUE: Standards

Standards for water resources consist of water quality standards for surface water and ground water, drinking water standards, and health risks limits. These standards are used in our water resource protection programs, and provide the gage for judging whether the waters are suitable for their intended uses. They are used for health assessments and cleanup criteria, and to evaluate and develop best management practices and water resource protection requirements.

Standards must be routinely reevaluated and revised to reflect our growing knowledge of impacts of contaminants. Surface water standards are currently being revised to include procedures for standards development and actual standards for 75 parameters. The federal Clean Water Act requires reevaluation and revision of standards based on priorities identified by the Environmental Protection Agency. Future areas are expected to cover several aspects of toxics, as well as lake and wetland standards.

The Ground Water Protection Act of 1989 calls for Health Risk Limits to protect those who drink ground water. The limits apply to all ground water. The Act has a goal of preventing degradation, which must be factored into existing programs.

Drinking water standards apply to the state's 12,000 public water systems (which may consist of more than one well) and are required through the federal Safe Drinking Water Act. Amendments to the Act required testing for 83 parameters starting in June of 1989.

Twenty-five more will be added every three years beginning in 1991. While providing increased protection for those people on public water systems, the costs of monitoring is high and will continue to be of concern.

Ten-Year Objective: To develop, implement, and update water quality standards to address toxics; and to implement the Ground Water Protection Act of 1989 requirements for incorporating the degradation prevention goal into water quality regulations and developing Health Risk Limits.

Major Actions Required During The Decade

- Develop standards for toxic pollutants, including pollutants in sediment, to limit pollutants to those levels shown to be least harmful. Standards must be established for air toxics as well as surface and ground water quality. Cleanup goals are also needed.
- Enact procedures for developing effluent standards and incorporating toxics into permits.
- Adopt biological criteria to evaluate overall environmental health, and water quality standards to protect wildlife in those situations where wildlife, or their habitat or food sources, are more sensitive than man.
- Adopt lake standards and water quality standards to protect wetlands.
- Develop Health Risk Limits.
- Revise existing rules to incorporate the requirements and degradation prevention goal of the Ground Water Protection Act of 1989.
- Expand and integrate systems for monitoring for compliance with standards.
- Reevaluate and revise standards on routine basis.

ISSUE: Water Availability

Minnesota has long been viewed as a water-rich state, but situations, such as the drought of 1988 and contamination problems, bring new awareness to this view. Because of the importance of water to so much of Minnesota's economic base - agriculture, forestry, mining, industry, and tourism - water availability and management will continue to be a critical concern for the 1990's.

Ground water and surface water are both important and interrelated. Some Minnesotans have lost their water supplies due to contaminated wells, others to drought. Pumping ground water for activities such as irrigation has depleted stream flows in some areas, reducing recreational use and adversely affecting fish and wildlife habitat. Better statewide quantitative information about ground water supplies is needed to address these issues.

The state regulates the amount of water used for commercial, industrial, municipal, agricultural and other purposes. Still, water appropriations have occassionally exceeded the amount of water available. With increasing water withdrawals in many parts of the state, potential out-of-state diversion, and the possibility of seasonal or long-term drought conditions, this problem could expand rapidly.

Effective mechanisms, such as water allocation planning, water emergency planning and conservation, must be developed to balance water supplies and diverse demands. In addition, the complexity of the issues calls for coordinated action at both the state and local level.

Ten-Year Objectives: To maintain surface and ground water supplies that meet long-term requirements for basic necessity, environmental protection, and economic vitality.

Major Actions Required During The Decade

- Develop state water allocation policies to address future interbasen transfers and out-of state water diversions.
- Accelerate the determination of ordinary-high-water levels for lakes and protected water flow levels on rivers and streams.
- Develop plans and programs for water conservation and drought and emergency preparedness.
- Develop aquifer capability estimates to establish optimum use limits.
- Improve computer-based information systems for surface and ground water hydrologic information, expand the observation well network, and increase collection of hydrogeologic information, including preparation of hydrogeologic altases.

ISSUE: Global Warming

Predictions of human-induced climate change within the next decade are becoming increasingly credible. Climatologists predict a 3 to 9 degree F rise in average temperatures over the next 60 years, unless worldwide efforts to reduce greenhouse gas emissions are undertaken. Even with such efforts, past emissions are expected to result in warming over the next few decades. These small climate changes can lead to serious problems in water supply, flood control and other resource planning areas that

could negatively impact Minnesota's water resources and quality of life.

Ten-Year Objective: To minimize the negative effects on Minnesota's water resources and the potentially serious economic and environmental problems that may result from global warming.

Major Actions Required During The Decade

- Establish Environmental Compact of the States to deal with interstate issues.
- Track national and international literature and trends, and identify system sensitivities and possible impacts on Minnesota.
- Foster research on possible Minnesota scenarios and adaptative measures.
- Foster prevention, particularly energy and water resource conservation and wetland preservation, both within Minnesota and worldwide.

Research Needs

1. Identification Of Contaminated Wells. Techniques are needed for locating contaminated and abandoned wells, for developing priorities for sealing abandoned wells, and for determining recharge rates of multi-aquifer wells.

2. Sustainability Of The Ground Water System. Research is needed to address the capacity of the ground water system to meet future demands. This research could include such topics as location of aquifers, storage capacity, water availability, optimum withdrawal conditions, improved model development, better definition of sustainable yield, vertical hydraulic conductivity and recharge rates of surficial and deeper aquifers, and mitigation of existing contamination and yield problems.

3. Quantity/Conservation. Research on water demand and conservation are needed, including return water to aquifers, artifical recharge and secondary use. Impacts of seasonal and climatic fluctuations on ground water levels and availability should also be researched and correlated with the use of ground water.

4. Sensitivity. Geologic sensitivity should be evaluated, including correlations between land use, sensitivity and quality, and susceptibility to contamination. New techniques for developing ground water sensitivity maps are needed, focusing on protection of confined aquifers.

5. Wellhead Protection. Research is needed on existing or new models to help predict impacts of contamination sources on ground water recharge zones.

6. Defining Ground Water-Surface Water Interactions. Interconnections between ground water and surface water are ill defined and can result in water quality impacts. Research is needed to locate interconnections, to develop new ways to accurately define the flux of ground water and surface water interaction particularly in areas of potential conflict, and to develop predictions and remedial actions for case-study problem lakes.

7. Hydrogeologic Data Base. There is an ongoing need to better understand the state's complex groundwater systems in bedrock and glacial aquifers. Specifically we must continue a) the county atlas program, b) the regional assessments program, c) regional aquifer studies, and d) groundwater data base development through the systems. Comprehensive interagency county level studies should be urged.

8. Water Policy. Several areas of water policy should be researched, including Indian treaty rights regarding land and water issues, water use policy, and the legal, economic, policy and institutional aspects of interbasin transfers.

9. Extreme Events. Research is needed on the hydrology of extreme events, including floods and droughts, hydrologic forecasting, and drought management.

10. Research To Support Development Of Standards And Criteria. Standards and criteria for specific pollutants are important tools for environmental regulators. Research to support these efforts is critical. Examples of areas where research is needed include examination of the relationship between pathogens and recreation, examining the effect of high sulfate concentrations in water on wild rice production, the development of biological critieria using fish and benthic macroinvertebrates to more directly assess the biologic integrity of Minnesota's surface waters, development of water quality criteria for sediments, and the synergistic effects posed by combination of pollutants such as pesticides in drinking water on human health.

Research is also needed on the synergistic effects of a combination of pollutants, including pesticides, in drinking water on human health.

Priority Area 2
Infrastructure

Minnesota's water resources infrastructure, including water and wastewater treatment systems and dams, has current needs which will increase in the future as these systems age. At the same time, government funds for infrastructure improvements are decreasing, and were never intended for replacement, repair or maintenance of previously funded systems. The ability to pay for system improvements will be of even greated concern in small communities and as the proportion of those on fixed incomes increases. Increased pressure from lakeshore and exurban development must also be addressed.

ISSUE: Water Supply Systems

Drinking water is supplied to Minnesotan's through public water supply systems and private systems (primarily wells). Public systems include municipal, institutional and apartment complex systems that serve residential populations, as well as schools, health care facilities, motels, parks and gas stations that serve nonresidential populations. There are more than 17,000 such facilities in the state, and an estimated 300,000 to 500,000 private wells.

A recent survey of municipal suppliers, to which approximately 50% responded, identified $43.8 million in needs. These included funds to remedy health-related problems, develop new supplies and upgrade or renovate facilities. These cost, however, reflect only the costs for responding municipalities to meet existing standards, and do not include costs for distribution systems or costs necessary for public water supply systems to comply with the federal Safe Drinking Water Act Amendments of 1986. New requirements include filtration for surface water sources and disinfection for all sources, except those receiving variances.

A large portion of the capital costs required to upgrade treatment facilities will be placed on small public water systems. Since these small systems serve a small number of people, the per capita costs of compling with new treatment requirements may be extremely high. In addition, a large portion of the infrastructure elements of the state's water supply systems have been in service between 20 and 50 years.

Aside from several small grant programs and Super Fund situations, cities must pay all the costs associated with financing their water systems. The same is true for other public water supply systems and private systems. As the impacts of decades of inappropriate waste and toxics materials management begin to show up in our water supplies, we must deal with processes for water treatment and procedures for financing improvements.

Ten-Year Objective: To ensure that Public Water Supply infrastructure needs are met for compliance with the federal Safe Drinking Water Act, and that options and guidelines for private systems are developed.

Major Actions Required During The Decade

- Inventory Public Water Supply compliance and future replacement needs and develop cost estimates.
- Develop and implement financing mechanisms for construction, maintenance and monitoring for both public and private systems.
- Evaluate treatment techniques for both public and private systems and assist the public in making treatment decisions.

ISSUE: Wastewater Treatment Systems

Approximately 75% of Minnesotan's receive wastewater treatment through centralized treatment systems ranging in size from the Metropolitan Wastewater Treatment Plant in St. Paul to group systems serving several dwellings. The past 20 years have seen continuous growth in the construction of wastewater treatment plants, primarily due to passage of the federal Clean Water Act in 1972 which encouraged the construction of wastewater treatment facilities by providing 75% grants. Since 1967, more than $1 billion in state and federal dollars has been granted to municipalities for wastewater treatment plant construction.

Construction of wastewater treatment facilities over the past two decades has brought significant improvements to Minnesota's lakes and streams and dramatically decreased violations of water quality standards. However, over 100 Minnesota communities are still waiting for first-time financial assistance to construct new or improved wastewater treatment facilities. In addition, the facilities already constructed must be maintained, operated and ultimately renovated when they reach their estimated life span of 20 years. Expansion of existing facilities will also be necessary as various areas of the state experience

economic growth and economic development.

Since 1985 the amount and percentage of federal funds available to communities has decreased. With the federal Construction Grants Program ending in 1990, more burden is being placed on the state grants program to provide enough funds to maintain Minnesota's high standard of water quality. The State Independent Grants Program includes state independent grants, corrective action grants, reimbursement grants and funds for administering these programs. Funds for the State Independent Grants Program are very critical for communities to be able to afford to construct wastewater treatment facilities in the future.

To take the place of the federal Construction Grants Program, a revolving loan fund is being funded with state and federal dollars to provide continuing funding for remaining improvements. The state must continue to provide matching funds to receive federal funds to capitalize the Water Pollution Control Revolving Fund. This loan approach will, however, place far greater financial responsibilities on local government for development of future treatment facilities.

Remaining needs for new facilities are primarily in communities with very small populations, and lower ability to pay. Innovative solutions to financing and solving wastewater treatment problems must be found so that these communities receive as much support as the larger communities in achieving treatment objectives. An example of an innovative program is the Individual On-Site Treatment Systems Grants Program which assists upgrading failed on-site wastewater treatment systems. This program was developed as a response to communities with failing on-site systems, where it is neither necessary or cost-effective to construct a collection and centralized treatment system. The impacts of these individual systems must, however, be scrutinized to ensure that they do not become tomorrow's problems. Privatization of municipal facilities is another approach to solving wastewater treatment problems of small communities.

Finally, the impacts of storm water systems on water quality must be further evaluated and systems and requirements upgraded as necessary. The separation of combined sewers in Minneapolis, St. Paul and South St. Paul has been proceeding since 1985, and is projected to be finished in 1995. This separation will eliminate the overflow of raw sewage into the Mississippi which now occurs with heavy rain or snowmelt. The impacts of discharging untreated stormwater and snowmelt are not well understood at this point and must be further evaluated. Further upgrades may be necessary in the future to maintain and improve the water quality in the Mississippi as it flows out of the Twin Cities.

Ten-Year Objective: To ensure that wastewater treatment facilities meet and continue to meet the health and environmental protection needs of the state.

Major Actions Required During The Decade

- Continue funding and support of the wastewater treatment independent state grant program and revolving loan fund.
- Develop and enact alternative funding systems addressing particularly small systems and low income populations.
- Develop innovative and inexpensive alternative treatment systems for small communities and individuals.
- Enact requirements for a wastewater treatment facility replacement fund within each municipality for financing future infrastructure improvements.
- Continue the Combined Sewer Overflow Abatement Program, and at the same time evaluate the impacts of the discharge of stormwater on the Mississippi.

Research Needs

1. Water Treatment Techniques. Effective, inexpensive techniques are needed for full scale water treatment plants plus point of use and point of entry treatment systems in situations where there is no alternative to the use of a contaminated water supply.

2. Grout Types. Development of new techniques and evaluation of existing techniques is needed with regard to effectiveness and permeability of grouting materials.

3. Structural Integrity. Evaluation of the integrity of engineering structures such as underground storage tanks and water distribution systems is needed.

ISSUE: Solid Waste Disposal Facilities

Protection of water resources has been a driving force shaping solid waste management policy and programs in Minnesota. Twenty-five years ago, the norm was disposal of all solid waste in town dumps where open burning occurred more often than burial. Concerns of air pollution and unsanitary conditions led to closure of these dumps and the transition to landfills which were constructed and operated to minimize the air pollution and unsanitary problems. However, ground water monitoring showed that the landfills were generating leachate which contaminated ground water. These landfills are now being upgraded and replaced with engineered features to protect ground water including liners under the waste and leachate collection systems. Problems with ground water contamination and

costs of up-to-date landfills have increased the attractiveness of alternative technologies like waste-to-energy incinerators.

This evolutionary scenario demonstrates the interrelationship between environmental media, and re-emphasizes the need for holistic solutions. The protection of air and surface water quality can led to ground water contamination, and now protection of ground water can lead back to potential air quality impacts. Leachate collection, too, protects ground water but may impact surface water quality by overloading wastewater treatment plants with pollutants they were never built to handle. All these concerns must be weighed and balanced as we move forward in solid waste management.

Money is a resource central to this issue. In the past, most facilities were privately owned. The increasing cost and needed rigor of environmental controls has discouraged many private landfill operators, leaving large corporations and local governments in charge. Defaults and abdication of responsibility by facility owners have demonstrated that it is too easy to defer costs and not prepare for future needs. The revised solid waste rules make this harder because they compel current accumulation of funds to cover responsibilities in the future, when there is no more income because the site is closed. These fund accumulations are based on projections of the long term (up to twenty years post-closure) care costs for each ton of waste buried, and apply to all landfills statewide.

To cover costs of landfills which closed without this financial asssurance, as well as costs incurred after the twenty-year period, the Metropolitan Landfill Contingency Action Fund (MLCAF) was established in 1984, for landfills in the seven-county metropolitan area. A similar fund for landfills in the rest of Minnesota was established in the Waste Act amendments of 1989.

While not without problems, these funds provide a vital first step in seeing that environmental concerns are met with actions needed to prevent or remediate impacts which may occur. The state Superfund is currently being used to remediate environmental problems at some landfills. However, funding for Superfund is a critical issue.

Alternative technologies, too, need good long-term planning. For incinerators, air quality standards must be met, and ash and other residue disposed in an environmentally sound way. Incineration reduces the waste in volume significantly, but 15-20% of the volume of the incoming waste remains to be disposed. Alternate disposal facilities must be found, to cover "down-time" at the incinerator and to properly handle the ash and other residuals produced. Financial planning is needed, too, with an eye to maintainance and replacement costs. Similar concerns apply to other alternatives such as compost and recycling facilities. At this time, no state funds or guidelines have been developed which apply to financial assurance for incinerators or other alternative facilities.

Ten-Year Objectives: To to manage solid waste in ways that minimize the environmental impacts which may occur from it's disposal. Waste reduction and recycling are major components of this effort.

Major Actions Required During The Decade:

- Production of less waste is critical. Alternate products, packaging, and practices must be encouraged.
- Reduction of the waste stream through encouragement of the "reuse, reduce, recycle" philosophy. Efforts just begun as a result of the SCORE initatives must be continued and improved throughout the decade.
- Detoxification of the solid waste stream must also continue. Household hazardous waste collections and encouragement of use of alternate, less toxic products are important to this effort.
- Those disposal facilities which remain must be carefully monitored to ensure their integrity.
- Financial assurance is needed for waste facilities, to cover costs incurred in the long-term care of the waste once disposed and for incinerator replacement and maintenance. Financial reserves need to be planned and provided through appropriate mechanisms and cooperation at all levels of government.
- Continued funding for Superfund.

Research Needs:

Landfill gases: Methane and other volatile organic compounds typically are components of the gases generated by landfills. Research is needed into effective ways to manage and eventually reuse these gases.

Leachate treatment: The current practice for leachate treatment is to discharge the leachate to a wastewater treatment plant. Leachate is a highly concentrated waste, and may tend to overload treatment plants. The pollutants in teachate, too, are different than normal wastewater components and may not receive the treatment necessary in a typical wastewater plant before discharge to the environment. The waste sludges produced may also become more of a problem when leachate is added to the wastewater stream. Research is needed into ways to more effectively handle leachate in wastewater treatment plants, and in developing alternate technologies for leachate treatment.

Priority Area 3
Information, Monitoring, And Assessment

There is an urgent need to organize information so it is readily available, fits with related information to provide a total picture, and can demonstrate trends in the environment. Agencies collect vast amounts of information for specific purposes and much is not readily available to other users.

We lack much baseline information about our water-related resources and about the impacts of pollution on species such as fish and wildlife. Needed baseline and trend information can come from accelerated collection of missing data and from organizing the present data collection system with a view toward obtaining a complete picture.

Local government is using state water-related information and also collecting its own data. To continue the partnership between state and local government, information needs to be easily shared.

There is an explosion of computer software for collecting and compiling data. There are already several Geologic Information Systems in use making interchange of information time consuming and costly. The EQB needs to take the lead in assuring state systems are readily compatible. Local government also needs to use compatible systems.

ISSUE: Data Automation And Integration

Geographic Information Systems are automated systems that can provide maps integrating information on land and water that are useful in understanding relationships in the environment. A user can analyze basic information on rivers and lake characteristics, wells, and ground and surface water quality in the context of soils, land use, topography, and geology information.

In the 1970s, the state developed the Geographic Information System MLMIS 40. This system provides information based on 40 acre parcels. Today there is a demand for data in much greater detail. Development of other Geographic Information Systems underway around the state prevent easy exchange of data. If other agencies or governmental units cannot readily have access to data, time and money will be wasted compiling data again for other systems.

Automation of data has come a long way in the state, however, important data is not computerized, is missing, or is out-of-date. Integration of data from multiple sources is a key to effective analysis of water rersources problems. Data collected for a particular program can be difficult to obtain for other uses. Even if data are compatible, access to multiple data sources is difficult unless it is integrated onto one system.

Ten-Year Objective: To establish a detailed Geographic Information System housed at LMIC that is readily accessible for other users.

Users will be able to obtain access to data on surface water, ground water, and related land resources from multiple sources that are automated and integrated onto one system.

Major Actions Required During The Decade

- The Natural Resources Geographic Information System (NRGIS) proposes standards for data classification, automation in geographic information system format, and data interchange.
- The Environmental Quality Board ensures that compatibility standards for data collection and automation are developed and followed.
- Agencies developing individual layers of information provide access through the Land Management Information Center.
- Develop ground water data integration and retrieval system.
- Develop an integrated system for retrieving stream, lake, and related watershed information.
- Expand the System for Water Information Management (SWIM) as a means for promoting integration of ground water, surface water, and related land resources data.
- Water related data is integrated and made available to users through the Land Management Information Center.

ISSUE: Water Resources Trends Monitoring And Reporting

Resource monitoring is usually done for a particular purpose and not to provide a broad understanding of the environment and changes over time. Our limited historic data usually were not gathered or compiled to evaluate resource trends. Lack of a coordinated monitoring strategy leads to gaps in information and hinders the transfer of information. In many places, baseline resource information is not available. This provides a poor background for analyzing impacts of current pollution problems.

Local governments preparing local water management plans look to the state and federal government for information. Many have or are initiating plans to collect specific water-related information. A comprehensive approach is needed that ensures baseline resource information and trend information are collected and analyzed.

Ten-Year Objective: To institute a system that provides adequate baseline resource information and trend development capability.

Major Actions Required During The Decade

- EQB, working with state, federal, local governments, and researchers, coordinates the development of a state water monitoring strategy that is periodically updated.
- Multiple and related uses are built into the collection and automation of data to provide needed baseline and trend information.
- Continued development and enhancement of surface and ground water models for water protection and management.
- Improved understanding regarding the affects of climate, the age of water, the interconnection between ground and surface water, and between water and land uses.

ISSUE: Hydrogeologic Atlas/Regional Assessments/Sensitive Areas

Understanding the ground water system is much more difficult than understanding the surface water system. Due to cost and complexity we have tremendous gaps in our basic knowledge about this vital source of water most people rely on for their water uses. We know that in some places ground water is more easily contaminated from land uses than in other places. We are seeing some of the results of past actions reflected in ground water quality.

There several activities underway to provide information about the ground water system. These include detailed county hydrologic atlases, regional assessments, sensitivity studies, and hydrogeologic modeling. Those regulating activities, whether state or local, need access to good information so they can direct their actions toward protecting the resource.

Ten-Year Objective: To develop a good understanding of the ground water systems and how to prevent contamination.

Major Actions During The Decade

- Complete hydrogeologic studies for the buried drift aquifers in western Minnesota that are the principal sources of supply for the communities. (This includes areas around Crookston, Breckenridge, Canby, and possibly Worthington, Marshall, Granite Falls, and Redwood Falls.)
- Complete County Geologic Atlas studies for a third of the state.
- Complete regional hydrogeologic assessments for the Anoka sand plain, the St. Cloud-Alexandria area, the Iron Range counties, and the Moorhead to East Grand Forks area.
- Ground Water Assessments underway in South Central and North Central Minnesota are used in state and local planning.
- Models are developed for assessing ground water sensitivity. Depth-to-water information must be collected across the state to support these models.
- State and local government work together to achieve appropriate controls for ground water protection.

ISSUE: Monitoring Contamination Effects On Various Populations

Minnesota fish are not presently tested for a number of toxic chemicals which are known to contaminate fish tissue. Yet we know there are high-risk human populations in Minnesota which consume large quantities of sport-caught fish. In some cases these populations take fish from waters where there are fish consumption advisories. These populations include the Fond du Lac reservation and the Hmong.

In addition, numerous species of wildlife eat fish which are contaminated. The nature and degree of impact on wildlife is unknown. The state has sampled fish in less than 300 of the more than 15,000 lakes. Since testing of all lakes and streams is not feasible, models are needed to predict problem hot spots.

Ten-Year Objectives: To better understand and assist populations affected by contaminated fish and wildlife, and understand the extent of fish and wildlife contamination.

Major Actions Required During The Decade

- Expand the sampling of fish for contaminants.
- Expand the sampling of wildlife for contaminants.
- Develop models to predict problem hot spots.
- Determine the nature and degree of impacts on affected populations.

Research Needs

1. Integrated Data Base Development Determine the feasibility of assembling hydrogeologic data (well logs, springs, water quality, etc) into an assessable

user-friendly system that combines water quality and water availability data. In order to manipulate data efficiently, an accessible, transferable, and integrated data base must be created within a system that is compatible with the existing data sources. Information systems that should be integrated and be part of this data base should include the SARA Title 3 entries, data bases for SPA, MDH, DMA, MGS, Federal Agencies, etc.

Procedures are needed to assure and monitor the consistency and quality of the information. Mechanisms for ongoing quality control of ground water data (e.g. field verification, hydrogeologic interpretation, geographic information system) are also needed.

2. Management and Accessibility of Locally-Collected Water Information Investigate and establish a system for collecting and disbursing information that ensures compatibility between and among units of government.

3. Contaminated Site Data Evaluation Data from environmental audits and contaminated sites is extensive and could greatly expand the current data base. This data should be analyzed and correlated with information about the hydrogeology.

4. Geographic Information System The statewide GIS system should be enhanced and research on Using GIS in watershed managment should be pursued. Pilot projects are needed using soils, ground water data, land use, topography, and other water related data entered onto a Geographic Information System and used for improving watershed management.

5. Technology Transfer A number of pilot studies need to be carried out at different scales (regional sensitivity mapping, delineation of wellhead protection areas) and in different geohydrologic and/or ecoregion of the state. These projects will serve as field demonstrations for technology transfer, as pilot studies to develop general methodologies, and as a means to verify and validate the complex simulation models and the simpler application models.

6. Climate Change Climatic change effects such as decreased precipitation/increased temperature and decreases in number of seasonal wetlands and length of time wet must be evaluated.

7. Ground Water Age-Dating Age-dating of ground waters should be undertaken on a statewide basis. This is especially important to do while the "window of opportunity" provided by nuclear testing of recent decades exists (before the radiation reverts to background levels). Improved methods for age-dating that involves various isotopes and contamiants, should be pursued.

8. Hydrogeologic Investigations Regional aquifer or county studies are needed in areas of growing ground water use or areas of existing or potential conflicts regarding ground water use, including 1) Twin Cities area, and 2) Western tier of counties in Minnesota. In addition, guidelines are needed for hydrogeologic investigations in Minnesota's karst settings.

9. Aquifer Characteristics Research is needed on methods to better delineate buried drift aquifers, including innovative research involving surface geophysics, downhole geophysics and existing information. Research is also needed on depth to water table statewide, vertical hydraulic conductivity, and recharge rates not only for surficial aquifers but also for deeper aquifers like the Mount Simon.

10. Sampling Technique Sampling techniques are needed to improve ease of sampling. Research is needed to develop surrogate tests, and other innovative techniques for various materials, including organics, to provide good, inexpensive screening of waters. Efforts are also needed to develop cost-effective and innovative methods to monitor lake, stream, and ground water systems from a quantity standpoint for small watersheds.

11. Quality Control/Quality Assurance Quality control should be evaluated in present monitoring programs. Better quality assessment and quality control procedures for monitoring programs should be developed.

12. Monitoring Efforts Efficient and effective monitoring programs need to designed at state, regional, site specific scales. In addition, Lake monitoring programs should be promoted, and natural resource monitoring for soil loss and water quality should be improved.

13. Trend Analysis There is a need for a broader ambient network than currently exists in order to understand trends in quantity and quality of ground water on a statewide (aquifer-wide) basis. Trends should be assessed in sensitive systems (e.g., aquifers, wells) for critical, health-related contaminants.

14. Fish and Wildlife Impacts Impacts of bioaccumulative pollutants, including mercury and PCB's, on fish-eating wildlife should be determined. In addition, the number of toxic chemicals fish are analyzed for should be expanded and models to predict lakes and streams with contaminated fish should be developed. Cooperative fish tissue monitoring should be pursued, as should Analysis of existing data bases by inter-agency networks to improve the understanding of factors controlling fish production.

Priority Area 4
Reduction Of Environmental Pollutants

Minnesota has made major strides in reduction of primary or traditional pollutants from point sources. However, water quality problems still exist in both surface and ground waters from nonpoint sources and toxics. Issues include products such as pesticides which are used on the land, pollutants released and transported in the air, and biotechnology which offers both threats and opportunities for water quality improvements. Sources must be reduced and cleanup methods must be found. Approaches must be holistic, so that we do not trade one problem for another.

The environmental degradation now being suffered in Northern Europe shows how human activities in populated areas can affect remote areas far away. Acidic deposition, in the form of acid precipitation and acidic dryfall, has virtually wiped out fish populations in many Northern European lakes. This pollution came from industrial smokestacks hundreds of miles away, and was carried north by the wind. The acidic components can be scrubbed out of the flue gases to a large degree, but the sludge that is formed in the scrubbers can seriously contaminate surface or ground water if not aggressively contained. For this reason, it is imperative that our environmental "fixes" be holistic in nature. We must not spare one part of the environment at the expense of another.

ISSUE: Toxic Pollutants

The increasing level of environmental pollution is an alarming trend. Small quantities of toxic pollutants are now found even in remote areas and formerly pristine lakes. Some discharges of pollutants are obvious, like the wastewater discharge into streams and lakes. Spills and leaks also are easily recognized as a source of pollutants, and cleanup back to pre-impacted conditions is not always possible.

Less obvious are the pollutants which result from nonpoint sources. An example of this type of pollution is that which results from the land application of pesticides, where surface waters may be impacted by polluted runoff or ground water may be impacted by pesticides which leach from the fields and migrate downward.

Even more subtle are those pollutants which volatilize from a number of human activities and are carried by the winds to be deposited in remote areas by rain or dryfall.

Ten-Year Objective: To minimize the impacts of toxic environmental pollution. This may be furthered by a number of means, including gaining a better understanding of the effects of small quantities of pollutants, developing and enforcing numeric criteria for toxic pollutants, and control of pollutant sources to reduce releases as necessary for environmental protection. The development and implementation of effective plans are a critical part of this.

Major Actions Required During The Decade

- *Evaluation of Impacts Resulting from Toxic Pollutants* - Pollutants have been detected throughout Minnesota in surface and ground water, precipitation and wildlife. In the next ten years we must improve our understanding of the impacts on human health and the environment which may result from this pollution. This understanding is critical to the establishment of numeric criteria for toxic pollutants which will minimize the negative impacts.
- *Control of Acid (Toxic) Precipitation* - Although Minnesota has the first and still toughest acid rain standard in the nation, impacts on vulerable Minnesota lakes continue to occur. Research now indicates that more than 90% of the emissions causing acid rain in Minnesota come from outside the state. Already, acid precipitation has decimated lakes in the northeastern United States and Canada, showing that this problem is global in nature. Our challenge in the next ten years will be to continue to work with other states in controlling acid and toxic emissions, in a forum such as the recently proposed Environmental Compact of the States.
- *Control of Facilities Which May Discharge Toxic Pollutants* - Minnesota has made major strides in reduction of primary or traditional pollutants for point sources. Expansion of our state's economy, however, means that more waste will be generated and must be dealt with. Regulation of facilities must reflect appropriate environmental goals and incorporate the numeric criteria developed for toxic pollutants.

  Solid waste can be reduced through reuse, reduction and recycling, but these technologies currently seem more difficult and costly to consumers than disposal. One major challenge in the coming decade will be to implement the 1989 recycling legislation and change the current mindset through education, market development, regulation and incentives.

Wastewater generation will also increase, requiring more funding for construction, upgrade and monitoring of wastewater treatment facilities. Air quality standards will need to cover toxic pollutants as well, and must be rigorously enforced as the economy grows.

Storage of products such as gasoline and agricultural chemicals will also increasingly affect the environment, and must be effectively managed. Cleanup at these sites will also be a major effort over the decade, with as many as 10,000 cleanups anticipated at petroleum tank sites.

- *Management of Pesticides* - The use of pesticides has become the standard practice in modern agriculture, helping to guarantee that major infestations of weeds or insects do not significantly affect crop yields. Valuable as this is, the land application of these chemicals has also increased the environmental pollutant load.

  Monitoring for pesticides must continue and increase in the next decade, as must research into pesticide breakdown and migration. We must also evaluate impacts of pesticides and pesticide breakdown products on surface and ground water, and develop cause and effect relationships.

  In the next two years the Minnesota Department of Agriculture will develop the state's overall pesticide management plan, as well as specific plans for individual pesticides. The development and subsequent implementation of these plans will coordinate public and private efforts to minimize effects on water quality.

ISSUE: Other Potential Problems And Opportunities

There are both old and new issues which do not fit into the conventional pollution management techniques. Among them are the old and yet very current problem of nitrate contamination, the reduction of the toxicity of the waste stream produced by human activities, public information on toxic releases in their area, and biotechnology. These and other emerging issues will ensure that environmentalists and regulators are challenged in the coming decade.

Ten-Year Objective: To address the challenges which current and new issues present in ways that are both holistic and far-sighted.

Major Actions Requires During The Decade

- *Management of Nonpoint Sources of Pollution* - Nonpoint sources of pollution account for significant environmental pollution in Minnesota. Since the sources are so numerous and diffuse, effective management can only be accomplished through an approach which includes education, technical assistance, regulatory incentives and a strong committment from all levels of government from local through federal. In the next ten years we will need to develop a comprehensive and coordinated nonpoint source and water quality management program which builds on the start we have made to date through programs like the Comprehensive Local Water Planning efforts being undertaken by local governments and the Clean Water Partnership.
- *Management of Nitrates in the Environment* - Ground water contamination from nitrate is widespread in Minnesota, especially in areas most sensitive to ground water contamination. Nitrate may cause some human health problems, especially in young infants, and is also indicative of other potential problems like the presence of pathogenic microorganisms. The presence of nitrate and other nutrients in surface water leads to growth of algae and other undesired aquatic plants, and affects not only aesthetics but also fish and wildlife populations.

  The sources of nitrates are ubiquitous, ranging from wastewater to manure to commercial fertilizer. To begin to get hold of this problem, the Minnesota Department of Agriculture and the Pollution Control Agency will be developing a nitrogen management plan in the next two years. Implementation of this plan in the remainder of the coming decade should bring about more effective nitrogen management practices, and lessen the environmental impacts.
- *Reducing Generation and Disposal of Toxics* - Since human activities frequently lead to waste and result in pollution, we must do what we can to reduce the toxicity of the waste which we generate. Efforts must include investigating and promoting alternatives to polluting products, such as CFC's.

  The Minnesota Office of Waste Management is responsible for developing the Hazardous Waste Capacity Assurance Plan, which is a 20-year plan for waste reduction and management. The goal of this plan is to determine waste management capacity shortfalls and use aggressive waste minimization and new facility development to address the shortfalls. Aggressive minimization efforts include the Minnesota Technical Assistance Program and waste reduction grants.

  Efforts at consumer education and collection of household hazardous waste aim to reduce the toxicity of domestic wastes. Also, the public awareness of the release of pollutants by industry is growing, thanks to the reporting and inventory required under current Superfund legislation (right-to-know). These efforts must continue and increase in the next ten years.

- *Community Right-to-Know* - The community right-to-know provisions of the federal Superfund Amendments and Reauthorization Act of 1986 have resulted in a wealth of information being available to citizens and decision-makers in all state programs. The challenge will be the management and utilization of this data. The data available through this program will provide insight and assist in priority and goal setting in a number of areas, including source evaluation and reduction, health risk assessment and emergency response planning.
- *Biotechnology* - Biotechnology, including such activities as cloning, innoculation with previously isolated and reared bacteria, and genetic engineering, is predicted to result in changes to society and industry as great as those caused by the industrial revolution. These technologies could benefit water resources in such ways as developing microorganisms designed to clean up hazardous wastes or engineering pest resistance into crops to eliminate the need for pesticides.

  Negative impacts are also possible, like competition between released and native organisms and inadvertant development of "superweeds". Starting now, and continuing through the coming decade, we must see that the development and use of biotechnology in the state will be orderly, safe and both environmentally and economically sound.

Research Needs

1. Understanding The Hydrologic Setting. The hydrologic setting must be clearly understood before pollutants can be effectively managed. Ground water settings, for example, are complex, multi-layered, and not directly observable without expensive drilling. There are also many unknowns about the movement and mechanics of surface water in any given setting. For both suface and ground water, trends in contaminant levels must be determined. Research is needed in the following areas:

- *Ground Water Movement* - Understanding ground water movement is necessary to predict contaminant movement. More research is needed to develop techniques for determining ground water flow patterns. Some techniques which show promise are age-dating, use of tracers, temperature profiling, and surface geophysics. In addition, testing is needed to determine the vertical recharge rates to aquifers.
- *Ground Water Conditions* - Understanding ground water conditions which affect the persistence of contaminants is also necessary. For example, there are may aquifers throughout the state that may have the right conditions for denitrification (the conversion of nitrate to nitrogen gas) to occur, but we do not now have sufficient knowlege of these conditions to predict this. Soil microbes also serve a vital, and currently not well understood, role in the treatment of contaminants. The presence of oxygen in the ground water can affect both denitification and microbe populations, and more information is needed on this as well.
- *Contaminant Movement to Surface Water* - Land use activities vary widely throughout Minnesota, and so do the impacts on surface water quality which result. Much remains to be learned about the movement of contaminants into surface water bodies. For example, the sedimentation rate for lakes in different ecoregions can be determined through sediment core dating. This information will be a valuable management tool in maintaining lake quality.
- *Receiving Water Sensitivity* - Sensitivity of receiving waters for various pollutants varies widely. Better knowledge of this factor will aid in setting appropriate discharge limits for specific pollutants and waters.
- *Ground Water/Surface Water Interactions* - More attention is being placed on the contribution of ground water to lakes and streams and the resulting water quality impacts. Additional work is needed to develop new ways to accurately define the flux of ground and surface waters, and the resulting pollutant flux.

2. Understanding and Managing Pollutant Movement. Not only must the flow of the water be understood, but the movement of pollutants in the environment is also a critical factor to consider. We must be able to accurately predict contaminant movement; detect contaminants where they occur; and then remove, treat or otherwise manage the contaminants so that critical resources are protected.

- *Contaminant Detection* - The development of new, low-cost methods for screening ground and surface water for contaminants would help researchers and regulators alike in prioritizing areas for further attention. Continued development of isotope tracing techniques is needed for various pollutant sources including nitrogen and radon.
- *Contaminant Transport* - More research is needed on ways to predict the path and fate of pollutants, so that we can effectively evaluate environmental impacts. This must include consideration of breakdown products, absorption (or leaching) characteristics and transport mechanisms such as macropore flow in soils, convection in surface water bodies, sediment dynamics, etc. Predictive models must be improved, calibrated and made more user-friendly to promote their use. The role of contaminant mixtures must also be assessed in these areas.
- *Contaminant Treatment* - Innovative treatment processes have been developed and are available for certain contaminants, but their application to remediation of contaminated soils and ground water

have not been demonstrated. Biodegradation of petroleum contaminants and chlorinated solvents are becoming more widely known, and show promise, but more research is needed here, too. A related and important research need is the development of economical and effective treatment technology for water supply treatment in situations where there is no alternative to the use a contaminated water supply source.

- *Contaminant Management* - The complicated nature and large scale of regional ground water contamination problems can overwhelm the normal remedial response measures. Research is needed to aid in reevaluation of our approaches on these types of problems in terms of resource management and protection, limitations on development and ultimate costs.

3. Evaluating Pollutant Sources and Finding Alternatives. Understanding and reducing pollutant sources is a vital component of the effort to reduce environmental pollutants. Prevention and treatment of contamination of ground water and soil environments will be the watchword here. Appropriate remedial technology is needed for managing pollutants that originate from defined point sources as well as diffuse sources.

- *Impacts of Specific Sources and Practices* - Minnesota has made major strides in reduction of pollutants from many point sources, but some still remain for which the environmental impacts can only be guessed at. Examples of potential pollution sources which have not been dealt with include scrapyards, salt storage facilities, road application of salt, stormwater retention basins, and animal waste treatment facilities.
- *Alternative Compounds or Practices* - In some cases, the use of alternative compounds or practices may lessen the environmental impacts. Waste reduction and immobilization or detoxification of toxic materials are important areas where more research is needed. Other alternative technologies would include such things as applying genetic engineering to treatment of contaminated water, waste water, etc.
- *Diffuse Sources* - Diffuse sources of contaminants such as on-site sewage disposal systems in suburban settings and urban use of pesticides and fertilizers also pose a challenge to assess and quantify. Problematic, too, is finding the sources of contaminants such as mercury and PCB's found in low levels in surface water bodies to which there is no known discharge. Research is needed to determine the sources and resulting impacts of these diffuse sources.
- *Better Cleanups* - The effectiveness of cleanup techniques must be assessed as well, and alternative technologies explored to find the most economic and environmentally sound method for treating each situation. An example of an area where more research is needed is in the decontamination of contaminated soils. Here, innovative and proven technology is needed to cleanse the soil back to acceptable pollution levels. This could be cost effective and would allow the site to again be used for contructive purposes in the future.

4. Management of Agricultural Chemicals. Nitrogen and Pesticides - Nitrogen and pesticides are used throughout Minnesota to sustain current agricultural production. The potential for surface and ground water contamination by these agricultural chemicals is high in many parts of Minnesota. Research is needed to refine exisitng practices and develop new practices that protect water quality while sustaining productivity and profitability, or Best Management Practices.

- *Application of Chemicals to Meet Site-Specific Needs* - This could be thought of as "farming by kind of soil" or "prescription farming". Areas where additional research is needed include integrated pest management, soil testing procedures, the effectiveness of techniques such as split nitrogen applications or use of nitrogen inhibitors, manure testing and appropriate application rates, and using legume rotation as a source of nitrogen.
- *Development of Alternative Technologies* - Integrated pest management is an example of an alternative technology which is becoming more mainstream. Other alternative technologies which may hold promise include the utilization of green manure crops to reduce nitrogen leaching and timing and techniques for cultural weed control.
- *Development and Testing of Best Management Practices (BMP's)* - Research is needed to identify and evaluate BMP's for surface and ground water protection. One example is the management of phosphorus. We need to evaluate BMP's in their ability to reduce phosphorus inputs into surface and ground water, and to evaluate the relationship between phosphorus management and crop productivity in a variety of crops, climate and soil characteristics.

Priority Area 5
Managing The Use Of Land And Water

Growth in Minnesota's population and economy will lead to increased pressure on land and water. Threats include increased development pressure on shoreland and other sensitive areas, such as wetlands, bluffs, and rural lands. Pressures for economic development and increased return on investments will also threaten agricultural land, urban open space, and forests. Recreational pressures on lakes and rivers will increase.

Minnesota has many programs that seek to manage the use of land and water. Programs like the Shoreland Management program and Clean Water Partnership have become national models. Comprehensive local water planning is demonstrating the key job of local government in identifying problems and developing solutions.

Still, the drought of 1988 exposed weaknesses in the way land and water uses are managed. At a small development focus, subdivisions depending on shallow wells ran out of water. In some areas, homes built on poor soils developed cracks in their foundations. At a large development focus, the single dependence of the City of Minneapolis on the Mississippi River raised issues of both water conservation and river use policy.

Other problems, not drought-related, indicate need for new approaches. Impoundments for flood management raise water quality and land management issues, yet watershed programs are not linked to project approval. Bluffs along the Mississippi are developed in ways many consider unwise, without effective use of local or state land management programs.

The challenge is to coordinate and concentrate local, state, and federal programs on protecting resources. A river protected from industrial pollution can be degraded by shoddy bluff development. A lake with well-managed shorelands can be made unattractive by polluted runoff from far upstream. Ground water can be the unintentional recipient of the by-products of land uses; or, it can place its own limits to growth when supplies are limited.

An integrated approach is needed to resolve and eliminate conflicts between the use and protection of land and water.

ISSUE: Holistic Management Of Land And Water Resources

We need to think about land when we manage water. We need to think about water when we manage land. We need to run state and local programs as if they were administered by one agency. This requires a special focus on the resource.

Each lake or river is unique. Each has different qualities and responds differently to demands placed upon it. Each also has unique demands placed upon it, and unique amenities that it can provide.

Therefore, each lake or river should be managed in a unique way to accommodate its special characteristics. The mix of practices, incentives, and regulations available to local, state, and federal government need to be applied in an integrated manner. The goal of this integration is to ensure that the best decisions are made for the particular lake or river.

While a special focus on the resource may enable managers and citizens to identify opportunities for that resource, unintended "external" effects need also to be considered. In particular, we must consider the effects of watershed management on ground water.

Because it would not likely be possible, initially, to approach the management of every lake or stream in this idealistic way, a pilot program focusing on selected resources is suggested for the timeframe of this Agenda.

Ten-Year Objective: To manage targeted water bodies and their related land resources holistically.

Major Actions Required During The Decade

- Establish a cooperative intergovernmental program that brings together authorities of local, state, and federal governments to manage selected rivers and lakes as units.
- Find and implement ways of effectively involving local citizens and interest groups, and local, state, and federal officials in identifying opportunities for holistic management within individual rivers, lakes, and their watersheds.
- Enact legislative changes as needed to eliminate

barriers to managing rivers and lakes as units.
- Use comprehensive local water plans as key "building blocks" for construction of comprehensive river and lake management initiatives under this program.
- Ensure that ground water concerns and opportunities are fully addressed when undertaking river, lake, and watershed management initiatives.
- Establish a program that brings together authorities of local, state, and federal governments to manage sensitive ground water systems holistically.
- Establish information management systems that facilitate management of river, lake and ground water systems holistically. This should include collection and assessment of water-related data, like land use, soil erosion information, set aside lands, flood prone lands, geologically sensitive lands, etc. on a small watershed, stream kilometer, and aquifer basis.
- Evaluate by the end of the decade the effectivenes of these new efforts in managing water holistically.

ISSUE: Sustainable Development Of Water And Land Resources

Water and related land management programs are usually geared to react to population and economic factors. Flood mitigation efforts, cleanup of superfund sites, and restoration of lakes are examples of management that is basically reactive to development. Inter-basin diversion of water to bring needed supplies to water-short regions is another example.

The concept of development that can be sustained over the long term without adverse impacts argues for a pro-active approach to land and water management. Prevention of problems is more likely to result when resource carrying capacities or limitations are accounted for in growth decisions. It should be possible to fairly and cooperatively manage growth within resource limits, rather than let uncontrolled, unplanned growth determine our quality of life and the quality of our water resources.

Ten-Year Objective: To build consideration of growth management into water and land protection programs in order to foster sustainable development.

Major Actions Required During The Decade

- Establish a cooperative local-state program to identify and manage areas sensitive to growth.
- Tie ground water sensitive areas, wellhead protection areas, water quality plans, water use contingency plans, and water allocation plans into water protection limits to be set in local areas.

  Areas with large volumes of water use, or with the likelihood of experiencing water quality problems, shortages, or use conflicts, would be the focus.

  "Water protection limits" would include best management practices, water resource protection requirements, wellhead protection measures, water quality standards, and protected stream flows and lake levels, as well as measures targeted to sensitive areas that might be designated by local government (e.g., in comprehensive local water plans).
- Link approval of inter-basin water diversion proposals to growth and water use projections and point of origin in-system (e.g., instream flow needs) needs. Diversions from growth sensitive areas would be restricted.
- Encourage the use of comprehensive local water plans as the vehicle for linking growth management concerns to land and water management initiatives.

ISSUE: Strengthening Integrated Management Capabilities

Many of the programs that can be used as building blocks to holistic management of water and land must themselves be strengthened. If we do not have all the tools necessary to identify and protect wetlands, we cannot fully integrate wetlands management into watershed, water quality, or flood management.

If we do not have an up-to-date information system — for example, with current land use, water quality and quantity data, wetland and ditch maps and characteristics, soils, and topography — then we will not be able to understand the river, lake, or ground water resource. We will not be able to manage these resources in a holistic or integrated manner.

Ten-Year Objective: To strengthen state and local capability to manage land and water uses in an integrated manner.

Major Actions Required During The Decade

- Implement comprehensive water plan recommendations according to timetables contained in the plans. Focus state efforts toward management of ground water, as well as rivers, lakes, and their watersheds targeted for integrated management initiatives.
- Promote and secure passage of a comprehensive wetland management act that incorporates a wetland enhancement and restoration policy, a no-net loss policy, a mitigation and compensation framework and an enforcement and monitoring framework. Development of a digitized mapping system for the

national wetlands inventory will also be required for effective implementation of this initiative, as well as integrated watershed management programs.
- Assess public participation in the drainage law. Identify opportunities to accomplish broad water resource enhancement that are available within the drainage program and drainage systems.
- Complete a automated statewide inventory of the public drainage systems and their characteristics.
- Statewide floodplain management regulations and local zoning ordinances need to be re-evaluated to see if they can be streamlined in order to promote administrative efficiency.
- Develop a comprehensive for evaluating a wide variety of development activities within watersheds to determine their potential impact on flooding.
- Enact legislation to protect the integrity of river and lake bluffs outside the shoreland and floodplain districts.
- Monitor to provide information on water quality trends to guide implementation of nonpoint source pollution control programs.
- Conduct comprehensive water quality assessments for major river, lake, and aquifer systems (similar to current efforts directed at the MN River).
- Continue development of Best Management Practices and technologies for identifying and controlling NPS.
- Initiate evaluation of existing programs for effectiveness in abatement of nonpoint sources of pollution (NPS).
- Provide adequate support for state and local programs geared toward holistic management of land and water.

Research Needs

1. Sustainable Development. Growth within water and land units like lakes or watersheds is dependent upon both social preferences or expectations and ecological requirements. In order to foster "sustainable development," research is needed on several water-related characteristics. These include:
- The long-term capacity of specific water bodies (including ground water) to assimilate contaminants, and to absorb uses like appropriations, recreation, and shoreland development without degradation of quality.

  This necessitates development of certain information on a statewide basis where important to assessing long-term carrying capacity. Examples include: survey of aquifer boundaries and safe yields; assessment of hydrogeologic sensitivity at the county level (through county geologic atlases); and age-dating of ground water.
- Integrated methods to identify growth sensitive areas of the state and the dominant growth-limiting factors in these areas.
- Methods to identify and mitigate economic and social impediments to sustainable development policies. In the area of sustainable agriculture, this would involve research on the potential implications of sustainable agriculture on businesses, as well as social and cultural practices.
- Procedures for allocating scarce resources in areas sensitive to growth.
- Use of geographic information systems in identifying areas sensitive to growth and their growth limiting factors. Data included in the GIS must be maintained routinely at a high level of quality (i.e., at a high level of resolution and currency). This would include detailed, up-to-date information on land use, topography, soils, hydrogeology, and quality and quantity of water resources.

2. Effectiveness of Watershed Management. The effectiveness of watershed management techniques and institutions needs to be examined. Research is needed on:
- The effect of various management practices on receiving water quality. This should include assessment of individual, ground water area-wide, and watershed-wide practices, and the effect of surface water "best management practices" on ground water. This will help in determining "BMPs" and "water resources protection requirements" called for in the Ground Water Protection Act.
- Simplified modeling of watershed processes, including the role of wetlands in watershed hydrology and water quality, and the impact of watershed activities on ground water. Improvements of predictive models like AGNPS, including simplification and calibration, is needed.
- The implementation of local water management programs. Local water planning is a key element of the Ten-Year Agenda. If local government is to fulfill this needed role, barriers encountered must be identified and addressed.

3. Integrated Pest Management. IPM, when properly used, means less chemicals applied and, consequently, less chance for water contamination. We need:
- Demonstration of the applications of IPM and documentation of the economic and environmental viability of IPM in Minnesota.
- Research on pest damage threshholds and pest control alternatives in various parts of Minnesota.
- Research on biological controls to minimize or eliminate the need for pesticide use.

4. Small Lake Water Quality/Eutrophication. Managing lands to reduce polluted runoff is a key component of managing lakes. But, in many cases, in-lake measures are necessary to improve lake quality. Lakes are

complex systems that more often than not do not lend themselves to simple solutions. Research is needed on:

- Elements of and procedures for developing comprehensive lake management strategies.
- Winter aeration technology and effectiveness.
- Lake sedimentation rates, using sediment core dating. Determination of sedimentation rates for lakes of different ecoregions and watershed sizes and types in Minnesota.
- Lake-ground water interactions including predictions and remedial actions for case-study problem lakes.
- The effectiveness of lake and wetland restoration methods.
- Techniques for addressing exotic plant problems (e.g., eurasion milfoil).

Priority Area 6
Provide Adequate Communication And Education

Continued improvement in water quality and wise management of available water will depend on individuals and groups voluntarily changing behavior. To precipitate that change in behavior, people need to understand how their actions affect the water and soil resources. The state needs to provide information about issues, programs, and research results with a view toward broad environmental effects.

An understandable state communication framework will connect the numerous actions and groups involved in water management. Citizens, local governments, and others need to understand how they can obtain information or provide information to the state. Training is needed at both the state and local level to assure that policy makers and staff have a broad understanding and needed skills.

Local government plays a key role in water management. The state needs to unify its delivery of information and assistance to local government to ensure problems are addressed in the broadest context.

ISSUE: Develop And Implement A Communication And Education Plan

Education and information are necessary for informed public participation and decision making. The state has a complex system of management and an agency's ability to provide information tends to vary considerably. Yet local and federal government and the public need to understand the broad issues and the total actions underway or needed for wise management.

The Environmental Quality Board has an education subgroup with a subcommittee on water resources. The 1989 Ground Water Protection Act requires the EQB to develop an information and education strategy.

Ten-Year Objective: To develop and carry out a water resources information and education strategy through the EQB.

Major Actions Required During The Decade

- Expand formal educational efforts so that all Minnesota children receive K-12 environmental education and appropriate water-related curriculum is available.
- Establish a process to ensure that the state's water education efforts, both formal and informal, occur in a coordinated, systematic manner.
- EQB/WRRC co-sponsors biennial water conferences (e.g. Water 88) to provide technical information to governmental staff, researchers, and others interested.
- Expand the EQB and state environmental agencies capability to provide non-formal education that bespeaks a comprehensive view.
- BWSR establishes an ongoing process to communicate with local government about land and water resources needs and programs.

ISSUE: Training About Range Of Water Issues And Programs

State personal best serve the state if they have a broad resource perspective and understand the variety of governmental actions and programs available for resource management. There is no institutionalized strategy for state staff to understand what programs are available. Such a strategy could help staff as resource managers, reduce competition between agencies (promote cooperation and coordination) and work toward a holistic view.

The state is committed to continuing the partnership with local government. In order to address water issues comprehensively, the state must be able to deal with local government in a unified manner.

The state is delegating to local government water protection and management programs. In addition, basic land use authorities rest with local government and need to be used for environmental protection. Local policy leaders and staff need to understand the issues and implication of local and state actions affecting the land and water. They need the technical capability to manage their regulations and programs and the ability to carry out delegated programs.

Ten-Year Objectives: To develop an ongoing process to meet local training and information needs, and ensure that state agency personnel serve as general resource educators with a broad understanding of programs and actions that can be used to protect or better manage water resources.

Major Actions Required During The Decade

- Ensure Minnesota schools of higher education educate enough people with technical skills to work on issues relating to the states complex hydrogeology.
- Set up a training program through the Department of Employee Relations to provide state personnel with a holistic view of the environment and an understanding of existing programs and laws.
- Establish better methods to increase communication between and by state agencies to ensure a holistic view and to provide a comprehensive link to local government.
- EQB/WRC co-sponsors biennial water conferences to provide technical information to governmental staff, researchers, and others interested.
- Conduct needs assessment based on content of comprehensive local water plans.
- Develop an ongoing process to provide training opportunities for local officials and local staff.

ISSUE: Refining The State's Public Participation Process

The state needs a well-understood strategy for public input into water policy development and for reaction to existing programs and actions. One part of that strategy should include the role and frequency of Environmental Congresses.

The Trust fund legislation calls for convening of a "Resouces Congress" every two years. The related efforts of the EQB's Environmental Congress need to complement the Trust fund work of the LCMR.

Ten-Year Objective: To have a clear process for public guidance on present actions and directions and for public input into water policy development.

Major Actions Required During The Decade

- Convene an Environmental Congress (biennially) with representatives of state, federal and regional agencies, citizen organizations, associations, industries, colleges and universities and private enterprises to receive reports and exchange information on progress and activities related to environmental improvement. (EQB priorities)
- Use biennial Environmental Congress to assess accomplishments, identify emerging issues, and to help establish priority environmental issues.
- Use annual Environmental Congress for water focus as needed;
- Continue agencies' use of task forces and advisory committees for input into specific topic areas.
- Develop standard, routine opportunities for obtaining citizen involvement in water management and policy development activities.
- BWSR establish an ongoing process for communication with local water planning and management groups and brings local water issues and priorities to state forums.
- Local water plans assessed for identification of state and local needs and used in establishing long range and biennial priorities.
- EQB work with the LCMR to ensure the Resources Congress and the Environmental Congress complement each other or are joint efforts.

Research Needs

1. Communication/Coordination. Analyze the mismatch between legal jurisdictional authority and natural systems:

- How can the fractured authority between city, county, state, and federal agencies be integrated?
- How can jurisdictional systems, natural ecologic systems, and social systems be brought into harmony?

2. Public Participation Needs. Evaluate the current array of public participation measures used by the state and recommended needed changes.

3. Education. Study the approaches needed to successfully cause people to change behavior. This could highlight non-point efforts such as reminding people of the effects of fertilizing near lakes, disposing of waste in storm sewers, and household hazardous waste management etc.

- Research how to develop a low budget mass educational campaign to change individual behavior. The approach would include such items as effective public service announcements for TV and radio.
- Analyze the use of symbols, pictures and verbal messages to bring about a resource protection ethic.