Proceedings of Interamerican Dialogue on Water Management

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MIAMI, FLORIDA, USA

October 27-30, 1993

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Sponsored by

The Florida Department of Environmental Protection
The Florida Water Management Districts
Interstate Council on Water Policy

Hosted by

South Florida Water Management District

Published by the South Florida Water Management District - April 1994

INTERAMERICAN DIALOGUE ON WATER MANAGEMENT
DIÁLOGO INTERAMERICANO SOBRE ADMINISTRACIÓN DE AGUAS
DIALOGUE INTERAMÉRICAINE DE L'ADMINISTRATION DES EAUX
DIÁLOGO INTERAMERICANO DE ADMINISTRAÇÃO DE ÁGUAS

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Abstract

This publication, *Proceedings of the Interamerican Dialogue on Water Management,* contain papers presented at the conference of the same name, held in Miami, Florida, October 27-30, 1993. The *Dialogue* provided a forum for the advancement of technical and institutional knowledge and promotion of sound and sustainable water management practices throughout the western hemisphere. Also, the *Dialogue* served as a linchpin for the consolidation of an international water resource partnership called the *Interamerican Water Resource Network,* to facilitate the exchange of information, promotion of cooperation and training among water resource professionals and institutions between North, Central, South America and the Caribbean. Emphasizing the diversity of water resource problems and solutions, emerging problem areas, and financial resource scarcity, many papers were presented under three main roundtable tracks: 1) Management of Aquatic Ecosystems; 2) Water Supply and Sanitation Infrastructure in a Sustainable Development Context; and 3) Water Governance and Policy. The *Dialogue* also hosted a series of keynote speakers, dignitaries and panelists from non-government organizations, multi-lateral financing institutions, international organizations, foreign governments, and federal, state, and local officials who presented their perspectives on the issue of water resource management, sustainable development and empowerment. In addition, traditional topics such as hydrological and wetlands research, environmental impact assessments, water supply modelling, and water policy were discussed.

Library of Congress Cataloging Data

Proceedings of the Interamerican Dialogue on Water Management, sponsored by the water management districts of Florida, the Florida Department of Environmental Protection and the Interstate Council on Water Policy; co-sponsored by the Organization of American States, Tennessee Valley Authority, MacArthur Foundation,... [et al.], Miami, Florida, United States of America; edited and published by the South Florida Water Management District, A.J. Palombo et al. (ed.)

490 p.
Includes Table of Contents

1. Water Resources - Congresses. 2. Water Resources - United States - Congresses. 3. Water Resources - International - Congresses. 4. Environment - Congresses. 5. Environment - United States - Congresses. 6. Environment - International - Congresses. 7. Sustainable Development - Congresses. 8. Sustainable Development - United States - Congresses. 9. Sustainable Development - International - Congresses. I. South Florida Water Management District. II. Interstate Council on Water Policy. III. Organization of American States.

April 1994

This publication contains selected papers and addresses from the conference *Interamerican*

Dialogue on Water Management, augmented by case studies presented during the conference. The views expressed in the papers and case studies are those of the authors and are not necessarily shared by their respective employers or organizations or the conference organizers.

Published by South Florida Water Management District

Manufactured in the United States of America

The Interamerican Dialogue on Water Management constitutes an important initiative to follow up on one of the critical themes of the Earth Summit of 1992. In the post-Rio period, sustainable management of water resources is being seen as one of the most demanding challenges confronting developed as well as developing countries. The launching of a sustained practical dialogue on this subject between the countries of the Western Hemisphere sets an important example for other regions around the globe.

Kirk Rodgers, Director of the Department of Regional Development and Environment, Organization of American States

An Illusion of Plenty

In the quest for better living standards and economic gain, modern society has come to view water only as a resource that is therefor the taking, rather than a living system that drives the workings of a natural world we depend on. Harmonizing human needs with those of a healthy environment will require new ways of using and managing water. And it will require adjusting our production and consumption patterns so as to remain within ecological limits.

Taking heed of water's limits, and learning to live within them, amounts to a major transformation in our relationship to fresh water. Historically, we have approached nature's water systems with a frontier philosophy, manipulating water cycle to whatever degree engineering know-how would permit. Now, instead of continuously reaching out for more, we must begin to look within - within our regions, our communities, our homes and ourselves - for ways to meet our needs while respecting water's life-sustaining functions.

On Bread and Water

Living, as so many of us do, in cities, suburbs, and towns, we leave concerns about food production to the farmers and irrigation problems to the engineers. In an age of space travel, telecommunications, and high-tech health care, it seems anachronistic to worry about something as simple as having enough water to grow sufficient food for the world's people.

From Sandra Postel's *Last Oasis.*

Foreword

Those who attended the Interamerican Dialogue on Water Management in Miami, Florida, in October 1993 know what a watershed event it was. It was *not* just another meeting of presentations and speeches. It was indeed a true dialogue of more than 400 natural-resource professionals and policy makers from 19 countries throughout the Western Hemisphere. They came together to determine the future of water-related issues on the information superhighway as we move toward the next decade, century, and millennium. The result was that the Dialogue laid the groundwork for the creation and development of the Interamerican Water Resource Network.

The creation of the Statement of Miami was the Dialogue's other major accomplishment. The statement contains the guiding principles that participants themselves developed as they proceeded through their discussion groups during the Dialogue. As was expected, *sustainable development* was the guiding principle for this important document.

While the Dialogue included eminent keynote speakers, plenary sessions, and two case studies comparing South Florida's Everglades with the Pantanal of Brazil, the actual “dialogues” occurred in three major roundtables and their respective small group discussions. What was truly amazing was that on the final day of the Dialogue, more than 200 people gathered - on a bright Saturday morning - to hear and react for the first time to the Statement of Miami. *That* is a statement of their commitment to the process they helped create.

The Interamerican Dialogue was more than two years in the making. It was an outgrowth of the 1992 Earth Summit in Rio and particularly the freshwater component (Chapter 18) of Agenda 21. The overriding question of the Dialogue was, “How do we take the Earth Summit results and begin to make a difference on-the-ground?”

Moving from the Dialogue to the Network, both successes we need to celebrate, we must consider what we learned. First, we ensured that all interested groups and individuals were involved. Not only did governmental agencies participate, but the Dialogue had strong input from influential non-governmental organizations. We were quite effective in our recruiting and in maintaining open channels with these organizations essential to the initiation of this ongoing network. Second, we kept all lines of communication open and active.

This Interamerican Water Resource Network will fill a much needed “institutional gap” that is part of an emerging transnational view of environmental restoration and sustainable development. It is part of a number of efforts that will result in a globally linked system of organizations that support sustainable development.

At its core, the water-resource network concerns building collaborative partnerships and shared understandings that transcend political and ideological boundaries. We must promote

cross-cultural bonds of trust and respect for diversity, and not lose sight of this ethos as we create a charter and bylaws for the network and begin its administration.

Ultimately, it is the quality of the people whom we attract, not the institutions to which we belong, that will make the difference in the success of this network. We must thank the staff of the South Florida Water Management District and its partners like Global Tomorrow Coalition for the work leading up to the creation of the Interamerican Water Resource Network. We also must thank the Organization of American States for its leadership in taking the reins of the network to ensure its smooth transition as it grows and becomes a viable instrument for water management throughout the Americas.

Tilford C. Creel, Executive Director
South Florida Water Management District
West Palm Beach, Florida

Acknowledgements

The organizers of the Interamerican Dialogue in Water Management are very much indebted to the members of the different committees (the Honorary, Policy Council and the Planning Committees), to the Chairpersons, Moderators, and Facilitators of the roundtable discussions; and to the contributors, for their efforts and commitment that made the Dialogue such a successful event.

This initiative could not have been possible without the financial support of the many contributors at all levels, but very especially to The John D. and Catherine T. MacArthur Foundation, The World Bank, Organization of American States, Tennessee Valley Authority, Blockbuster Video, and the South Florida Water Management District. Also, very special thanks go to the U.S. Army Corps of Engineers, whose facilitation and process design enabled the moderators to guide the roundtable discussions towards a definite and coherent direction, and to the Together Foundation for Global Unity, the provider of the WATERDIALOGUE electronic network platform - a crucial component of the ultimate objective of the dialogue, the Interamerican Water Resource Network.

In the day-to-day preparation of this sizable undertaking, we appreciate the work and counsel of the Global Tomorrow Coalition, our working partner, whose dedication and administrative involvement smoothed the road to the Dialogue and subsequent follow-up to the conference.

The Interamerican Dialogue on Water Management was hosted by the South Florida Water Management District and sponsored by the following organizations:

Florida Department of Environmental Protection,
Northwest Florida Water Management District,
Suwannee River Water Management District,
St. Johns River Water Management District,
South Florida Water Management District,
Southwest Florida Water Management District, and
Interstate Council on Water Policy.

The Dialogue sponsors gratefully acknowledges the generosity of the following co-sponsors, who made this event possible:

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Part I - The Statement of Miami

Statement of Miami - Interamerican Dialogue on Water Management Resolutions and Conclusions

October 30, 1993

I. PREAMBLE

All nations face a fundamental and critical challenge - to create compatible environmental reform and economic development in order to achieve true sustainable development. This was the driving theme of the United Nations Conference on Environment and Development in Rio de Janeiro in June 1992. We endorse this worldwide goal, recognizing that environmental reform and economic development depend on each other so both can succeed.

Water, life's most basic necessity, is the most obvious and most abused natural resource. It is the one we take most for granted. Because of its vital importance to both man and nature, water is imbued with a public interest and is considered a public resource. Water also is a strategic resource and a catalyst to generate wealth. A sufficient supply of water is a fundamental building block for healthy economies. The “return on investment” for wise water management is an exponential increase in the variety and value of the products and services water enhances or makes possible.

Water sustains the world's fish and wildlife and supports its natural systems and human enterprises. It is an essential component for recreation and tourism, which contribute to many economies. And, of course, water is required to propagate crops and to produce most commercial goods.

To advance the crusade for sustainable development and integrated water-resource management, more than 400 professionals from throughout the Western Hemisphere convened in Miami, Florida, in October 1993 for the Interamerican Dialogue on Water Management.

The meeting had two main objectives. One was to increase awareness and understanding of the importance of sustainable development and integrated water-resource management.

Establishing an Interamerican Water Resource Network was the second objective. Nations have managed resources separately in the past, but now we must manage them cooperatively across political boundaries. To achieve the goals of sustainable development and water-resource management, government, business, and other organizations must clearly define existing hydrologic and political conditions, interrelationships and interdependencies.

II. STATEMENT OF CRITICAL ISSUES

A. Research and Educational Needs for Aquatic Systems

Nations must preserve biodiversity, manage ecosystems, and achieve sustainability to maintain this planet for future generations. These efforts, together with individual, communal, and global stewardship, also raise ethical and economic issues which all nations must address. Despite disagreement on the exact meaning of "sustainability," Dialogue participants embraced a definition derived from "Our Common Future" by the 1987 Brundtland Commission: *"... We must meet the needs of the present without compromising the capability of future generations to meet similar needs."*

Research for aquatic ecosystems should identify appropriate methods to assess impacts on these systems; define approaches to managing them; conserve biodiversity within them; assess the economic potential of eco-tourism; develop methods to manage transboundary watersheds, and develop monetary and nonmonetary measures to express the energy and environmental costs of products and the value of environmental resources.

Educational needs for water resources should include demonstration projects; a workable means to transfer information from one country to another (such a clearinghouse), and development of indices which list available information and identify experts within specific fields. Timely and comprehensive information must be available to assess the magnitude of environmental problems and the value of aquatic resources. Educational programs should emphasize the value of wetland systems and the variety of benefits they provide.

A multi-disciplinary approach is essential to assess, protect, and restore aquatic ecosystems. Natural watershed boundaries, rather than political borders, should be used to define the problems and identify the solutions. Early integrated resource planning and an adequate assessment of the environmental impacts of water-resource projects are necessary to avoid inadvertent, yet catastrophic, destruction or the need for costly restoration of these resources.

We need new institutional approaches. Public and private entities, including non-governmental organizations, should implement joint ventures. Existing institutions should be strengthened.

Indeed, it is not always the absence of law that results in the degradation of the environment. It is the absence of political will to enforce the laws designed to protect the environment. In this regard, it is vital that informed citizens become involved in this decision-making process at all levels of government. An inter-American institution would promote the transfer of information for water managers, planners, technicians, and the public. As such, this institution also could foster a political commitment throughout the hemisphere to environmental protection and enforcement and could help strengthen the laws of many nations.

B. Water Supply and Sanitation

We need an inter-American commitment to address water-resource problems, especially in the realm of drinking water supply and sanitation. A multi-national effort also will promote water efficiency, economic development, and environmental protection. Nations should pursue the relationship of land use to water planning, including the implementation of soil conservation practices to protect water quality.

Developing and developed countries all have knowledge to share. Because of the interdependence of nations, educational efforts throughout the hemisphere should include an exchange program in which water-resource professionals could gain experience in other

countries.

Nations must strive to use resources more efficiently and to prevent the critical consequences of waste, mismanagement, and overuse. Because of the range of issues involved to achieve sustainability, public and private institutions - including nongovernmental organizations - must be involved in a meaningful way in cooperative problem solving. Such efforts are particularly necessary regarding transboundary watersheds and ecosystem management.

Local communities, especially in rural areas, need financial assistance to operate and maintain water supply and sanitation services. Governments should decentralize the planning for water supply and sanitation, and where compatible with the public nature of water resources, they should consider privatizing these two services.

Governments also need a regulatory framework to protect water resources through enforcement. Multi-lateral lending institutions can ensure adequate financing for the necessary infrastructure by adhering to priorities set by each nation according to their needs and economic and social realities.

C. Governance and Policy

Poverty and overconsumption are the enemies of sustainable water-resource use and management in North and South America. Decisions relating to sustainable resource use depend on public education and participation. In some areas, public control of water resources should be implemented to ensure the public's interest is fulfilled (although some areas would benefit from privatization). Specific legal frameworks, appropriate institutions, and decision-making processes do vary from nation to nation. However, public entities can best make decisions within the context of integrated ecosystem management, by using the watershed as the fundamental planning unit and ensuring that all interests are represented.

Water-management professionals should foster the sustainable development of water resources by encouraging increased public participation in water-related planning and decision making. They should also develop mechanisms to exchange national and international information, experiences and expertise, as well as to promote increased public awareness, and to espouse and adhere to an ethic for sustainable development in water-resource management.

Several desirable communication approaches exist to increase the effectiveness of existing and proposed water policies. These include newsletters; existing electronic networks; curriculum development for public education; training in technical communication; public participation and interaction; an increased capacity to disseminate information; an improved accessibility to technical assistance (in pricing, water-use efficiency, legislation, and legal issues), and funding.

III. GUIDELINES FOR ACTION

A. Promote an understanding of the nature and character of aquatic systems;

B. Stress ecosystem planning and management, using principles of watershed management;

C. Use resources more efficiently, and avoid misuse, abuse, and overuse of water;

D. Encourage communication, the sharing of knowledge and experience and

inter-American partnerships;

E. Explore and promote principles of environmentally responsible privatization in water-resource development to the extent that is consistent with the inherently public character of water;

F. Develop mechanisms to value water appropriately and to protect and preserve that value;

G. Strengthen the capabilities to manage the inherent complexities of multipurpose, long-term water-resource management, and improve the ability to respond to uncertainty in a flexible, adaptive manner;

H. Encourage broad involvement in decision-making by encouraging public participation, empowering all stakeholders, and responding to the views of all affected parties, and

I. Adhere to the principles of comprehensive, long-term, integrated, transboundary water-resource management.

IV. THE INTERAMERICAN WATER RESOURCE NETWORK

A primary goal of the Interamerican Dialogue on Water Management was to launch a vital, active network that would combine existing resources throughout the hemisphere. It would provide opportunities to share information and technology, foster innovative partnerships, and provide internship and training opportunities free of national and political constraints.

Another goal of this Dialogue was to find ways for water-management policy makers, practitioners, and non-governmental organizations to develop and enhance their internal and external communications and cooperative ventures and to support sustainable development and integrated management of water resources worldwide.

In order to achieve these goals and to implement the “Agenda 21” principles from the 1992 United Nations Conference on the Environment and Development, the conferees agreed to help establish an Interamerican Water Resource Network. It is their hope this network will do the following:

A. Clarify water resource needs and priorities at the hemispheric level;

B. Build collaborative partnerships to solve complex technical problems and enable people to pool existing resources and mobilize untapped resource in creative and efficient ways;

C. Build shared understandings around basic values that transcend national and ideological boundaries to promote learning from one another's successes, failures, and tribulations;

D. Seek institutional structures and processes that give individuals and identifiable groups a stake in governmental decision making, including more influence, additional responsibility, and greater accountability over policy making;

E. Increase hemispheric access to skills, knowledge and strategies for

water-management problem solving and support for the development of new organizational forms that will foster new cooperative attitudes and capacities for sustainable use of water;

F. Promote crosscultural bonds of trust and respect for diversity, especially where misunderstandings or misapprehensions already exist;

G. Enhance awareness of the history and vital role of water in sustaining natural and social systems in the hemisphere, and

H. Encourage appreciation and respect for shared interests as well as diversity in language, culture, and other socioeconomic characteristics in order to advance and maintain the hemisphere's capacity to manage water in a sustainable manner.

Part II - Background and Framework Documents

Sustainable Development & Resource Management: Twin Strategies for a New Millennium

Stephen S. Light, Ph.D. and Marsha Kirchhoff[1]

[1] Stephen S. Light, Ph.D., Policy Director; and Marsha Kirchhoff, Senior Public Communications Officer, South Florida Water Management District, West Palm Beach, Florida, USA.

Introduction

In February of this year Frank Popoff, CEO and President of The Dow Chemical Company, speaking before the Economic Club of Detroit, said that the overarching challenge to the industrialized nations is to make environmental reform and economic development compatible (Popoff, 1993). The underlying theme of the Rio Earth Summit - sustainable development - was based on the recognition that there can be no environmental reform without economic development, and no economic development without environmental reform. Popoff referred to this tandem symbiotic relationship as the "...New Gemini - twin issues, interrelated and inseparable in policy and in fact - for all of us."

This world view is a radical departure from the traditional "business" stance of the 1970s and 1980s - which completely separated environmental issues from the larger production processes of society. Defenders of that status quo dismiss the New Gemini as "magic" - eco-rhetoric - an unrealistic world view that is inflating government and forcing business to spend billions of dollars on unnecessary environmental costs (CE Roundtable, 1992). Fortunately, conventional wisdom has moved beyond that shortsighted view of the world, to a fundamentally new way of thinking, not just about the results of human activity, but also about our individual and collective relationships to nature, and to one another.

In many ways, civilization is in the midst of a metamorphosis - changing in spite of itself from a collection of discrete, often isolated cultures to a shifting amalgam of communities which are

interlinked on a myriad of levels: by economics; and the elements of the “global commons,” the air, land and water resources upon which *all* life is dependent. This metamorphosis into a post-Cold War, post modern era is in many ways driven by a new kind of enlightened self interest which recognizes that all peoples' fates are intertwined.

Yet this new era is still in its infancy - struggling to emerge from a cocoon made rigid by the tendency of humanity to resist change and avoid unfamiliar, untried paths. Today, we all live in a world in transition, a world that is disordered and unpredictable, where distinctions between foreign and domestic threats or opportunities are shadowy, or ill defined. The end of the “Cold War” has been the most visible, and therefore the most recognized symptom of this change. But more subtle, and perhaps more powerful changes in the global “balance of power” are also occurring.

We face a new class of problems that require different solutions than the military and economic threats we faced in the post-WWII era. In fact, many of the solutions we developed during the Cold War to achieve a shifting, yet stable “balance of power” (weapon arsenals, large militaries, war-based economies) now stand in the way of global security, where power must be drawn as much from sharing finite resources, and sharing the responsibility for their protection.

National interests now span the globe, often ignoring political, geographic and cultural borders which once strictly defined them. Centuries of local and regional exploitation of resources have created worldwide problems. Excessive greenhouse gases are thinning the earth's protective ozone shield, fueling changes which could be disastrous. Rampant human development has changed the face of our planet. Unique habitats and ecosystems worldwide have been altered or destroyed, bringing accelerating rates of species extinction and the loss of biodiversity. Even renewable resources such as freshwater and forests have been harvested at reckless rates which could negate their ability to recover. The causes of these environmental problems are complex and multifaceted, and their manifestations are both local and half-a-world away. The environment has become our global commons, and its preservation and restoration a global responsibility.

In 1919, at the Versailles Peace Conference, President Woodrow Wilson foresaw this need for a shift in humanity's relationship to the world - to what Popoff called the “Gemini” era. Wilson still reminds us that we are participants in the life of the world. What befalls other nations is our concern as well. We are inevitably all partners - our fates are intertwined - in a global destiny.

Now, it seems obvious that sustainable development will be a central feature of international affairs in the 21st century. The end of the 20th century presents us with an unparalleled opportunity to launch the Gemini era, to internalize the lesson that human development does not and cannot occur apart from nature, that there is a subtle but critical balance between short-term individual human needs and the long-term needs which will shape our common future.

The Global Importance of Wise Water Management

Today's new, world class environmental threats are introducing even more uncertainty into an already uncertain realm of water resource management. Joyce Staff, chairman of the Global Water Summit Initiative for the United Nations, predicted that water will soon become as politically charged as oil has been, and become one of the most important foreign policy issues of the coming decade. This is already true in pans of the Middle East.

Water is wealth which can no longer be taken for granted. It is a strategic resource and a catalyst for generating additional wealth in any society. Water in sufficient quantity and quality is a fundamental building block of any healthy economy. Water repays for its wise management over and over again in the sheer variety and value of other products and services it enhances or makes possible. Water helps to stock and maintain the world's fish and wildlife, supporting natural systems and the human enterprises most directly dependent on functioning natural systems. It provides opportunities for recreation and tourism, and is at the very backbone of the propagation of crops and the production of most goods. Potable drinking water is one of life's most basic necessities.

In the western hemisphere, we are blessed with 42% of the world's freshwater supplies, yet only 14% of the world's population. Even with this abundance, there are huge disparities between demand and supply. For example, according to a recent National Audubon Society report (Nelson and Sandell, 1992), per capita water availability in Mexico is half that of the United States. The Mississippi River carries more water than all of Mexico's rivers combined. Close to 15% of worldwide rainfall is deposited within the Amazon, while in Iquique, a Chilean desert, no rain fell for 14 years! Similar disparities exist at smaller scales throughout this water-rich hemisphere.

Freshwater is a precious resource which is becoming increasingly scarce as a direct result of pollution and/or wasteful use. Only 3% of the Earth's water supply is freshwater, and 90% of the world's population rely on that limited supply. (Approximately 10% of the world's population relies on desalination or other costly water treatment technologies.) Already, 20% of the world's population has minimal or *no* access to adequate and/or safe water supplies.

The world's population is expected to double - from 5 to 10 billion - in the next 25 years. But the supply of water will remain constant, or will continue to decrease through degradation and mismanagement. In addition to the soaring food and housing needs represented by human population growth, and increased demands on water resources from burgeoning industrial development, unenlightened water management practices and inefficient uses add to the stress on available water supplies.

Our wanton exploitation of local, regional and global water resources is having another devastating side effect. Critical sources of biodiversity such as wetlands and rainforests - which also store, purify and mediate excess flows - are being lost at staggering rates. The time is now for the emergence of cross-scale strategies for dealing with these local problems which are also becoming global resource issues.

From Stockholm to Rio: A New World Vision Unfolds

To paraphrase Gus Speth (1992), recently appointed Administrator of United Nations Development Programme, the Four Horseman of the Apocalypse in our lifetime are: nuclear arsenals; widespread suppression of human rights; global poverty; and the unrelenting assault on the environment. The first two appear to be in retreat in most pans of the world (though individual examples are still all too common), while the latter two loom larger than ever. In recognition of these issues the United Nations (June 1972) held a conference in Stockholm, Sweden on the Human Environment. The initial intent was to focus on “local” environmental problems. The 1972 agenda was reportedly heavily influenced by modern intellects like Paul

Ehrlich and Garrett Hardin (Hecht and Cockburn, 1992) - who blame increased population for environmental degradation and the destruction of commonly shared resources. While the developed countries still held to the hope for a “Green” technological revolution, the message from the developing world was quite clear and beautifully articulated by Indira Gandhi - “Poverty is the ultimate polluter.”

The Stockholm conference acknowledged states' sovereignty over national resources - but married that sovereignty to the belief that states *also* have a responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other states, or of other areas (Haas, et. al, 1992). The United Nations Environmental Program was established, and conventions on marine pollution, and world cultural and natural heritage sites were signed. As a final testament to its success, over two-thirds of the international environmental treaties in existence today have been signed since the Stockholm conference (French, 1992).

In the 20 years since this first UN environmental conference, the framework for a global environmental and developmental ethic has become more sensitive to local cultures and ecosystems, and to indigenous knowledge. The Brundtland Commission report in 1987 (Our Common Future) sharpened the vision by placing more emphasis on issues of equity and the critical need to eliminate the artificial separation of environment issues from economic production (Strong, 1992). Authors of “Our Own Agenda” and “Compact for a New World” helped raise awareness of the problems of sustainable development that relate directly to the Americas.

The Rio Conference

In 1989, the United Nations agreed to host a Conference on Environment and Development (UNCED) in Rio de Janeiro, Brazil (June, 1992) to: (1) celebrate the twentieth anniversary of the Conference on Human Environment; (2) extend the international dialogues on the continuing deterioration of the worldwide environment and (3) encourage sustainable development in countries on the verge of repeating the mistakes of developed countries. According to Maurice Strong (1992), the Secretary General for the conference, UNCED's purpose was to elaborate strategies and measures to halt and reverse the effects of environmental degradation in the context of environmentally sound development in all countries, to raise standards of living worldwide without harming world resources.

This conference, more than any of the past, recognized that environment and development were really “two sides of the same coin” - a dual, yet symbiotic entity - which should not be treated separately. In actuality, the use of the term “conference” in this instance was misleading. The Earth Summit, as it has become known, was in reality an international negotiating process, spanning the globe with two years of intense formal and informal discussions involving representatives from non-government organizations (NGOs) as well as government officials.

The Rio Earth Summit reportedly attracted 130 heads of state and delegates from over 170 nations. Thousands of journalists attended. In addition to the formal meetings, an Alternative Global Forum was held in downtown Rio. It is estimated that thousands of representatives of NGO groups participated in this dialogue - from 165 different countries. Overall, as many as 250,000 people participated in the meetings, performances and exhibits.

In line with this more holistic approach to the twin concerns of environment and economy, the

Earth Summit also embraced the segment of society most associated with cooperation, caretaking and nurturing - women. Although only two dozen women took the podium during several hundred speeches at the Summit, thousands of women worked at the Women's Planet tent at the Global Forum. A full chapter of the Conference recommendations (Agenda 21) focuses on women's economic and social needs. In addition, one of the 27 principles in the Rio Declaration pledges commitment to women's participation in all environment and development work (Esserman, 1992).

The Rio Earth Summit, the largest assembly of world leaders ever held, resulted in three non-binding agreements: the Rio declaration in environment and development; Agenda 21; a statement of forest principles as well as two binding agreements on global warming and biodiversity. Maurice Strong, the UNCED General Secretary, summarized the Conference by focusing on new beginnings and not conclusions - “The Earth Summit is the first step on a pathway to our common future” - a pathway that puts development and environmental objectives on a par with international political and security commitments (Haas, et al., 1992).

Agenda 21

Agenda 21 is a blueprint for a global partnership to integrate environment and development into the 21st Century. It is a key product of the Earth Summit and a point of reference for governments, NGOs and the public at large. It is also a remarkable expression by the world's leaders calling for fundamental reform in our economic behavior - based on a new understanding and awareness of the impact of human activity on the biosphere. Agenda 21 is a mandate for global environmental security, with security defined as the maintenance and support of economic and environmental values. The document is a 600-page non-binding agreement that covers a broad range of conservation and natural resource topics including combating deforestation, promoting sustainable agriculture and rural development, the conservation of biodiversity, managing fragile ecosystems and the protection of freshwater systems.

Of special interest to the Interamerican Dialogue on Water Management, Chapter 18, entitled the *Protection of the Quality and Supply of Freshwater Resources,* sets forth objectives, activities and means of implementation in seven distinct program areas:

- Integrated Water Resources Development and Management
- Water Resources Assessment
- Protection of Water Resources, Water Quality and Aquatic Ecosystems
- Drinking. Water Supply and Sanitation
- Water and Sustainable Urban Development
- Water for Sustainable Food Production and Rural Development
- Impacts of Climate Change on Water Resources

Implementing Agenda 21

“The challenge after Rio is to maintain the momentum of commitment to sustainable development to transform it into policies and practice and to give it effective and coordinated organizational support.” (U.N. Secretary General Boutros Boutros-Ghali) What has happened since Rio? At the United Nations, the General Assembly established a Commission on Sustainable Development to oversee Agenda 21 implementation; to monitor its follow up; and to ensure that UN programs share this common commitment to sustainable development. Some

view this Commission as a transitional organization that will eventually be succeeded by an “Environmental Security Council” (French, 1992).

Other institutions that were inspired by or embrace this philosophy include the Business Council For Sustainable Development, Geneva, Switzerland; the Earth Council, San Jose, Costa Rica; and the International Institute For Sustainable Development, Manitoba, Canada.

Individual states are being encouraged to establish national coordination structures responsible for the follow-up to Agenda 21; and are also being invited to prepare national action plans and reporting mechanisms. Recently United States President Clinton established a President's Council on Sustainable Development. Its mission is to develop an overall strategy for implementing Agenda 21 in the United States (Barron, 1993).

The need for regional and subregional cooperation was highlighted at the Conference. Specifically, organizations that advance technical and economic cooperation were seen as contributing to the process by promoting capacity building, the integration of environmental policies and cooperation on transboundary issues at the regional level.

Finally, NGOs were recognized as partners in the implementation of Agenda 21. Organizations representing scientific and technical communities, the private/business sector, women's groups, and others were encouraged to contribute to sustainable development and to establish relationships with the United Nations system. Less formal alliances, which reach beyond outdated social structures, politics, ideologies or economics are likely to be as important as the more traditional alliances in fulfilling a vision of global prosperity and ecological well-being.

Moving Beyond the Earth Summit

The international networks which embody the “new organization” are sometimes described as being without boundaries. But this characterization can be misleading. A true international network functions more like nature's untamed rivers than like human-engineered waterways; forming natural and constantly evolving borders that follow the elemental contours of “problemsheds.” The networks or groups' shape should change as problems change, because problemsheds - like rivers, lakes and deltas - neither see nor are they moved by political boundaries. To succeed or problem-solve like a river, we must let go of our isolated, human-centered view of the world. Our Native American leaders prescribed this kind of functional vision by maintaining a healthy respect for and interdependent relationship with the world.

From a water management perspective, the 1992 Earth Summit in Rio, under the United Nations' aegis, helped advance the labor of many water related activities before it, particularly the action plans adopted at the Mar del Plata (1977) and the Dublin (1992) conferences. The 1992 Earth Summit challenged the peoples of the world to recognize this defining moment.

We can choose to perpetuate business as usual and ignore the growing disparities within and between nations, the worsening of poverty, hunger and the deterioration of the ecosystems on which we depend. Or we can decide to change course, to assume personal and collective responsibility for the welfare of all mankind and our natural systems.

No nation or international institution can achieve this alone. No set of edicts, treaties, and laws -

no matter how well written or well-meaning - can blaze the trail toward global ecologic and economic equity. This path is one that must be marked and cut out in small parcels, beginning at the grassroots and continuing in the interactions between scientists, citizens and politicians. These are solutions that need to be constructed from the ground up, by people who are familiar with the view. That's a large part of the reason why we are gathered here: to start the needed groundswell, and to establish a support system for individuals, agencies or work groups, regions or nations - for the people who are a part of the Interamerican Dialogue on Water Management.

Building an International Water Resource Network

To implement the UNCED Agenda 21 principles, the conferees of the Interamerican Dialogue on Water Management have assembled to help fashion an international network. This network can provide the support, energy, and cross-scale collaboration needed to build bridges between existing institutions and emerging transnational organizations; to link action at local and regional levels with other efforts and resources at larger geographic scales; and advance the cause of sustainable development and integrated water resource management.

The major objectives of the Interamerican Water Resources Network must be defined. The following is an initial offering for the conferees of the Interamerican Dialogue on Water Management to consider.

- Clarify water-resource needs and priorities at the hemispheric level.
- Build collaborative partnerships to solve problems that are technically complex and uncertain. Enable people to pool existing resources and mobilize new untapped resources in creative and efficient ways.
- Build shared understandings around basic values when dealing with divisive issues that transcend national and ideological boundaries, so that we may learn from each other's successes, trials and tribulations.
- Seek ways for institutions to create structures/processes which give individuals and identifiable groups a stake decision-making - more influence, responsibility and greater accountability over policy making. Help institutions and governments to actively involve their constituencies?
- Increase hemispheric access to skills, knowledge and strategies for water management problem solving. Support the development of new organizational forms that build new cooperative attitudes and capacities for the sustainable development of water resources.
- Begin to build cross-cultural bonds and a sense of trust and respect for diversity, especially where misunderstandings or apprehensions already exist.
- Enhance awareness of the history and vital role of water in sustaining natural and social systems in the hemisphere.
- Encourage cross-cultural appreciation and respect for diversity in language, culture and other sociologic variations - to advance the hemisphere's capacity to manage water in sustainable ways.

Goals, Objectives and Key Questions for the Dialogue

The goal of the Interamerican Dialogue on Water Management is to launch a continuing network that couples existing resources in the hemisphere for sustained information sharing, project review, technology cooperation, as well as internship and training. There are two major Dialogue objectives. One is to increase the awareness and understanding of the importance of sustainable development and the management of water resources. The second is to find ways in which water management policy makers, practitioners and NGOs can develop and enhance communication and cooperation leading toward the sustainable development and management of water resources.

Key Questions

The following questions will be the focus for participant discussions, case study presentations, panels, papers and keynote presentations. By the conclusion of the Dialogue on Saturday, the conferees will provide answers to the following questions.

1. What are the most important problems and priorities that need to be addressed to move toward sustainable development and improved management of water resources? (WHAT SHOULD WE BE DOING, AND WHY?)

2. What has experience taught us about the problems and obstacles, and the opportunities and successes in sustainable development and management of water resources? (WHAT HAVE WE LEARNED?)

3. What can water management policy makers, practitioners (businesses, engineers, scientists and other professionals), NGOs and others do to improve communication and cooperation in their quest for sustainable development and more effective management of water resources? (HOW CAN WE HELP ONE ANOTHER?)

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Part III - Case Studies

Case Study 1: Comparative Analysis of the Florida Everglades and the South American Pantanal

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Interamerican Dialogue on Water Management

Miami, Florida, USA
October 27-30, 1993

I. OVERVIEW

A. Ecosystem Structure and Impacts

Though the Pantanal and Everglades share important physical and biological characteristics, there are significant differences in the structure and ecological functioning of the two systems. Both are large, internationally significant freshwater wetland systems, though the Pantanal watershed is several times larger than that of the Everglades. Both systems are dependent on larger watersheds. The Pantanal receives direct rainfall and water from many riverine systems and is drained by a major river. The Everglades, in addition to rainfall, is dependent on a single river and lake system which historically supplied sheetflow to the system. It drained, in turn, to a dependent estuary. The differences in elevation and degree of natural sedimentation rates from surrounding uplands are much greater in the case of the Pantanal. The Everglades developed as an oligotrophic ecosystem, more vulnerable to slight increases in nutrients. Variability in the sub-basins of the Pantanal make generalizations difficult concerning that system. It appears that the Pantanal evolved with higher nutrient levels associated with sedimentation processes.

Soils in the upper basin of the Pantanal appear to be more susceptible to erosion than those in the upper basin of the Everglades. Generally, soils in the lower basin of the Pantanal are less organic than those in the Everglades lower drainage areas. Yearly and wet season rainfall totals appear to be approximately equivalent in each system. Both ecosystems depend on water regimes with yearly wet and dry cycles, however the Pantanal experiences greater differences in water levels between dry and wet seasons. Historically, the relative abundance of wildlife in the two systems appears to have been roughly equivalent, though diversity may have been greater in the Pantanal. Currently, the Pantanal supports much more diversity and abundance of wildlife.

Some of the more significant impacts to the water regime in both Pantanal and Everglades ecosystems involve planned or existing large scale water development projects. Since the 1880s, a government-subsidized process of dredging, draining and channelization within the Everglades watershed has profoundly altered the quantity, quality, timing, rate and distribution of water flows to that ecosystem. Impacts on ecosystem functioning have included the significant loss or degradation of native plant communities, the loss or destruction of wildlife habitat, including that of threatened and endangered species and estuarine-dependent fish, and the loss of hydrostatic pressure in fresh water aquifers.

For many years, the natural resources of the Upper Paraguay Basin have played an important role in local economies. Large scale water development projects have not been attempted in the Basin, due in large part to its remoteness and lack of national economic importance. However, the planned Paraguay-Paraná Waterway (Hidrovia), being promoted by international development interests, has the potential to cause significant disruption of ecosystems in the Pantanal. As currently promoted, the first phase of the project would involve the dredging of a large percentage of the Paraguay River below Corumbá, with possible negative impacts on wetlands ecosystems in the Pantanal. The second phase of the project appears to include major water control structures, dredging and channelization above Corumbá, with potentially significant negative effects on ecosystem function and extensive secondary impacts.

There are very large soybean, sugar, rice and corn plantations in the highlands *(planaltos)* of the Pantanal watershed. Deforestation of the region, including loss of gallery forests and other vegetation along rivers, as well as poor water management practices on farms, appear to be contributing to extensive sedimentation of rivers in the Pantanal plain. The intensive agricultural techniques used in the relatively poor upland soils include the application of large amounts of agrochemical pesticides, fungicides and fertilizers, a significant percentage of which may be entering the Pantanal lowlands, primarily during periods of higher rainfall and flooding. Cattle ranching on the plains *(planície)* is dispersed, however impacts to vegetation from burning and grazing have been noted and the introduction of non-native grasses with low survivability leads to sedimentation.

Agricultural development in the Everglades is concentrated in areas just south of Lake Okeechobee, but is also present in several areas near Everglades National Park. Extensive diking and drainage were necessary to expose the muck soils which support many thousands of hectares of sugar cane just south of Lake Okeechobee. Rock plowing, intensive use of agrochemicals, and massive groundwater withdrawals are necessary to support winter vegetable and citrus production in areas farther south near Everglades National Park. In addition, a long history of dairy farming in regions around the Kissimmee River contributed to the eutrophication

of Lake Okeechobee. The cumulative negative impacts on the hydrologic regime and on water quality in the Kissimmee/Lake Okeechobee/Everglades (KLOE) ecosystem have profoundly altered the functioning of the Everglades.

Mining and industrial operations represent important manipulations of the water regime of both Everglades and Pantanal ecosystems. The extent of various extractive industries and specific impacts of gold mining in the Pantanal watershed appear to have greater total negative consequences than those of extractive industries in the Everglades.

At present the consequences of urban development are more significant in the Everglades than in the Pantanal, with population pressures still very high. However, urban development pressure is increasing within the Pantanal watershed. A very low percentage of households in the region receive advanced sewage treatment, and control over other associated urban effluents is inconsistent. Continuing population influx will require infrastructure development, and careful planning and regulatory response.

Current conditions in the Pantanal and historic conditions in the Everglades represent what might seem to be virtually unlimited opportunities for exploitation of wildlife. In the case of the Everglades, fish, alligators and deer were taken by subsistence and commercial hunters beginning early in the history of human occupation of the area, at generally sustainable levels. However, the killing of tremendous numbers of wading birds from the 1870s to 1930s to satisfy the fashion industry's need for plumes was unprecedented. Millions of birds were taken before public opinion, changing styles and new legislation ended the slaughter. Several rookeries were completely extirpated and many have never recovered. Though by the 1960s, the alligator had been placed on the endangered species list for protective purposes, by the 1980s, populations had increased significantly. The controlled hunting program for alligators now in effect is a measure of the current success of the species. Other species have experienced serious declines in population for reasons only partially related to hunting, and authorities have been generally unsuccessful in helping those species recover.

Biological, social and economic conditions in the Pantanal roughly approximate those of the Everglades much earlier in its history. The sheer numbers of fish and other wildlife offer seemingly limitless opportunities for commercial and recreational harvest. Historically, the Pantanal ecosystem was used for subsistence level hunting and fishing by relatively small populations of indigenous peoples, whose activities had little impact on ecosystem functions. Currently, commercial overfishing has become a serious problem, essentially mining fish from the system at unsustainable rates. Though illegal, the taking of caiman for hides and many species of birds for the pet trade also continues to reduce populations.

B. Legal and Policy Response

The regulatory and enforcement tools available to agencies with jurisdiction over the Pantanal and Everglades share some similarities and differences. Though the Brazilian Constitution includes clearly articulated environmental rights, and specifies additional protection for the Pantanal as part of the “national patrimony,” the federal and state laws intended to implement those protections do not adequately address all potential threats and are inconsistently applied. The establishment of Everglades National Park placed protective boundaries around the lowest sections of the Everglades, but other related parts of the watershed have received very little

specific protection. Regulatory exemptions, lack of coordination between agencies, and gaps in legislation have allowed continued degradation of the KLOE ecosystem. Only recently have issues concerning water resources for the Park and other sections of the Everglades been given the priority that is necessary in order to restore and maintain ecological functions.

There are very large differences in the physical, technical and monetary resources available to regulatory, research and planning institutions in the two ecosystems. Federal, state and regional agencies in Florida have access to sophisticated technical equipment, with relatively good research, monitoring and enforcement capabilities. The Brazilian economic crisis, combined with a general ambivalence toward environmental regulation, has resulted in a lack of institutional capability for most institutions in the Pantanal. In the past, a centralized approach to governmental regulation gave more authority and resources to federal institutions, while state agencies suffered. Recent changes in institutional emphasis, combined with a growing cultural appreciation of the need for environmentally sustainable development, have translated into increased resources for state level institutional development and greater regulatory authority. However, there is still a crucial need for funding to support adequate research, planning, permitting, monitoring and enforcement for environmental purposes in Brazil.

The problem of political will affects agencies in both ecosystems. For many years scientific information on the Everglades has documented a system in environmental decline, yet despite debate, increased regulatory authority and institutional capabilities, the degradation continued. It has taken near crisis conditions, and a federal lawsuit, to force responsible parties toward an effective response. A low level of perceived environmental threat to the Pantanal, combined with politically powerful development interests and a national drive for economic growth have allowed for ill-advised agricultural, industrial and mining operations to be permitted in the Pantanal watershed, particularly in the highlands.

II. ECOSYSTEM DESCRIPTIONS

A. Pantanal

The Pantanal, or “swampland” in Portuguese, is an immense alluvial plain within the Upper Paraguay River Basin in western Brazil, eastern Bolivia, and northeastern Paraguay. (Fig. 1) The Upper Paraguay Basin, including all associated upland areas, contains 496,000 square kilometers (191,500 square miles), of which approximately 80%, or 396,800 square kilometers (153,200 square miles) lie within Brazil, primarily in the states of Mato Grosso and Mato Grosso do Sul (SEMA, 1993). The Pantanal itself includes only the 140,000 square kilometers (54,000 square miles) of alluvial plain or *planície,* but a complete understanding of the ecology and management of the Pantanal requires consideration of the associated highlands, or *planaltos.* Altitudes range from 80-150 m (260-490 ft.) on the plains, to over 250 m (820 ft.) on the *planaltos* (Ferreira, 1992), with some isolated peaks over 1000 m (3250 ft.) southeast of Corumbá (Scott and Carbonell, 1986).

Fig. 1. Location of Pantanal Watershed Within Brazil

Though the Pantanal is one of the largest wetlands in the world, it is more properly characterized as a related series of river floodplains. Principal rivers in the basin include the Paraguay, Miranda, Cuiabá, São Lourenço, Negro, Taquarí, and Aquidauana, all originating in the *planaltos.* (Fig. 2) The Paraguay River is the major north-south watercourse in the Pantanal,

extending 2800 kilometers (1735 mi.) from its source in the northern highlands of Mato Grosso, Brazil to Corrientes, Argentina, where it joins the Paraná River. Situated at the interface of three major South American ecosystems, the Pantanal includes characteristics of Amazon rainforest, *cerrado* scrub forests of central Brazil, and the *chaco* vegetation of nearby Bolivia and Argentina. Within the watershed, ten different ecological subregions have been identified (Adámoli, 1992). The area is dominated by a matrix of seasonally-flooded savanna, streams, rivers, ponds, lakes and marshes. Principal vegetation consists of scrub forest and savanna characterized by native grasslands interspersed with gallery forest, humid semi-deciduous forest and wetland vegetation.

Fig. 2. Map of the Pantanal Region

Source: Bucher et al., 1993.

Total yearly rainfall in the basin is approximately 1100-1500 mm (43-59 in.), 80% of which falls from November to March (Scott and Carbonell, 1986). Beginning in November, up to 70% of the 450 kilometer long Pantanal basin is slowly inundated, turning it into a vast, shallow inland sea, interspersed with higher areas which do not flood. The lowland plain slopes from north to south at about two centimeters per kilometer, allowing only very slow movement of flood waters. Depending on local elevation, flooding lasts from three to nine months. Maximum water levels in the northernmost reaches of the Paraguay River normally occur during January and February, and in the southern areas during May and June. Within several months after peak floods, evaporation, evapotranspiration, absorption and outflow transform the area into a huge savanna, including rivers and tributaries, open grasslands, isolated pockets of *cerrado* forest vegetation, and many shallow waterbodies with large numbers of trapped fish, attracting wading birds and other wildlife.

The Pantanal supports a great diversity and abundance of wildlife. Over 650 species of birds have been identified. The region is one of the world's largest breeding grounds for wading birds, an important migratory bird stopover point, and probably the most important area in South America for wetland birds (Mittermeier et al., 1990). Over 260 species of fish have been identified, with about 10-12 species caught for commercial purposes. Large numbers of other species of wildlife exist in the region, encompassing approximately 80 mammal species, 50 species of reptiles and over 1.000 species of butterflies. Some of the most unique animals in the world inhabit the Pantanal, including the giant anteater *(Myrmecophaga tridactyla)*, giant river otter *(Pteronura brasiliensis)*, maned wolf *(Chrysocyon brachyurus)*, capybara *(Hydrochoerus hydrochaeris)*, tapir *(Tapirus terrestris)*, jaguar *(Panthera onca palustris)*, puma *(Felis concolor)*, caiman or jacaré *(Caiman crocodylus yacare)*, swamp deer *(Blastocerus dichotomus)*, howler monkey *(Alouatta caraya)*, blue hyacinth macaw *(Anodorhynchus hyacinthinus)* and the jabirú stork *(Jabiru mycteria)* (Mittermeier et al., 1990).

B. Everglades

The Everglades is a system of shallow sawgrass marshes, tree islands, wet prairies and aquatic sloughs that historically covered most of southeastern Florida (Davis, 1943). (Fig. 3) Formation of the Everglades began over 5000 years ago as organic matter and sedimentary deposits accumulated in a limestone depression which underlies much of the southern tip of Florida (SWIM, 1992a; Parker and Hoy, 1943). By the end of the 19th century wetlands covered about 10,000 square kilometers (3,900 square miles). The original Everglades extended from the south shore of Lake Okeechobee to the mangrove estuaries of Florida Bay, and were over 64 km (40

mi.) wide and 160 km (100 mi.) long (SWIM, 1992a). The Everglades is an integral part of the larger Kissimmee/Lake Okeechobee/Everglades system, which covers much of south and central Florida below the City of Orlando. They are bordered on the east by the Atlantic coastal ridge and on the west by the Immokalee rise (SWIM, 1992a; Parker and Hoy, 1943).

Fig. 3. Map of Everglades Watershed (Historic)

Source: Light and Dineen, in press.

Historically, water from the Kissimmee river basin flowed slowly south toward Lake Okeechobee, overflowed the Lake's southern rim, and moved as a shallow sheetflow through the Everglades and into Florida Bay and adjacent coastal waters. Natural drainage of the Everglades occurred to the east through a series of breaches in the coastal ridge, to the south through several sloughs, and to the west through the Big Cypress Basin. In addition, as a result of direct connections between ground water and surface waters in portions of the area, groundwater seeped through the porus limestone aquifer and discharged as freshwater springs into coastal waters (SWIM, 1992a; Parker et al., 1955; Harlem, 1979). Rainfall, evapotranspiration, and outflows to the sea resulted in a constant exchange of water between the atmosphere, salt and fresh surface waters, and the aquifer (SWIM, 1992a; Davis, 1943; Parker et al., 1955; Wagner and Rosendahl, 1987). The volume of water which flowed through the historic Everglades system is greater than what occurs today (SWIM, 1992a), due to drainage and flood control discharges to the sea.

Climate and weather patterns are closely tied to the hydrology of the region. Average yearly rainfall is 1350 mm (53 in.), about 75% of which occurs during the wet season (May to October) (SWIM, 1992a; Shih, 1983). Rainfall during the wet season is typically in the form of convective showers which occur almost daily, while winter rainfall is typically associated with winter frontal storms. Rainfall over the region is characterized by considerable variability between seasonal and annual amount, and in areal distribution (SWIM, 1992a).

Elevations in the Everglades region are generally less than 6 m (20 ft.) above sea level. The ground surface slopes gently from north to south with an average gradient of 2.8 cm/km (.15 ft./mi.) (SWIM. 1992a; Parker et al., 1955). The predominant soils of the Everglades region are organic histasols (muck or peat), overlying limestone formations. The muck soils have accumulated in a layer of up to 5.5 m (18 ft.) thick in the northern Everglades (SWIM, 1992a; Stephens and Johnson, 1951) where limestone elevations are lowest, to about one meter (3 ft.) or less in the southern Everglades. Another dominant soil type, calcitic mud, occurs in shallow peripheral marshes of the southern Everglades which undergo shorter periods of inundation than where muck soils occur.

The interaction of climate, geology, and topography with surface water, which makes up the hydrologic cycle of the region, shaped the biological system which developed in the Everglades. Everglades ecosystems evolved under conditions in which water availability varied from season to season and from year to year. The systems depend on the annual pattern of wet summer and dry winter seasons, as well as on a certain degree of variation in rainfall and the amount of surface water, for their continued existence (SWIM, 1992a). Accordingly, the variability and diversity of the biological systems are related to the natural variability of the hydrologic system (SWIM, 1992a).

The original Everglades comprised about one million hectares (2.5 million acres) of freshwater

marsh (SWIM, 1992a). Major Everglades plant communities include the periphyton (algae) community, the sawgrass community, the wet prairie, aquatic sloughs, bayheads or tree islands, willow heads, tropical hardwood hammocks, cypress forest, and coastal mangrove forest communities (SWIM, 1992a). The Everglades were historically bordered by seasonal or short hydroperiod wetlands and upland pine habitat (Davis, 1943).

The major habitat types found in the Everglades region include upland forests, wetland forests, marshes, wet prairies, open water ponds and creeks, and mangrove forest (SWIM, 1992a). Most of the animals utilize a variety of habitat types, in response to the drying out and flooding of various areas during the annual water cycle.

Historically, wildlife species diversity in the Everglades was relatively poor, particularly compared to the species rich Pantanal, though the ecosystem did support tremendous numbers of birds and alligators. The majority of animal species, including the land mammals, and most of the breeding birds, reptiles and amphibians, appear to have colonized from the temperate southeastern coastal plain (SWIM, 1992a; Layne, 1984; Gunderson and Loftus, in press). The wetland and wading birds are dispersed throughout the West Indies (SWIM, 1992a; Robertson and Kushlan, 1984). Animals endemic to the region include the Everglades mink, the rice rat, the hispid cotton rat, the round-tailed muskrat, and the Cape Sable seaside sparrow (SWIM, 1992a).

The relatively low species diversity found in the Everglades is probably due to a variety of factors, including the young geologic age of the region, the lack of diversity in aquatic and terrestrial habitats, and its peninsular location (SWIM, 1992a). At least 44 species of amphibians and reptiles (SWIM, 1992a; Duellman and Schwartz, 1958), almost 400 species of birds (SWIM, 1992a; Robertson and Kushlan), and about 30 species of mammals (SWIM, 1992a; Schwartz, 1952; Layne, 1984) occur within the Everglades. About 60% of the bird species are wintering and migrant birds.

III. HUMAN USE AND DEVELOPMENT

The quality and quantity of water are key variables in the functioning of both the Pantanal and Everglades ecosystems. Both systems are highly dependent on the duration, distribution and timing of water flows. These characteristics, in turn, are subject to human interference through large scale water development, flood control and navigation improvement projects. The Everglades has been most significantly altered by such projects, but plans under consideration for development in the Pantanal may significantly alter that system as well.

Water quality has also been affected by human activities in both the Pantanal and Everglades. In both cases, there are significant threats from agricultural development in the watershed. Both systems are also contaminated by mercury. In the Pantanal the source is gold mining in the watershed. The source of mercury contamination of the Everglades is not yet known, but it has probably been transported by atmospheric processes. In addition, the Pantanal also receives point source discharges from industrial and urban sources.

Other key variables are the degree to which land cover has been altered through clearing, grazing or other activities and direct utilization of fish and wildlife. Much of the Everglades has been drained and convened to urban and intensive agricultural uses. The remaining Everglades is largely protected from such alteration. It is highly susceptible, however, to an ongoing invasion of non-native plant species, principally melaleuca *(Melaleuca quinquenervia)*, Brazilian pepper

(Schinus terebinthifolius) and Australian pine *(Casuarina equisetifolia)*. Land cover in the Pantanal plains remains largely intact, though it is subject to extensive grazing, limited logging and some clearing for pasture improvement. Many parts of the Pantanal highlands have been extensively cleared for agriculture and pasture.

The protected status of most of the remaining Everglades, and its relative lack of human habitation, means that direct utilization of fish and wildlife have relatively insignificant impacts on their populations. The commercial harvest of fish and the illegal harvest of several species of wildlife may have significant impacts in the Pantanal.

A. Large-scale water development projects

1. Pantanal

The Pantanal ecosystem is based on an annual cycle of flooding and drought, including a multi-year pattern involving occasional greater fluctuations, or pulses, in the cycle. The Pantanal plains absorb and moderate the flow of water through the Paraguay River (Bucher et al., 1993). Though wildlife in the region is adapted to the natural cycle of flooding and drought, extremely high water conditions can cause loss of caiman nests, and restriction of habitat for capybara and many other non-aquatic wild and domestic species (Ferreira et al., 1992). Conversely, extreme drought conditions can severely stress both domestic animals and wildlife, and greatly restrict aquatic and wetland habitats.

A potentially significant interference with natural hydroperiods and flow patterns is the proposed Paraguay-Paraná Waterway (Hidrovia), a massive navigation project which would increase transportation efficiencies for several products of the Pantanal and surrounding areas. The primary impetus for the Hidrovia is an agreement among Brazil, Bolivia, Uruguay, Paraguay and Argentina to create a regional common market, known as MERCOSUL or MERCOSUR (Andersen, 1992).

Though the proposal is at an early stage, there are concerns that the project could have serious negative environmental impacts (Bucher et al., 1993; Ferreira et al., 1992). As presently configured, the Hidrovia would include two modules or phases. The first is a short-term, fairly restricted project consisting primarily of channel dredging from Santa Fé, Argentina to Corumbá, Brazil, as well as signposting from Corumbá to Nueva Palmira, Uruguay. Currently, the Inter-American Development Bank is funding a US$2 million study of potential environmental impacts of this phase, and close to US$8 million for engineering and economic pre-feasibility studies. The second phase would include dredging, course changes, channel straightening and stabilization, and construction of water control structures for navigational purposes between Cáceres, Brazil and Nueva Palmira, Uruguay, including additional work within the Pantanal (Bucher et al., 1993).

There are many direct and indirect impacts associated with the proposed works. Direct impacts from the first phase of the project would include dredging and channel maintenance, deposit of dredged material and the physical effects of increased barge and ship traffic on the river banks. Dredging destroys habitat and organisms in the affected area, changes the composition of bottom material and increases water velocity in the dredged channel (Bucher et al., 1993; Allen and Hardey, 1980; Rasmussen and Harber, 1981). Changes in stream velocity are associated with water quality impacts caused by increased turbidity and suspended sediments. Depending

on where dredged material is deposited, there may be direct destruction of habitat for nesting fish or birds, spawning fish or other vertebrates (Bucher et al., 1993; Allen and Hardey, 1980; Rasmussen and Harber, 1981). The single most potentially damaging impact of the Hidrovia project would be the loss of the Pantanal's function in moderating and absorbing flood waters on the Paraguay River (Bucher et al., 1993).

The hydrological regime of upper reaches of rivers can be significantly altered by construction and maintenance of downstream navigation channels, if channel capacity is increased at points of natural geomorphological constriction, increasing rates of drainage. In addition, channelization can exacerbate downstream flooding by increasing peak flows in a river (Bucher et al., 1993). Channel dredging and straightening can also affect the hydrological regime controlling wetland ecology. Though there is relatively little technical understanding of the hydrologic functioning of the Paraguay Basin, researchers have estimated that if the river channel were deepened by approximately 0.5-1.0 meter in that area, the extent of important floodplain wetlands might be significantly reduced in upriver regions which normally flood to less than one meter (Ferreira et al., 1992).

Of particular concern are the long-term impacts that alteration to the hydrology could have on the flora and fauna of the Pantanal. As evidenced in the Everglades, changes in water regimes can have many substantial and unanticipated adverse effects, including disruption of nesting and feeding behavior of wildlife, and changes in species composition and diversity. Ultimately, depending on the scale of the alterations, water management projects can substantially change the character and integrity of freshwater ecosystems.

In addition to impacts from dredging and channel straightening, channel maintenance structures, water control structures and the harbors and terminals that would be included in construction of the Hidrovia, there is also concern that a related increase in agricultural, industrial and urban activity (Bucher et al., 1993; Internave, 1992) would cause corresponding increases in pollution from agrochemicals, and industrial and urban wastes (Bucher et al., 1993).

2. Everglades

There has been extensive manipulation of water flows in the Kissimmee River-Lake Okeechobee-Everglades system by federal and state government, beginning in the late 1880s. Efforts to drain the region for agricultural purposes began as early as 1907, with the creation of the Everglades Drainage District. Early efforts included construction of a canal between Lake Okeechobee and the Caloosahatchee River, channelization of the Caloosahatchee and Miami Rivers, and digging of other canals through the Atlantic Coastal Ridge to facilitate drainage from Lake Okeechobee to the Atlantic Ocean. By 1927, six major drainage canals and many smaller canals had been built, including 440 miles of levees and 16 locks and dams.

Between 1926 and 1947, hurricanes and long periods of drought caused extreme fluctuations of water levels in the region. While flood control had been the primary concern in the past, the region was now faced with the additional problem of maintaining an adequate water supply for the rapidly increasing populations on the lower east coast of Florida. In response, Congress initiated the Central and Southern Florida Flood Control Project in 1947 to provide urban and agricultural flood control and to ensure adequate water supply. The U.S. Army Corps of Engineers constructed a series of canals, levees, water retention areas, pump stations, and

water control structures that extended throughout the entire length of the Everglades system. Today, this system includes over 2250 km (1,400 mi.) of canals, levees, water retention areas, pump stations, and water control structures in and around Lake Okeechobee and the Everglades. (Fig. 4)

Fig. 4. South Florida Water Management District (Drainage Canals and Surface Water Control System)

Source: Light and Dineen, in press.

Early drainage efforts had the desired effect, opening up much of the area to farming and other uses. However, construction of early canals also resulted in a number of readily observed problems. Water levels in Lake Okeechobee dropped from 6.7 to 4.6 meters (21.9 to 15 feet) above mean sea level between 1889 and 1927 (SWIM, 1992a). Water tables were lowered 1.5 to 1.8 meters (5 to 6 feet) below 1900 levels, thereby stressing natural wetland systems (SWIM, 1992a). Other adverse impacts to the system included muck soil loss of up to 1.8 meters (6 feet) in depth, loss of water storage capacity (Davis, 1946), and uncontrolled fires.

During the 1960s, much of the Kissimmee River, the northernmost component of the KLOE system, was channelized. Channelization efforts considerably altered the hydrology of the Lower Kissimmee Basin and led to the loss of about 16,200 to 20,235 hectares (40,000 to 50,000 acres) of wetlands (SWIM, 1993). Drainage of the historic floodplain led to increased agricultural development (improved pasture and intensive dairy operations) along the river. Channelization and destruction of floodplain marshes reduced the natural phosphorus removal capabilities of the river. The reduced phosphorus removal capability of the river coupled with runoff from agricultural operations led to increased phosphorus loadings in Lake Okeechobee (SWIM, 1993; Lamonds, 1975; Federico, 1982). Channelization also altered the rate and amount of water which enters Lake Okeechobee.

Efforts to drain the Everglades and to control flooding substantially altered the quantity, timing, distribution, and rate of water flows in the natural system. These changes in the historic hydrologic regime of the Everglades, in combination with other factors, have resulted in substantial impacts to the biological components of the system, including significant loss or degradation of native plant communities and loss or destruction of habitats of threatened and endangered plants and animals. Almost one half of the original 1,619,000 hectares (4,000,000 acres) of wetlands in the Everglades have been lost to agriculture and urban development. Various species of wildlife have been adversely impacted by changes in natural flooding regimes. These changes have also contributed to problems associated with the quantity, timing and discharge of freshwater into the estuaries of Florida Bay, Manatee Bay, and Barnes Sound. Such changes have significantly reduced the ability of these estuaries to support fisheries at formerly highly productive levels.

B. Agricultural development

In the past twenty years, primarily in response to national economic goals, use of the *planaltos* surrounding the Pantanal plain has shifted dramatically toward intensive agriculture and cattle production. Though the low quality and erosive tendencies of soils in the region was known at the time, the drive to develop superseded concerns over the ecological functioning of downstream lowlands. The placement of intensive agricultural operations in the highlands

continues to threaten the Pantanal *planície.* Use of massive amounts of agrochemicals and poorly planned water management systems have chronic long-term negative effects on the biology and hydrology of the area. Though public attention has recently begun to focus on the impacts of large scale agricultural operations, given the continuing economic crisis in Brazil and traditionally low concern for environmental values (Guimarães, 1991), it may be difficult to achieve meaningful change in agricultural practices in the near future.

The program is not dissimilar to that pursued by federal and state authorities in Florida at the turn of the century, when they officially supported and subsidized a program of drainage and agricultural development in the Everglades region south of Lake Okeechobee. The resulting impacts on water quality, quantity, timing and distribution to the rest of the Everglades have severely affected the functioning of the ecosystem.

1. Pantanal

Most of the rivers and tributaries draining into the Pantanal have their sources in the surrounding highland plateaus, or *planaltos.* In several regions, the *planaltos* are patchworked with extensive agricultural operations, most dedicated to soybean production, but including sugar cane, rice and corn. In the *planaltos* surrounding the Pantanal to the north and west, approximately 75% of the original *cerrado* forests and savannas have been converted to agriculture or pasture. Soils are relatively poor, yet intensive farming in these areas has been growing since the 1970s. To maintain soil fertility and combat crop pests, farmers have increasingly relied on extensive use of a wide variety of agrochemicals, including fungicides, pesticides, and fertilizers. Deforestation, including the clearcutting of vegetation bordering rivers, and poor water management practices have resulted in extensive agrochemical runoff, soil erosion and river sedimentation.

During the rainy season, extensive flooding, and some sedimentation and movement of river channels is considered normal in several rivers entering the Pantanal. However, there is growing concern that increased sediment load as a result of deforestation and farming on the surrounding uplands may be worsening flood conditions in the lowlands during the rainy season. In Mato Grosso, approximately 14 metric tons of soil per hectare per year is being eroded from farms on the *planaltos* (Teixeira, 1993). Higher sediment deposition in a river bed causes a decrease in flood storage capacity and a corresponding increase in flooding and channel movement (Bucher et al., 1993; Alho et al., 1988; Ferreira et al., 1992). The problem appears to be particularly severe on the Taquarí River, one of the major tributaries of the Paraguay River. Approximately 1,800,000 hectares (4,446,000 acres) of the upper Taquarí River basin have been deforested since the early 1970s, primarily for livestock pasture and intensive agriculture (Bucher et al., 1993).

There is a question concerning the rate and effects of sedimentation on the Taquarí River, which runs for more than 250 km (155 mi.), with a declivity of 10-15 cm/km (.65-.75 ft./mi.). Recent sediment loads have been estimated at several million tons per year, however the Taquarí formed an alluvial fan of over 50,000 square kilometers (19,300 square miles) long before humans arrived in the area, and has shifted its riverbed many times over its history (Adámoli, 1992). Thus, a problem lies in determining just how much this process has been accelerated by human activity and what corrective measures should be taken to conserve the basin. Some researchers believe the Taquarí River alluvial fan was not active in historical times due to dense vegetation which covered the entire basin, but has been reactivated by human-induced

sedimentation (Bucher et al., 1993, citing Tricart, 1982).

Sediment loading changes the process of river movement across a floodplain, causing the river to break through surrounding natural berms more easily, thus creating large distributary channels and flooding areas not normally flooded. In attempts to eliminate such channels and increase total grazing area, several ranchers in the Pantanal have closed off breaks in the berms containing the Taquarí River. These actions have interfered with the migration and reproductive behavior of many water dependent species as the waters recede, occasionally stranding large numbers of fish in areas which eventually dry. Widespread action of this son would also raise questions concerning impacts to temporary lakes and wetlands, and effects on ecosystem functioning on a regional basis.

Another major problem related to the intensive agriculture in the *planaltos* is the widespread use of agrochemicals and their migration into the lowlands. There is growing evidence indicating that agrochemical pollution may be an important factor in the Pantanal, though actual magnitudes and impacts have yet to be evaluated systematically (Bucher et al., 1993; Alho et al., 1988; Ferreira et al., 1992). Herbicides, pesticides and fertilizers, as with sediments, enter the Pantanal primarily by way of stormwater runoff and seasonal floods. However, agrochemicals, particularly those with higher persistency, will tend to travel much farther on flood waters. Dilution and degradation by natural processes are additional factors in estimating the degree of harm ultimately posed by agricultural chemicals (Adámoli, 1992).

In addition to intensive farming in the highlands, another activity with potential impacts on ecosystem function in the Pantanal is cattle ranching. Roughly 95% of the Pantanal plains has been divided into privately owned cattle ranches, known as *fazendas,* owned by approximately 3500 *fazendeiros.* The tradition of cattle ranching in the Pantanal goes back approximately 200 years. The *fazendas* averaged 100,000 hectares during earlier periods, though now many have been subdivided into smaller ranches of 5000 hectares or less. The fencing required for these partitions tends to restrict the movement and migration of animals, and may have negative effects on some wildlife populations, particularly during flood periods when access to isolated higher areas is important to survival.

Though cattle densities are relatively low, there are questions concerning the effect that grazing has had on natural vegetative communities and sedimentation rates, and the systemic effects of manure from the large number of cattle raised in the Pantanal. An estimated three to eight million head of cattle in the watershed produce many millions of pounds of manure per day. Relatively low animal densities are thought to have prevented significant adverse effects on water quality, but no studies have been attempted which would evaluate the total effects on ecosystem functioning. Similarly, low densities are thought to have prevented significant deterioration of vegetative communities from grazing, but research is lacking. It is worth noting that on a government owned research *fazenda* in the Nhecholândia region of the Pantanal, the exuberant regrowth of vegetation in a small fenced area included species that have not been detected for many years in areas of open range accessible to cattle (Gomes, 1992).

In many *cerrado* regions, excessive pasture burning also reduces native vegetation, resulting in increased populations of undesirable vegetation, increased soil erosion and river sedimentation. The attempted cultivation of non-native grasses is also problematic, since these do not survive dry season conditions as well as native lowland grasses, and contribute to sedimentation

problems when they die off.

The educational level of the *fazendeiros* is relatively high, and there appears to be general support for protecting and maintaining this existing use of the lowlands system. In recent years, ranch associations have been formed in an effort to support and inform the *fazendeiros.* One of the more visible of these associations is the NGO, known as Society for the Defense of the Pantanal (SODEPAN) in Mato Grosso do Sul, which offers workshops and educational materials to improve cattle and forest management, teach sustainable agricultural technologies and fish farming, and conduct research into the possibility of commercial farming of capybara and caiman. There are also attempts to advise and educate ranch owners on the possibility of supplementing cattle ranching with appropriate types of ecotourism (Azevedo, 1993).

2. Everglades

Agricultural land use practices within and adjacent to the Everglades have had significant adverse impacts on the historic natural system. Adverse impacts have resulted from both the physical disruption of natural habitat and hydrology caused by converting lands within the Everglades to agricultural and urban uses, and by the pollutants (pesticides and nutrients) associated with both activities. There are approximately 810,000 hectares (2,000,000 acres) of agricultural lands in these areas. The construction and operation of the water management system necessary to support these land uses have played a role in the large scale destruction of wetlands, water shortages, disruptions of the timing and distribution of water supply, nutrient pollution, and disruption of habitat. Such manipulation of the natural hydrologic regime has also contributed to fragmentation of the Everglades, resulting in the loss of connections between the central Everglades and adjacent transitional wetlands. Generally, there are several predominant forms of agricultural activities which impact the Everglades system. Crop production in the east Everglades area, including portions of Dade County, is typically preceded by rock plowing, a process of breaking up and crushing the native limestone rock formation until it reaches a consistency which can be plowed and planted. The subsequent agricultural use requires intensive use of water, pesticides, herbicides, and fertilizer (SWIM, 1992a; Baker, 1988). Agricultural activities in this area are shifting from seasonal crops such as tomatoes and vegetables to year-round crops and plants such as citrus, tropical fruit, and ornamental nurseries that require more intensive water management (SWIM, 1992a; Metro-Dade, 1989).

Agriculture in the Everglades Agricultural Area (EAA), comprising about 283,000 hectares (700,000 acres) along the southern edge of Lake Okeechobee, relies on drained areas consisting of muck soils formed from the decay of sawgrass *(Cladium jamaicense).* Drainage of these soils causes soil oxidation and release of nutrients, and has been shown to contribute significant nitrogen and phosphorus loads to receiving waters. The principal crop is sugar cane, although vegetables, sod, corn, and rice are also grown in the area. Although sugar cane typically requires little or no fertilization, vegetable crops, which cover about 10% of the EAA, are responsible for about one third of the phosphorus fertilizer applied in the area (SWIM, 1992a; IFAS, 1989).

Fertilizer use on vegetable crops has been shown to significantly increase the phosphorus content of soils and to result in high concentrations in soil waters, groundwater, and drainage waters (SWIM, 1992a; IFAS, 1989). An extensive system of irrigation ditches, canals, levees, and pump stations exists to irrigate and drain fields. Nutrient contributions from surface waters

from the EAA may have had significant adverse impacts on water quality and composition of flora and fauna. In addition, receiving waters are contaminated with high concentrations of chlorides, dissolved minerals, iron, and trace levels of pesticides (SWIM, 1992a).

Nutrient pollution from large dairy and cattle fanning operations located north of Lake Okeechobee has had adverse impacts on the water quality of the lake and downstream waters (SWIM, 1989). The primary concern is the large amounts of phosphorus and nitrogen that are discharged into the lake through surface water runoff from these operations. Excessive nutrients in the lake have led to massive lake-wide blue-green algae blooms and subsequent fish kills due to low oxygen levels in the water. In addition, nutrient rich waters flowing south from Lake Okeechobee and the Everglades Agricultural Area are altering native flora and fauna. Phosphorus is assumed to be the growth-limiting nutrient in Lake Okeechobee. Accordingly, current management strategies are focusing on controlling phosphorus inputs to the lake.

Only approximately half of the 1,619,000 hectares (4,000,000 acres) of original Everglades now remain, and are contained within various impoundments, cut off from essential sources of sheet flowing water. Everglades wildlife communities and the sustainability of the ecosystem are impaired by this separation and isolation. Runoff from dairy operations and backpumping from the Everglades Agricultural Area have resulted in increased nutrient loads to Lake Okeechobee, the water conservation areas, and Everglades National Park. These discharges are causing significant changes in the composition of plant and animal communities and other natural characteristics, and threaten the ecological integrity of the Everglades ecosystem (SWIM, 1992a; LOTAC-II, 1988; Swift and Nicholas, 1987; Davis, 1989, 1991).

C. Extractive and industrial activity

1. Pantanal

Extractive industries for iron, manganese, diamonds and gold have the potential for significant impacts on the Pantanal ecosystem. Iron and manganese mining, primarily in areas near Corumbá, produces mostly localized effects in the Pantanal, but does have negative impacts on nearby agricultural areas that are important to local markets (Ferreira et al., 1992). Mining also appears to be related to changes in the direction of groundwater flow and in streams draining the area, and creates problems with iron and manganese contamination and sedimentation, particularly when dams containing mineral wastes break during heavy rains (Ferreira et al., 1992).

Sedimentation from operations occurring directly in or near rivers has significant long-term impacts on hydrological and ecological functioning. Two diamond mining areas in Mato Grosso contribute very high sediment loads to the Paraguay River and São Lourenço River. Operations in these areas include activities which occur directly in the river channels.

In the upper Paraguay Basin, of the various mineral mining operations, gold mining represents the greatest environmental and human health risk. Since the early 1980s, gold mining has been concentrated in the state of Mato Grosso, in the upper reaches of the basin. There are approximately 300,000 miners *(garimpeiros)* in Mato Grosso (PRODEAGRO, 1992), and more than 500 mining operations in the Poconé area alone (Santos, 1993), with production estimated at 400 kilograms per month (Teixeira, 1993). Environmental impacts include destruction of riverine vegetation, soil erosion and sedimentation, changes in river bed topography and water

pollution.

Estimates are that 40 metric tons per year of mercury are used by miners in Mato Grosso in order to amalgamate gold particles contained in the mined soil and mud slurry (PRODEAGRO, 1992). There are serious questions concerning how carefully mercury is being handled, and how much is being released to the environment. Environmental officials state that recent advances in technology allow the containment of 80% of mercury used during this phase of the process, but it is unclear to what extent the new technology is being employed. Pits for discarded slurry are often poorly designed and constructed, sometimes allowing pit walls to break or overflow during high water periods.

Typically, the mercury/gold amalgamate is heated in open containers with blowtorches to vaporize the mercury. Public health officials estimate that three grams of mercury are used for every gram of placer gold mined, and that 70% of the volatilized mercury eventually finds its way into the food chain, bioaccumulating at higher trophic levels. Environmental officials in Mato Grosso state that new volatilization processes recapture 80-90% of the volatilized mercury, though small miners do not tend to use such processes, and the state's low enforcement capability makes it difficult to control small operations.

There are several documented cases of elevated mercury levels in native fish and birds, particularly in the northern Pantanal (Hylander et al., 1993; De Lacerda et al., 1991). Though some questions have been raised concerning the sources of mercury in migratory fish (Santos, 1993), there appears to be general consensus among most regulators and academics that a significant part of the problem is related to gold mining activity (Adámoli, 1992; Espíndola, 1993). The political pressure behind the mining is significant. In Poconé alone, approximately 70% of the population is dependent on the income from gold mining (Santos, 1993). When IBAMA, the federal environmental agency, closed all mines in the area earlier this year, in an attempt to properly survey and permit mining operations in the area, and determine the extent of the mercury pollution problem, the mayors of several *municípios* pressured federal and state authorities to force IBAMA to reopen many of the mines.

Agroindustrial activities represent another significant potential source of contamination, since wastewater treatment systems are very rare. Primary agroindustries in the Pantanal watershed include alcohol fuel distilleries, slaughterhouses, meat processing plants, and dairy processing facilities. Generally, industrial, urban and mining waste effluents are deposited directly into rivers on an ongoing basis. There are approximately ten operating alcohol fuel distilleries in Mato Grosso and one in Mato Grosso do Sul. In the northern part of the basin, the cumulative productive capacity of alcohol distilleries has been estimated at 1,500,000 l/day (396,000 gal./day), with a waste discharge of about 27,800 m^3/hr. (7,345,000 gal./hr.) (Ferreira et al., 1992).

At present, there are internationally supported plans to construct a natural gas pipeline from Bolivia to São Paulo, through Corumbá and the Pantanal. In conjunction with this project, the Brazilian federal government is planning for Corumbá to be the first of a series of fourteen export processing zones to encourage economic and industrial growth within the country. The ultimate size and number of industrial operations in the Zona de Processamento e Exportação (ZPE) could result in severe environmental disruption, however environmental officials in Mato Grosso do Sul have expressed the opinion that existing authority and enforcement capability are

adequate to regulate the expected impacts (Espíndola, 1993). Recently, the environmental impact assessment required for larger development projects was presented at a public hearing for another proposed ZPE at Cáceres along the upper Paraguay River in the northern Pantanal.

2. Everglades

Mining activities in the Everglades region have primarily involved mining of water and limestone. Though limestone mining operations have destroyed considerable habitat in the eastern Everglades, generally they are not considered to have significant negative effects on water quality or quantity. Currently, a very large scale limestone quarrying operation is close to starting up in Dade County. There is some concern that the operation could lead to adverse impacts to ecosystem functions. Another extensive industrial project involves the mining of water east of the perimeter levee near Conservation Area 3 (to the east and south of Lake Okeechobee). Potential impacts from this operation are unclear.

Oil drilling has occurred in the Everglades region, but to date commercially viable operations have occurred only at the Raccoon Point Wellfield in the Big Cypress Preserve and in Immokalee region to the west. There are several pipelines which carry oil from the Raccoon Point and Immokalee wellfields east across the Everglades to the Fort Lauderdale area. Generally, the pipelines parallel the path of Alligator Alley, the major east-west highway which cuts through the Everglades system. These pipelines have ruptured in the past, most significantly about six years ago when a casing of one of the pipes deteriorated and had to be replaced. Cleanup of the spill was accomplished within about one year of the spill. The pipelines are located underground, and their construction and placement pipelines causes some disturbances to the Everglades. Generally, the pipelines are not considered to cause adverse impacts to the hydrology.

Currently, there is also a proposal to drill an exploratory well on the Miccosukee Reservation in the Everglades. The directional well would be constructed on Reservation property at a slant, in order to access areas under adjacent Water Conservation Area 3.

D. Urban development

Urban development within a watershed has associated with it many direct and indirect impacts on the natural functioning of the system. These include but are not limited to the direct loss of habitat to clearing of vegetation, siltation and contamination of water resources as a result of vegetation loss and urban effluents, loss of many wetland values as a result of drainage, consumptive uses of surface and ground water.

1. Pantanal

Approximately three million people live in the Brazilian portion of the Pantanal basin, and surrounding highlands. Direct habitat losses to conversion of land for urban development are, for the most part, restricted to a few population centers in the upland areas of the Pantanal. Indirect effects of urbanization include urban requirements for natural resource inputs and waste assimilation. Relative to the amounts of freshwater available from surface water sources, consumptive uses of water related to urban development in and around the Pantanal are probably negligible. However, advanced treatment of urban sewage and solid waste is rare in the area. Millions of gallons of untreated domestic waste enter waterways each day, resulting in

significant contamination of surface and subsurface waters.

Urban wastes originating from Cuiabá, in the state of Mato Grosso, have been estimated to be responsible for a 20% reduction in concentrations of dissolved oxygen and for a mean abundance of 1,533 fecal coliforms/100 ml of water in the Cuiabá River, within a short distance downstream (Ferreira et al., 1992; Gomes and Shimada, 1985). In the state of Mato Grosso do Sul, it has been estimated that the organic waste load for the Paraguay River basin results in a total biological oxygen demand of 12,083 kg/day, of which 75% originates from the city of Corumbá and from the upper basin of the Miranda River (Ferreira et al., 1992). Fish kills regularly occur during low water periods, but such dieoffs apparently also occur from natural processes, and the cumulative effects of chemical, viral and bacterial contamination from urban wastes on fish and wildlife are not known. During high water periods, flooding patterns and other dispersive and assimilative processes tend to prevent large numbers of massive fish kills related to water quality impacts (Adámoli, 1992).

2. Everglades

The intense urbanization of lands within the Everglades has had significant adverse impacts on the natural system. Currently, there are 4.5 to 5 million people living within the Everglades and on the low coastal ridge separating the Everglades from the Atlantic Ocean. In 1986, residential uses were the most prevalent use in the southern counties, comprising a total assessed value of over $94 billion (SWIM, 1992a). Agricultural lands east of the Everglades are continuing to be converted for urban development, which forces farming activities further west into areas closer to the perimeter canals and levees which border the Everglades. Other predominate urban land uses include service industries, retail trade, financial industries, manufacturing, tourism, and recreation.

The urbanization of this region has had considerable impacts on water supply, wildlife habitat, groundwater recharge, and water quality of the Everglades system. Significant portions of the system have been adversely affected or destroyed. Development has directly impacted the hydrology of the region by increasing the amount of surface runoff and by decreasing the amount of storage available (SWIM, 1992a). The drainage necessary for urbanization causes two to three million acre feet per year of fresh water to be shunted to the sea. Under historic conditions, this water would serve to extend Everglades hydroperiods and increase fish production and other components of the food chain necessary for wading birds. Current regulatory initiatives are focusing on the need for increased water conservation and investigation of water supply alternatives, protection and preservation of wetlands for groundwater recharge and wildlife habitat, and the need to address impacts of stormwater discharge from existing and future development on water quality (SWIM, 1992a).

E. Wildlife exploitation

Wildlife exploitation in both ecosystems has followed a similar track, with prehistoric and early historic use by indigenous peoples at subsistence levels, followed by semi-indigenous uses with slightly more impact. Early colonial uses tend to be very extractive, and are eventually moderated to allow more sustainable use of wildlife resources.

Modern approaches to wildlife exploitation include the significant potential for non-extractive “exploitation” in the form of ecotourism. There is a growing worldwide market for opportunities to

experience wildlife species in their natural and undisturbed habitats, with potentially significant financial returns for local economies. The Everglades National Park is only one manifestation of that market in south Florida, and current visitation rates are approximately one million visitors per year.

With large numbers of wildlife, including some of most unique and beautiful species in the world, the Pantanal represents a tremendous, relatively untapped, market for ecotourism. Visitation rates in recent years are on the order of 10,000 people per year (Bucher et al., 1993), though accurate figures are difficult to obtain. Dry season conditions are particularly favorable to wildlife viewing, with relatively pleasant weather, and wildlife tending to congregate near areas of surface water. It is extremely important that environmental planning and regulatory authorities survey existing ecotourism facilities and practices, in order to assure that habitat is not destroyed or contaminated and wildlife populations are not compromised as a result of what appears to be a burgeoning and lucrative industry.

1. Pantanal

Historically, the Pantanal ecosystem was used for subsistence level hunting and fishing by relatively small populations of indigenous peoples, whose activities had little impact on ecosystem functions. Native tribes in the area include the Kadiwéu, Terena, Kinkinao, Guaraní, Guató, Boror, Caduveo Uutina, Pareci, Komba and Ufaiê-Xavante, though most have now moved to FUNAI reserves, been assimilated or become extinct (Bucher et al., 1993).

Beginning in the colonial period, and continuing to the present, semi-indigenous uses of the Pantanal have included low levels of subsistence farming, in addition to hunting and fishing. Closely associated with the history of cattle ranching in the Pantanal are the *pantaneiros* or Pantanal cowboys, many of whom support families. This relatively small, semi-indigenous group, with its own rich cultural tradition, has been an important part of the growth of cattle ranching since its inception over 200 years ago. The economic viability of the *fazendas* is closely related to the work done by *pantaneiros,* while the viability of the *pantaneiro* culture itself is tied to the economic fortunes of the ranches. Wildlife diversity is also related to the health of *pantaneiros* and *fazendeiros.* Though hunting is illegal in the Pantanal, *pantaneiros* often have an implicit understanding with ranch owners that hunting their lands for caiman, jaguars and other wildlife is acceptable. The practice gives the low wage *pantaneiros* the opportunity to sell hides for money and takes care of what is often seen as a wildlife nuisance.

Current trends in wildlife harvesting are probably not sustainable. With about 30,000 fishermen and very little enforcement presence, a serious problem in the Pantanal involves uncontrolled fishing throughout the year. The situation is particularly problematic during the *piracema* (spawning season), which occurs at different times, depending on the fish and the region. Estimates in 1990 were that about 3000 kgs (6600 lbs) of fish were taken illegally each month.

Until fairly recently, the poaching of caiman or *jacaré* for skins was essentially unregulated. In 1988, an estimated 1,000,000 hides were illegally taken, with almost no effective intervention by authorities (Mittermeier et al., 1990). Increased enforcement activity in Mato Grosso do Sul, combined with international pressure on Bolivia and Paraguay to close down the markets for skins in those countries, have significantly reduced the illegal poaching, but the problem has not been completely abated (Rabelo, 1993).

The taking of animals for the illegal trade in pets has also damaged populations of such animals as the hyacinth macaw, parrots, parakeets, monkeys and anacondas. Hyacinth macaws have a market value of up to US$8000 a pair in the United States and US$15,000 in Europe. Recent surveys have indicated that a maximum of 3000 individuals remain in the wild and that 50 per cent of all smuggling in Brazil is for the national market (Mittermeier et al., 1990).

2. Everglades

Historically, portions of the KLOE system were used for subsistence hunting, gathering, and fishing by small essentially nomadic populations of indigenous peoples. At the beginning of the period of Spanish settlement in Florida, aboriginal groups inhabiting the KLOE system included the Jeaga (coastal area east of Lake Okeechobee), the Mayaimi (all sides of Lake Okeechobee), Tequesta (coastal areas southeast of Lake Okeechobee) and Calusa (coastal region southwest of Lake Okeechobee) (Larson, 1980). These early groups followed a seasonal cycle of utilizing particular plant and animal species that were in sufficient abundance to support the population. The primary food sources were fish, whales, shellfish, cocoa plums, saw palmetto berries, zamia (starch source), sea turtles, and various land mammals, including deer and bear (Larson, 1980). The subsistence activities of early aboriginal peoples probably had little impact on ecosystem functions.

Early aboriginal groups in the region were extinct by the mid-1700s, primarily due to massacre and disease (Derr, 1989). Later occupation of the area by Native Americans (primarily Seminole and Miccosukee tribes) also probably had relatively little impact on the natural system. By the turn of the century, official U.S. policy had almost completely removed Native Americans from the region (Derr, 1989). Current uses of the Everglades system by the Seminole and Miccosukee Tribes include traditional activities such as hunting, fishing, and harvesting timber for personal dwellings, as well as modern economic activities (Quetone and Koening, 1992).

Certain animal species have suffered tremendous declines in the Everglades region. Excessive hunting at the turn of the nineteenth century severely stressed populations of a number of species, many of which have never fully recovered. Several species have been extirpated from the area, including the Florida red wolf and the Carolina parakeet (SWIM, 1992a). Wading bird populations, estimated at about 2.5 million birds in 1870, were reduced to 500,000 in 1910 as a result of plume hunting (SWIM, 1992a; Robertson and Kushlan, 1984).

While wildlife hunting laws helped ease the pressure on certain species, other factors have resulted in continued declines of many species. The causes of these declines include the loss of habitat to urban and agricultural use, intensive harvest and over harvesting, altered hydroperiods, changes in the composition of native vegetation, introduction of exotic vegetation, water management practices, and alteration of fire patterns (SWIM, 1992a). Wading bird populations have declined by about 90% during the past 60 years.

Presently, at least 44 species which use the Everglades area are considered threatened, endangered, or of special concern. Threatened and endangered species include the Florida panther, mangrove fox squirrel, Florida black bear, everglades mink, manatee, wood stork, snail kite, cape sable seaside sparrow, peregrine falcon, southern bald eagle, brown pelican, American alligator, eastern indigo snake, and American crocodile (SWIM, 1992a).

F. Cross-scale Threats

In addition to localized anthropogenic impacts on watershed functioning, management of the Pantanal and Everglades may be influenced by cross-scale threats with wide ranging sources and effects. Both systems have the potential to be affected by many types of activities and events occurring outside the boundaries of the watershed. A potential example includes shifting weather patterns and sea level rise as a result of global warming. Even slight differences in the amounts, location and timing of rainfall can have unanticipated and greatly magnified effects in terms of ecosystem functioning. Though the effects of sea level rise would probably be felt more in the Everglades than on the Pantanal, shifts in rainfall patterns could have significant, essentially unforeseeable negative impacts on the habitats of resident and migratory birds in the Pantanal, as well as wetland and aquatic habitats for a large number of other species.

Additionally, contaminants in several forms can be transported by different processes over long distances and deposited within a watershed. Examples include long distance movement of metallic and organic forms of mercury, which in the Pantanal, are closely associated with gold mining and periods of high water. Volatilized forms of mercury may also be transported long distances by wind and rain patterns. The true scope of the resulting damage to human health and environment from mercury is only beginning to be realized. In the Everglades, mercury deposition appears to be associated with atmospheric processes. Though at present, they appear not to be a significant problem in south Florida or western Brazil, increases in the rates and concentrations of acid deposition from sources hundreds of miles away, particularly in combination with other regional or cross-scale threats, have the potential to affect ecosystem functions.

Larger trends in economic conditions and trade policy should also be appreciated as potential cross-scale threats, since intensity of development in an area may be closely associated with national and state efforts to respond to such trends and conditions. In the Everglades, the most obvious example is sugarcane production, which has been heavily subsidized by price supports and import quotas. In the Pantanal, agricultural development on the *planaltos* was rapidly accelerated and subsidized beginning in the early 1970s, in response to national economic goals to increase foreign exchange and service the debt to international lending sources. The lack of concern for, and apparent inability to regulate the environmental impacts of such large, intensive operations were at least partially related to forces acting on a very large scale. In these circumstances, the negative impacts on a watershed are just as much a result of cross-scale threats as is atmospheric mercury deposition, and equally as difficult for regulatory authorities to control.

IV. REGULATORY AND POLICY RESPONSE

A. Legal Authority and Institutional Capacity

Agencies responsible for research, planning and regulation of impacts to the Pantanal and Everglades have varying degrees of effectiveness, which appear to be related to factors such as: agency missions, allegiances and funding; the degree of regulatory and planning authority granted to an agency; principal constituencies served by an agency; power relationships between agencies; potential for political manipulation of an agency; and whether equipment and training levels of personnel are sufficient to meet program responsibilities imposed on the agency.

There is generally adequate legal and regulatory authority to control activities with negative environmental impacts in the Everglades and in much of the Pantanal, although the authority in both regions is weakened somewhat by exemptions and gaps in the regulatory structures. Several other factors affect the ability of agencies to act effectively. Beyond certain projects financed by international lending institutions which support much needed research, regulation and institutional development in the Pantanal, lack of funding and resources is a chronic problem for state environmental agencies. The Brazilian economic crisis has severely restricted available funds for equipment and staff. As a result, it is difficult to retain qualified personnel. Environmental agencies in the Pantanal express a general need for expertise in several areas, including basic scientific understanding of ecosystem functioning, increased enforcement capability, and the processes and forms for creating effective, enforceable legislation. Laboratory testing facilities and technical capabilities are not sufficient to allow complete chemical and bacteriological testing.

1. Pantanal

a. Federal

The Brazilian Constitution of 1988 is considered by the U.N. to be one of the most advanced constitutional texts on environmental issues in the world (Guimarães, 1991). Chapter VI (Article 225) of the 1988 Constitution is devoted to public environmental rights, and specifies the Pantanal as one of several ecosystems which are recognized as part of the “national patrimony.” Also included are the Amazon, the Atlantic Forest, the Serra do Mar or Sea Mountains and the Coastal Zone. All states with jurisdiction over such areas must provide for their specific protection based on financial capability and applicable resources. At present, realizing the full potential of available constitutional and legal controls is difficult. Federal bureaucratic controls suffer from excessive jurisdictional overlap and political pressure from development interests (Guimarães, 1991). State environmental agencies have only recently gained sufficient authority to address many problems and suffer from a general lack of institutional capacity (Brazil 92, 1992).

There are approximately 120 federal laws related to the environment in Brazil, not including articles and resolutions. Generally, federal laws set minimum standards of review and regulation on a certain topic, while state laws may address particular issues and problems with more specificity. State laws must be consistent with federal law on a particular subject and must meet federal minimum standards, as set by the National Environmental Council (CONAMA). Most federal laws are implemented and enforced by the Brazilian Institute for Environment and Renewable Natural Resources (IBAMA), the primary federal environmental agency.

The Brazilian National Environmental Policy Act (Federal Law No. 6938), enacted in 1981, serves as the foundation for federal environmental regulation in Brazil, essentially requiring a permit from federal or state environmental agencies for many types of projects with the potential for environmental impacts. Before permits can be issued, environmental impact assessments must be completed and must be subject to public review and comment *(audiência pública)* (Findley, 1988). The Brazilian Forest Code (Federal Law No. 4771/1965) as amended, is a complex law which includes substantive and procedural rules concerning property rights, the exploitation of protected areas, methods for managing forests in most regions of the country, and permit conditions and penalties. The law requires a 30 to 200 m (100-650 ft.) protection zone on

either side of rivers and other watercourses, depending in part on the size of the stream, the rate of flow and the flooding regime (Santos, 1992; Espíndola 1993).

In addition, the CONAMA has established six classifications of water use, based on existing water quality in surface waters of the country (Resolution No. 20, 1986). Most states apply the federal minimum standards for water quality, depending on the classification of use. Industrial effluent is not allowed to violate these standards. A cumulative impact analysis, or assimilative capacity analysis is also required for developments with impacts on a river based on the classification of the particular section of the river potentially impacted. No additional industrial effluent may be allowed in an area if assimilative capacity standards would be exceeded. Accurate evaluation, monitoring and enforcement of these requirements is problematic.

A new federal law has been proposed by which federal agencies would regulate impacts to water quality and quantity in interstate waters within Brazil. One feature of the proposed legislation is the creation of river basin commissions and where necessary, sub-basin commissions, overseen by a national collegiate, which would work together to plan and evaluate permits for the proper use of water resources. It appears that the legislation is still being revised and debated.

On paper, Brazilian environmental law has a powerful enforcement tool. Federal Law No. 7347 was enacted in 1985, creating and regulating a type of citizen suit *(ação civil pública)* (Findley, 1988). Such suits may now be brought against the government or private parties by the Attorney General or by legally recognized entities other than individual persons, in order to enforce environmental statutes. Standing is broadly defined, allowing groups to sue for enforcement of laws in remote parts of the country regardless of their presence in the applicable area (Muller and Ninio, 1992). Though the law has the potential to increase control over environmental violators, it has not been widely used as yet in the Pantanal.

Before adoption of the 1988 Brazilian Constitution, all impacts to flora and fauna were regulated solely by IBAMA. States could legislate and act on these topics only through agreements with, and authorization by, the federal agency. The agreements allowed for federal intervention whenever necessary. States now have concurring authority to regulate flora and fauna, though not all states have acted on this authority (Oliveira, 1993). In some states, IBAMA has no presence at all, such as in the state of São Paulo, which has a powerful state environmental agency.

In the past two years, Brazil has initiated a “National Program for the Environment,” financed by the World Bank. The program has three fundamental components: institutional development, focused primarily on IBAMA; ecological protection of the Pantanal, the Atlantic forest and the Atlantic coastal area; and the establishment and protection of approximately fifty Federal Conservation Units, identified as ecologically important areas, with responsibility for the plans delegated to IBAMA. Environmental agencies in states with jurisdiction over the Pantanal and other representatives of the “national patrimony” are responsible for administering those components of the program in their respective states.

b. Mato Grosso do Sul

The Brazilian portion of the Pantanal is divided between the states of Mato Grosso and Mato Grosso do Sul. In addition to regulatory agencies in these states, IBAMA and local environmental authorities exert influence over efforts to develop the basin. In Mato Grosso do Sul, which has

jurisdiction over approximately 52% of the Brazilian Pantanal watershed (SEMA, 1993), environmental and land use activities are regulated primarily by the State Secretariat for the Environment (SEMA). The federal research agency known by the acronym EMBRAPA maintains a research complex (CPAP) in Corumbá, Mato Grosso do Sul dedicated to agricultural, ranching and environmental issues in the Pantanal. In Mato Grosso, the responsible environmental agency is the State Foundation for the Environment (FEMA), and there is a small EMBRAPA research unit in Poconé.

In recent years, federal and state governmental officials have provided support for institutional strengthening which has increased SEMA's capacity to monitor and regulate activities with environmental impacts. FEMA, created in 1987, is a relatively young organization which appears to have received somewhat less support from policymakers. A new agro-environmental development program being funded by a World Bank loan includes a component for the institutional strengthening of FEMA (PRODEAGRO, 1992).

In Mato Grosso do Sul, SEMA and IBAMA are responsible for the regulation of activities with effects on the environment. The Secretary of SEMA oversees three technical departments with about 120 technicians (permitting of polluting activities, conservation of natural resources, environmental education); a center for environmental control, including physical/chemical and bacteriological laboratories; a financial and administrative department; and two advisory departments for technical and legal matters. The agency maintains regional offices in Bonito, Aquidauana, Corumbá and Coxim (Espíndola, 1993).

The Forest Police, a unit of the State Military Police, provide environmental protection and preventive policing through formal agreements *(convênios)* with IBAMA and SEMA. There are approximately 250 members of the Forest Police covering Mato Grosso do Sul's portion of the Paraguay Basin, only about 50 of whom have specialized training in environmental enforcement (Rabelo, 1993). The agreement with IBAMA calls for the Forest Police to enforce laws controlling hunting, fishing in interstate waters, and the exploitation of forest resources. Through the agreement with SEMA, the Forest Police enforce laws concerning fishing in state waters and activities that have the potential to cause soil degradation. The agency also participates in the research efforts of SEMA and EMBRAPA, including monitoring and reporting environmental conditions and the status of wildlife (Oliveira, 1993).

There are two primary state environmental laws in Mato Grosso do Sul. The first of these laws, the State Environmental Policy Act (Law 90) was the first law of this type in Brazil, adopted in 1980, one year before a similar federal law. The law requires that all activities with the potential to harm the environment must obtain a permit from SEMA. It deals with the licensing and control of polluting activities, addressing all potential environmental impacts. The requirements are detailed, and apply to all of Mato Grosso do Sul. Under this legislation, SEMA has permitting authority over the approval of the project itself; location and siting; control of air pollution; and control of effluents, with standards and controls depending on the sensitivity or classification of the area (Oliveira, 1993).

The second such law, the Pantanal Protection Law (Law 328), was adopted by the legislature of Mato Grosso do Sul in 1982. This legislation divides the state into two areas, the Paraná and Paraguay river basins, and requires that all proposed economic activities in the Paraguay basin provide an environmental impact assessment, allowing for public review and comment

(audiência pública) on any activity with potential environmental impacts. Most evaluative criteria for permits relate to land use and water management. After staff review and public discussion at the *audiência pública,* SEMA either rejects the proposed activity, or imposes technical conditions to meet applicable standards. The law also prohibits industrial fuel alcohol distilleries within the Pantanal region of the Paraguay Basin.

c. Mato Grosso

The situation in Mato Grosso is somewhat different. The state's history and current orientation toward development suggest a political climate not favorable to environmentally sustainable management of natural resources. However, the state constitution of Mato Grosso does require that the Pantanal be protected, and requires that local governments take measures to ensure this protection. It also mandates that environmental measures in the Pantanal be implemented in conjunction with the state of Mato Grosso do Sul. It is worth noting that recently, the top official at FEMA (also serving as Special Secretary for the Environment) was replaced, at least partially for an inability to make progress on several environmental programs. Currently, the agency is undergoing an organizational review and restructuring. Though new management has the potential to increase the efficiency and effectiveness of the agency, it remains to be seen whether it will become a significant force in promoting environmentally sustainable development.

At present, FEMA enforces a State Environmental Policy Act (Law 4894/1985) which generally tracks the federal legislation on which it is based. The law requires permits for construction and operation of several activities with the potential to pollute the environment, based on environmental impact assessments which are subject to public review and comment. Although comprehensive, the state law did not adopt provisions specific to local conditions, and did not include higher levels of protection for the Pantanal. For example, in its original formulation, the law did not prohibit fuel alcohol distilleries in the Pantanal. In 1985, CONAMA required FEMA to suspend any licensing of new alcohol distilleries in the Pantanal, though existing distilleries were allowed to remain in operation. Farm projects over 1000 hectares (2500 acres) are also subject to the law, but agricultural developers have been able to avoid these requirements by subdividing projects into units less than 1000 hectares, then operating cooperatively to achieve efficiencies of scale. In Mato Grosso do Sul, the applicable size threshold for farm projects requiring environmental impact assessments is 500 hectares (1250 acres). Several attempts have been made to develop and adopt more stringent environmental legislation, in Mato Grosso, but development interests within the state have hindered those efforts (Oliveira, 1993).

A relatively new program of planning and regulation in Mato Grosso is the Project of Agro-Environmental Development, known as PRODEAGRO, which includes environmental components related to several types of threats. The specific policies and regulations for most of these components have yet to be developed. One of the primary elements of the program is agro-ecological zoning, which attempts to locate particular types of farming and ranching activities in appropriate areas of the state (PRODEAGRO, 1992). The program also contains a component for the management, protection and monitoring of natural resources, with subcomponents which include: establishing conservation units; sustainable management of primary and secondary forests; registration, rationalization and control of mining activity; environmental licensing, monitoring and regulation; informal environmental education; institutional reform and development of FEMA; support of indigenous communities; monitoring of cover vegetation, mining activities and remote sensing (PRODEAGRO, 1992).

The Mato Grosso Forest Police, were created in 1986 to enforce several state and federal laws, including those concerning illegal burning, illegal skin hunting and out of season commercial fish netting. The Police maintain a primary office in Cuiabá, with branch offices in Cáceres, Caracara, Poconé, Porto Cercado, Isla Diamon, Barão de Melgaço, and Porto Joffre. The force includes about 150 soldiers divided into detachments. Recruits receive special instruction in the applicable environmental laws and in dealing with tourists along the Transpantaneira Highway (Teixeira, 1993). However, as a result of low salaries and few operating funds, the agency may not be as effective as its counterpart in Mato Grosso do Sul, and is currently undergoing reorganization (Rabelo, 1993).

With relatively low enforcement capability, FEMA has pursued several efforts at achieving environmental goals through public education. In agricultural areas, the agency promotes the use of small contour plowed berms in order to decrease soil erosion. In cattle ranching areas, there are public service announcements to decrease the amount of pasture burning which normally occurs during the dry season. In gold mining areas, pamphlets are distributed which warn of the dangers of uncontained volatilization of mercury, and which promote a relatively simple technology for containing the mercury vapors. The agency has also produced educational pamphlets which explain the need to avoid fishing during the spawning season.

2. Everglades

There is no institution in South Florida, other than the South Florida Water Management District (SFWMD), with the combined capacity to conduct the research, planning, construction, operation, acquisition, regulation, and public education necessary to protect and restore the Kissimmee-Lake Okeechobee-Everglades (KLOE) ecosystem. The Everglades National Park has responsibility for research, planning and management in a significant portion of the lower part of the KLOE system, though it does not hold regulatory or permitting authority for activities outside the Park boundaries. The SFWMD encompasses the entire watershed. District staff have been closely involved, with the Corps of Engineers, in designing, constructing and operating the Central and South Florida Flood Control Project. The District also has an extensive regulatory program for urban and agricultural activities. Several intensive planning efforts focused on the Everglades are now coming to fruition. These include the Everglades SWIM Plan and the District's Water Supply Plan.

The District has a staff of 1517, many of whom are highly trained and experienced professionals, with an additional 50 positions being considered for the coming fiscal year. Its 1993 budget was approximately $259 million. When compared to the likely challenges and costs of restoring the Everglades, however, the District must have the active cooperation and assistance of the federal government and local governments. Current planned projects are expected to cost $1.24 billion. These include: Kissimmee River Restoration ($372 million); Everglades Agricultural Area Restoration ($465 million); Modified Water Deliveries to Everglades National Park ($187 million); and the C-111/Florida Bay Restoration ($220 million). It is generally understood that these efforts will not be enough to restore the system. The Corps is currently conducting a reconnaissance study for a major restudy of the entire system. It is not yet known what the study might cost, let alone the implementation of it. In addition, it seems likely that the urban areas along the East coast will have to invest hundreds of million of dollars in water supply facilities so that additional water can be retained in the Everglades system.

a. Consumptive Use

The South Florida Water Management District regulates consumptive use of water in the Everglades region under the authority of the Florida Water Resources Act of 1972 (Chapter 373, Part II, F.S.). Under the Act, applicants proposing new uses must establish that the proposed use is: 1) a reasonable beneficial use, 2) will not interfere with a presently existing legal use of water, and 3) is consistent with the public interest.

The Act contains several provisions relating to the effects of consumptive uses on the environment, including a statement of policy to preserve natural resources, fish, and wildlife. The Act mandates that minimum flows be established for surface waters, as well as minimum lake and groundwater levels. In addition, under the public interest standard, adverse environmental impacts can be considered when evaluating a proposed consumptive use. The Act also provides for adoption of water shortage plans and water emergencies.

b. Manipulation of water flows

In 1972, the Florida Legislature created the South Florida Water Management District (District) with the enactment of the Water Resources Act. The Act provides the District with management authority for water quality protection and environmental protection and enhancement, as well as for the traditional objectives of flood protection and water supply.

Today, several federal and state laws apply to management of water supply and flood control in the Everglades region. The legal requirements for water supply are governed primarily by federal law which resulted in the authorizations for the Central and Southern Florida Flood Control Project. The law establishes Lake Okeechobee and the Water Conservation Areas as the water supply source for Everglades National Park, Florida's lower east coast, and for the Everglades Agricultural Area. Flood control is also regulated under the authority of Project, which provides that Lake Okeechobee provide flood control for the Everglades Agricultural Area, and that the Water Conservation Areas provide flood protection for the Everglades Agricultural Area and the Lower East Coast.

The state of Florida is responsible for allocating water supply releases from storage areas, except where specified by federal law. The Florida Water Resources Act (Chapter 373, F.S.), is the primary state law which regulates water supply on the state and regional level. Chapter 373 provides for planning for water use and water supply as part of a state-wide planning effort, authorizes development of a consumptive water use permit program, and authorizes water shortage orders when water supplies are reduced due to drought or overuse. Flood control and surface water management is regulated under Part IV of Chapter 373, F.S., which requires that adequate flood protection be provided by dams, impoundments, reservoirs, and other works which can affect the water resources of the state.

Water supply and flood control on lands owned by Indian tribes are governed by water rights compacts between the respective tribe and the South Florida Water Management District. The compacts are superior to any other federal or state laws on the subject of water supply or flood control.

c. Water quality impacts

Water quality in the Everglades is regulated by several federal and state laws. The original Central and Southern Florida Flood Control Project did not address water quality, other than to provide relief from the effects of flooding upon septic and sewer systems. Water quality was first recognized as a prime objective of the Project in a 1969 Congressional authorization for additional works, which stated that operation methods should evaluate and minimize concentrations of pesticides, herbicides, and nutrients.

The federal Clean Water Act has as its objective to restore and maintain the chemical, physical, and biological integrity of the nation's waters. (U.S.C. § 1257a). Prior to 1987, the Act focused primarily on controlling point-source pollution. The 1987 amendments authorized a program to provide federal support for state efforts to control diffuse sources of pollution, known as non-point source pollutants.

The National Environmental Policy Act requires that an environmental impact assessment be conducted for certain projects in which there is federal participation. Major federal actions significantly affecting the quality of the human environment may be required to conduct an environmental impact assessment, including impacts to water quality.

Several state laws and other documents regulate water quality in the Everglades region. The Water Resources Act of 1972 (Chapter 373, F.S.) authorizes the South Florida Water Management District to consider water quality as part of its management of water and related resources. Chapter 373 also establishes the Legislature's intent that water quality be promoted through environmental enhancement. The Surface Water Improvement and Management (SWIM) Act, adopted in 1987, requires that the District create and implement plans for the protection and restoration of designated priority water bodies. The Marjory Stoneman Douglas Everglades Protection Act of 1991 requires the District to adopt a SWIM plan for the Everglades Protection Area which includes additional protections to those required under the SWIM Act of 1987. Additional requirements include strategies for meeting water quality standards and to restore the Everglades hydroperiod. In 1989, the District was also given authority to regulate stormwater.

Chapter 403, Florida Statutes, establishes a statewide pollution control program, and provides the Department of Environmental Protection (DEP) with authority to regulate point source discharges to surface waters and ground waters, dredge and fill activities, classification of water bodies, and adoption of state water quality standards. Under authority of Chapter 403, DEP has designated the Everglades National Park and Biscayne National Park as “Outstanding National Resource Waters,” which imposes an anti-degradation standard for those water bodies.

d. Land use regulation

The use of private lands within and adjacent to the historic Everglades is regulated primarily by local government jurisdictions. The Florida Local Government Comprehensive Planning and Land Development Regulation Act (Chapter 163, Part II, F.S.) requires that local government comprehensive plans, zoning codes, and development approvals be consistent with conservation oriented provisions in the state comprehensive plan (Chapter 187, F.S.). The state comprehensive plan establishes goals and policies relating to water resources, coastal and marine resources, natural systems and recreational lands, hazardous and nonhazardous materials and waste, mining, land use, and agriculture. The conservation and protection of

natural systems, wildlife, and water resources are clearly identified as priorities in the State Comprehensive Plan.

State and federal entities may impose conditions or prohibit certain projects on private lands through regulatory permitting programs. The primary permitting programs in the Everglades pertain to stormwater, management and storage of surface waters, point sources of pollution, and dredge and fill.

Publicly owned lands may be used for government facilities, managed for the benefit and or use of the public, or leased for private uses, such as silviculture or mining, depending upon the mission of the particular governmental entity.

B. Jurisdictional Divisions

In both ecosystems, there are significant jurisdictional divisions based on geography and subject matter. In Florida, the Everglades watershed is partitioned between local governments, federal and state authorities, and water management districts. Responsibility for the review and permitting of the many types of potential environmental impacts can also be divided among several agencies. The Pantanal is also divided according to geography and subject matter. Partitioning the watersheds among agencies with different constituencies and mandates makes the development or implementation of basinwide water management programs extremely difficult.

1. Pantanal

Regulatory authority for the Pantanal is geographically split between the states of Mato Grosso and Mato Grosso do Sul, and jurisdictionally split between environmental agencies in those states, IBAMA, and the local governments. Until fairly recently, there was little coordination between these agencies on the management of the Pantanal. Environmental officials in Mato Grosso and Mato Grosso do Sul now report excellent cooperative efforts between those states. Under the Brazilian Constitution, areas of “national patrimony” are eligible for special laws applicable over and beyond general environmental laws. However the economic crisis, a lack of information and expertise and in some cases, a lack of political will have created difficulties in developing and adopting such legislation for the Pantanal. Mato Grosso do Sul has adopted several restrictions and controls on development in and around the Pantanal, and its environmental agency is working with its counterpart in Mato Grosso, in its efforts to devise effective legislation in that state.

A relatively new initiative being jointly administered by environmental agencies in the two states is known as the Pantanal Project, financed by the World Bank, which is channeling US$10,000,000 each in funding to Mato Grosso and Mato Grosso do Sul. The project, part of the National Program for the Environment, is divided into two components. The first includes emergency actions, which are short term measures designed to ameliorate the effects of environmental degradation. The second component is known as the Plan for Conservation of the Upper Paraguay Basin (PCBAP). Essentially, this is a network of actions emphasizing the regulation of natural resources and institutional development for the management of the Pantanal ecosystem. The project encompasses an area of approximately 396,000 square kilometers (152,900 square miles), including portions of the Pantanal *planaltos* and *planície* in the states of Mato Grosso and Mato Grosso do Sul.

Officials recognize that in order to carry out the plan, it will be necessary to broaden scientific understanding of natural systems and socio-economic conditions which characterize the basin. Studies are planned in several research disciplines, including the fields of soil science, geology, geomorphology, meteorology, botany, wildlife sciences and hydrology. The project will also undertake studies of the socio-economic environment, demographic dynamics, land use, and economic indicators. A data bank of research products is planned.

Federal authorities also have a role in management of the Pantanal, although the federal presence, including enforcement presence, appears to be relatively small. Two areas of the Pantanal lowlands are officially protected: a remote national park and a small ecological reserve in the state of Mato Grosso. The former Caracara Biological Reserve was expanded and converted into the Pantanal National Park in September 1981, covering about 138,000 hectares (341,000 acres). However, the boundaries of the park were not related to wildlife needs, and there are international efforts underway to purchase additional contiguous lands to allow for wildlife movement during periods of high water. This park and the much smaller, state-owned Taiamá Ecological Station (12,000 hectares; 29,650 acres) to the north are the only protected areas in the entire Brazilian sector of the Pantanal *planície.* Northeast of Cuiabá, the Chapada dos Guimarães National Park comprises about 33,000 hectares (81,500 acres) in the northern *planaltos,* including the headwaters of several rivers which form the left arm of the Cuiabá River. At present however, the national park designation appears to have little practical significance. Both areas are considered “paper parks,” with no infrastructure or protection plans, few if any government rangers on site, and very low operating funds.

2. Everglades

The watershed for the Everglades lies entirely within the state of Florida and at least one of the many agencies with some responsibility for managing it has responsibility for that entire watershed. The South Florida Water Management District is the one institution with a mandate to plan for the protection and restoration of the Everglades. The Marjory Stoneman Douglas Everglades Protection Act requires the District to develop strategies for restoring and protecting water quality and the hydroperiod of the Everglades. In this respect, the Everglades is very different than the Pantanal, whose watershed includes parts of two states in Brazil and parts of Bolivia and Paraguay.

There is a strong federal presence in South Florida, as both a regulator and land manager. The U.S. Army Corps of Engineers designed and built most of the system of levees, canals, pumps and spillways that controls the vital flow of water through the system. It is currently beginning a major replanning of the system. In addition, the Corps regulates the discharge of dredged or fill material, and thus plays a major role in controlling the further conversion of wetlands to other uses. The U.S. Environmental Protection Agency (EPA) also plays a role in wetland permitting, with authority to veto Corps permits and establish the criteria for permit issuance. The discharge of all other pollutants is subject to regulation by EPA, except that Congress has exempted from regulation the most problematic pollutant: agricultural discharges.

The U.S. Fish and Wildlife Service assists the regulatory agencies through commenting and technical support. It has a more direct responsibility for endangered and threatened species, which benefit from research and recovery programs, and the regulatory oversight of the agency.

In addition, the Service manages a significant part of the Everglades through a lease of Conservation Area 1, the Art Marshall Loxahatchee National Wildlife Refuge. The National Park Service owns and manages the Everglades National Park, at the bottom of the watershed, as well as the Big Cypress National Preserve, which protects an important part of the Everglades watershed.

The state agencies or entities with primary responsibility for managing the Everglades include the Florida Department of Environmental Protection, the Florida Department of Community Affairs, the South Florida Water Management District, and the Florida Game and Freshwater Fish Commission.

The Department of Environmental Protection (DEP) was created this summer by merging the Department of Environmental Regulation (DER) with the Department of Natural Resources (DNR). The DEP regulates facilities that discharge pollutants to the atmosphere or water; solid and hazardous waste facilities; stormwater discharges; and dredge and fill activities. The agency also has supervisory authority over the South Florida Water Management District, implements the districts' rules for certain types of facilities (e.g. landfills), and administers the state's environmental land acquisition programs.

The Department of Community Affairs (DCA) has responsibility for implementing the state's role in land use planning and control. It does this primarily by reviewing local comprehensive plans for consistency with state policy, reviewing large scale “Developments of Regional Impact” (which do not include agriculture), and implementing a closer level of state control in Areas of Critical State Concern, which include the Big Cypress and Florida Keys. The DCA works closely in the region with three Regional Planning Councils, which represent all of the local governments.

The counties and cities of the watershed have major responsibility for land use planning and regulation. In addition, there are a number of special districts which operate drainage systems to benefit landowners within their boundaries. Such districts operate most of the secondary drainage systems within the Everglades Agricultural Area and for many of the drained areas of the former Everglades along the eastern edge of the remaining Everglades system.

The South Florida Water Management District (SFWMD) was created by the Water Resources Act of 1972, which was largely a response to the problems of water supply and environmental degradation triggered by the droughts of 1970-71. In the Water Resources Act, the Legislature established a system of regional districts along surface water hydrologic boundaries. The South Florida Water Management District thus includes all of the Everglades watershed, from the headwaters of the Kissimmee River, through Lake Okeechobee, the Everglades Agricultural Area, to the Everglades National Park and Florida Bay.

The decision to create an institution encompassing the entire watershed actually had its genesis in the floods of 1947 and Congressional authorization of a massive, multipurpose public works project, the Central and Southern Florida Flood Control Project, which was implemented by a predecessor agency, the Central and Southern Florida Flood Control District. That district in turn, was the successor to the Everglades Drainage District, which had been created primarily to drain and develop the Everglades Agricultural Area.

The South Florida Water Management District operates today under a broad mandate to

manage water and related land resources. It maintains and operates the levees, pumps, canals and structures of the flood control project. It also acquires land for restoration and management in a more natural state. The District also has comprehensive regulatory authority over the consumptive use of water, stormwater and drainage works and wetlands alteration. These efforts are supported by various planning responsibilities, the authority to levy ad valorem taxes, and some degree of autonomy from undue political influence through a governing board appointed by the Governor.

V. CONCLUSIONS AND RECOMMENDATIONS

A. Importance of basic scientific information, and environmental education

Analysis and comparison of the Everglades and Pantanal ecosystems and of the systems by which they are managed, leads to several conclusions. Effective management for sustainable use and development must be grounded in a fundamental scientific understanding of the area. Research that is targeted to developing information to support management is therefore essential. Many of the mistakes that have been made in managing the Everglades might have been avoided with better scientific understanding. Even today, management of the Everglades, one of the most heavily researched systems in the world, continues to be constrained by the limitations of available information. The need for research in the Pantanal is especially acute. Major projects such as the Hidrovia cannot be properly evaluated without, for example, sufficient understanding of the hydrology of the area and the response of plant and animal communities to hydrologic alteration.

Crucial to the effort is the continued financial support of collaborative research between universities, research institutes, regulatory and planning agencies and non-governmental organizations. To encourage optimum use of scientific research, it is also important to support wide dissemination of research findings, including establishment of clearinghouses for scientific information, regular conferences at which researchers and policymakers can share and discuss findings, and electronic information networks for data transfer and on-line discussion of issues by water managers and researchers.

Another extremely important factor in the management of both systems is the value of environmental education based on scientific findings. Funding, resources and enforcement ultimately depend on political will, which in turn is related to cultural recognition of and support for certain values. Thus, environmental education plays a crucial role in developing and implementing sustainable management schemes. In the case of the Pantanal, the relationship is particularly important, in the face of strong development pressure, low enforcement capability and a nascent environmental consciousness. There are many potential audiences, messages and media for the distribution of such information.

B. Economic and environmental significance of planning for and maintaining all water-related natural functions

The undisturbed hydrologic regimes of the Everglades and Pantanal ecosystems have served many environmental and human-related functions. A failure to recognize, evaluate and manage for a broad range of functions has placed the Everglades on the list of endangered ecosystems. Policymakers in Brazil have an opportunity to observe the failures and successes of management schemes for the Everglades, and develop or adjust policies for the Pantanal which

will allow for the sustainable development of that watershed. The primary goals of planning efforts should be to develop plans which account for and properly manage all water-related functions of the ecosystem, helping avoid the crisis management approach which has characterized the situation in the Everglades for many years. This approach allows for the consideration and development of economic uses of water while maintaining ecosystem functions.

Management policies in the Everglades watershed which sacrificed certain functions of the system in favor of flood control and drainage for agriculture and urban development have led to a water control system that is now among the most complex and expensive in the world, and which is struggling to sustain the ecosystem. Economic gains derived from agriculture and urban development have come at tremendous cost. Efforts to understand the functioning of the ecosystem, create technical and managerial approaches for maintaining its viability and replace lost functions have cost hundreds of millions of dollars, and will require many hundreds of millions more. Many environmental and economic values of the ecosystem will probably never be fully regained.

The current hydrological regime of the Pantanal also serves a large number of ecosystem and human-based functions, most of which appear to be relatively intact. However, policymakers in Brazil have already begun to favor high return economic uses and manipulations of the system which threaten to significantly alter the hydrologic regime in ways which may reduce its long-term sustainability.

C. Importance of watershed management approach

Another insight derived from a comparison of the two ecosystems is the crucial importance of a basinwide watershed management approach. Many problems in the Everglades have developed as a result of single purpose, localized water development and management decisions which failed to consider the functioning of the watershed as a whole. Decisions made to channelize the Kissimmee River affected Lake Okeechobee. Efforts to protect the water quality of Lake Okeechobee resulted in shifting the discharge of nutrients into the Everglades. Drainage of the East Everglades has deprived Florida Bay of freshwater inflow. The necessity of considering the entire watershed has been conclusively demonstrated in the Everglades system.

The Pantanal is a much larger watershed, but a watershed approach seems equally important there. Like the Everglades, the Pantanal is vulnerable to poorly planned and managed development in the watershed. The effects of gold mining activities and agricultural development in the watershed must be considered as part of a comprehensive watershed management plan. The challenge for Brazil is how to accomplish that in a basin that is almost the size of Florida, which is under several jurisdictions with different political constituencies, and in a continuing economic crisis.

D. Necessity of coordination among all planning/regulatory authorities

Related to basinwide water management is the necessity for developing a coordinated approach by all planning and regulatory authorities with water management responsibilities. Though the Everglades watershed has, since 1972, been under the jurisdiction of the South Florida Water Management District, the permitting and regulatory authority granted to the District has not allowed it to address all potential impacts to the system. One example is water quality impacts,

which were not originally part of the specific regulatory mandate of the District under Chapter 373, F.S. As a result, potential project impacts have been addressed by several regulatory and planning bureaucracies. Until recently, there was relatively little coordination or planning among those bureaucracies, resulting in management goals and priorities which sometimes worked at cross purposes. The lack of a coordinated and cooperative approach by all relevant agencies worked to slowly but inevitably degrade ecosystem function in the Everglades watershed.

With a watershed divided between two states in Brazil, and parts of Bolivia and Paraguay, regulatory and planning authorities with jurisdiction over the Pantanal face a more difficult task in developing a structure and process for coordinating management goals and permitting criteria to achieve a basinwide approach.

At present, though the Brazilian Constitution requires that states with jurisdiction over the Pantanal enact and enforce laws to protect that watershed, there is no overarching plan to guide permitting and development decisions in the Pantanal. As a result of the Pantanal Project, funded by the World Bank, there has been recent cooperation between environmental agencies in the two Brazilian states, but there is no evidence that permitting decisions have been coordinated.

Until a watershed management plan can be developed and implemented, the result will continue to be degradation of the Pantanal ecosystem. There is a crucial need for the development of approaches and structures to allow for creation and coordinated implementation of such a plan, incorporating plans for all sub-basins within the Pantanal. The research, training, institutional development and regulatory initiatives funded under the Pantanal Program have the potential to advance the effort to develop such plans.

The need to coordinate a wide range of programs must also be pursued. In the case of the Everglades, many of the problems of agricultural water pollution may be related to U.S. trade and agricultural policies, which have supported a domestic sugar industry. The expansion of urban areas in South Florida, and the resulting demand for drainage and water supply, may be related to immigration policy. There are similar relationships in Brazil. Environmental policy must be coordinated with economic, agricultural, trade, immigration and other social policies.

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ACKNOWLEDGEMENTS

The authors would like to thank the following people, who reviewed and commented on various drafts of this paper: John Ogden, Sandra Postel, Adalberto Eberhard, Edson Espíndola, Gonzalo Castro, Pete Rosendahl, Nelson da Franca dos Anjos, Steve Hamilton, Steve Light, Jorge Marban, Neil Grigg, Steve Davis, Jim Stone, and Diane Lowrie.

Case Study 2: Infrastructure for Water Supply and Sanitation in the Hemisphere

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Interamerican Dialogue on Water Management

Miami, Florida, USA
October 27-30, 1993

Introduction

A farmer rises early to face a day of hard work in the fields. His village water supply is not always reliable, and no one checks to see if it's safe. Meanwhile, another worker rises in an urban apartment, prepares for her day with a modern water supply system, and worries more about urban crime than about the reliability or safety of her water supply.

In the village, there is no sewage system, and the nearby waterway has caused children to get sick. The city dweller's water supply is safe, but her community discharges sewage into a river that has toxic chemicals, and the fish cannot be eaten.

These experiences, separated by a wide gulf in distance and culture, are faced daily in the Hemisphere, and both deal with issues that are important to our citizens in their villages, towns and cities.

The farmer's family needs assurance that their water facilities are safe and reliable; and they are too poor to worry much about the environment. The city worker lives alone, and she takes water supply safety and reliability for granted, but sees her bills rising, and she might have to worry

more about safety and reliability in the future. She is an environmentalist, but her urban life style contributes to the problem.

Our Hemisphere includes a vast array of cultures and lands, ranging from those above the Artic Circle to those in the steamy jungles of Amazonia. In between are examples of living in mountains, plains, and coastal areas; and living in mega-cities, industrial towns, and rural villages. While the needs for water supply and sanitation in these areas vary in many ways, the Hemisphere shares the fundamental need to provide adequate, safe, and affordable water and sanitation systems to the people.

The issues are economic, social, and environmental. They were summed up by Chapter 18 of Agenda 21, which adopted seven program areas for the freshwater sector. Four of these relate directly to water and sanitation infrastructure: drinking-water supply and sanitation, water and sustainable urban development, protection of water resources, and water for rural development. The remaining themes also relate, because “integrated water resources development and management” must include water and wastewater infrastructure.

This paper takes a broad view of water supply and sanitation in the Hemisphere. It presents case studies to illustrate how conditions vary in the Hemisphere. It concludes with an assessment of current conditions, and suggests how the Dialogue can contribute to improving conditions in the Hemisphere by initiating more collaboration.

Before discussing conditions in the Hemisphere, it might be well to review the general global problem of water and sanitation infrastructure, a subject that received much attention during the International Drinking Water and Sanitation Decade of the 1980's.

International Drinking Water and Sanitation Decade

In a 1977 paper prepared for the United Nations Water Conference, the Intermediate Technology Development Group concluded that there were just over 1000 million people in the world's rural areas who lacked access to a safe water supply. (Pacey, 1977). These same people lack, for the most part, access to healthy conditions for sanitation.

As a result of these findings, and others that were just as dramatic, the United Nations (UN) proclaimed the 1980's as the International Drinking Water Supply and Sanitation Decade. The Decade was conceived at the UN Water Conference in 1977 at Mar del Plata, Argentina, and endorsed by the General Assembly of the UN in November 1980. The goal was to supply all of the world's population with safe drinking water and sanitation by 1990. Suffice it to say that this goal has not been met; in fact, wars and other social and economic problems made the problem worse in many areas during the 1980's.

Canemark (1989), World Bank division chief for the water supply sector, reported in 1989 that the coverage had improved, but that the greatest achievement had been the communication, awareness and priority-setting that had occurred to deal with the problem.

The problem of rural water and sanitation is one of the most urgent problems that the water sector faces. It illustrates the multi-sectoral and interdisciplinary aspects of meeting basic water related needs.

Anatomy of the Problem. Dan Okun, a professor of environmental engineering with over 50

years of experience in working on problems of water and sanitation, summarized his theories of the causes of the problems in urban areas in a 1991 paper to the National Research Council (Okun, 1991). The paper was for the Abel Wolman Distinguished Lecture, and how appropriate the topic was, given the enormous contributions of Abel Wolman in this field, especially in the Hemisphere.

Okun reported, to his regret, that in his 50 years of work on the water and sanitation problems in urban areas, they had gotten worse. The reasons were an inadequate supply of water in the cities attributable to limited water resources, and/or poor facilities for treating and distributing the water compounded by an absence of proper sewerage.

What happens is that intermittent supplies of water create opportunities for infiltration of heavily contaminated water into the distribution systems when the pressure is off. Water-borne infectious agents then can reach taps, even when the water is safe as it leaves the treatment plants.

Infrastructure for both water supply and sewerage can be inadequate in the cities of developing countries, even when the city skylines are most impressive. Wastewaters that are discharged into drainage channels can pollute wells and the groundwater table, and really create unsanitary conditions. This is aggravated in the fringe areas, where many poor and landless families live.

Okun's paper emphasizes the need for water resources capacity-building to create a favorable policy climate and appropriate institutional development which would include establishing sound management systems, incentive structures, and the human resources development needed for sustainable development of water-related programs.

Responding to the Decade, the US Agency for International Development organized a special project called the Water and Sanitation for Health (WASH) project, and in 1990 reported the lessons learned (US Agency for International Development, Lessons Learned from the WASH Project, USAID, Water and Sanitation for Health Project, Washington, 1990).

WASH organized their lessons learned in terms of principles and lessons as follows:

> Principle 1: Technical assistance is most successful when it helps people learn to do things for themselves in the long run. Lessons were: local institution-building is the key to transferring sustainable skills; technical assistance in water supply and sanitation requires and interdisciplinary approach, not a narrow, specialized one; a participatory approach, facilitation not dictation, maximizes the chance for sustainable programs and projects; coordination and collaboration are important but often depend more on professional networking and personal relationships than on institutional and contractual relationships; and an active information service can expand the reach of technical assistance as well as its visibility and credibility.
>
> Principle 2: Water supply and sanitation development proceeds most effectively when its various elements are linked at all levels. Lessons were: water supply projects do not achieve their full impact unless they are linked first to hygiene education and then to sanitation; health benefits are the major, but not the sole, justification for support of water and sanitation projects, such projects also have wide economic benefits; behavioral changes combined with greater access to facilities are the basis for health benefits through improved water supply and sanitation; and a

participatory approach to planning helps ensure linkages and cooperation in implementation.

Principle 3: The basic measure for success of both the national system for development and the community management systems it creates is sustainability, the ability to perform effectively and indefinitely after donor assistance has been terminated. Lessons were: successful institutional development projects strive for comprehensiveness and wide participation; training yields the best results when it employs participatory, experiential methods; full consideration of appropriate engineering design and application is essential to system sustainability; making plans for operations and maintenance before facilities are constructed and in place helps to ensure that sustainable technologies are selected; and plans for system finance that ignore the cost of long-term operation and maintenance are inadequate.

Principle 4: Sustainable development is more likely to occur if each of the key participants recognizes and assumes its appropriate role and shoulders its share of the responsibility. Lessons were: the national government role is to assume primary responsibility for sector management, including planning, donor coordination, policy reform, regulation, and institutional and financial aspects of development; the donor role is to provide coordinated support in the context of national plans; the non-governmental organization (NGO) role is most effective if it is played out in the context of national development plans; the community role is to own and manage the facilities constructed and to be actively involved in decision-making in all phases of project development; and private enterprise has a definite role in water supply and sanitation; that role is determined by the overall government strategy for the sector.

The Decade. At the time of the U.N. Water Conference in 1977, the world economy was on a relative upswing. However, the 1980's were a time of economic and social decline. More than half of the developing countries experienced negative economic growth, and their debt burdens increased. Levels of investment in water and sanitation did not keep pace with population growth or rates of urbanization. While global water and sanitation coverage increased in the 1980's, it fell in some areas such as Sub-Saharan Africa.

According to Canemark, the Decade was a joint effort of the international donor community, and it provided lessons in six areas: advances in technology, broadening of institutional options, changing of conventional wisdom, spotlighting the rural poor, acceptance of integrated approaches, and better agency cooperation.

Technology advances focused on the development of low cost approaches. These included handpumps, improved latrines, and related technologies.

Institutional options led to the option of village-level operation and maintenance, sort of a self-help approach at the village level. It was learned that women can play a pivotal role in successful community management of such services. Other institutional lessons were also learned, such as in both rural and urban areas the joint participation of public and private sectors, NGOs and the communities themselves.

Conventional wisdom that changed focused on the adoption of more appropriate technologies, such as to replace the thinking that full-scale piped water supply systems are always required.

Also, changes in institutional approaches and financing strategies have occurred, not always without difficulty in changing attitudes.

Spotlighting the rural poor resulted in redressing the imbalance between emphasis on urban and rural populations, and with the adoption of more appropriate technologies, has increased awareness of the plight of the rural poor.

Integrated approaches in water and sanitation provide links between the fields of water, wastewater, hygiene education and behavioral changes.

Better agency cooperation is, of course, an extremely valuable achievement. Cooperation is said to have increased between agencies, developing country governments, external support agencies, development banks, donors and NGOs.

Issues for the 90's. Canemark identified the issues in six categories, four that were carried over from the Decade, and two new ones. The four that carried over were focus on poverty, maintaining momentum in rural areas, improving agency cooperation and building local capacity. The two new ones are water resources and improving sanitation and the urban environment.

Poverty is an insidious cause of many social and economic problems. Water and sanitation are fundamental support blocks for building the health, living systems and economic development of poor areas. Every day the victims of poverty appear on television screens in richer countries. They suffer from malnutrition, dysentery, famine, and other maladies that are mostly restricted to the poor countries.

Poverty is especially serious in rural areas which are remote and sometimes invisible to aid agencies and governments.

Improving agency cooperation is a key to using resources better and making programs more effective. Canemark describes a collaborative council of governments involved in the development process and NGOs. What remains to be seen is whether this can be effective at the country level where the programs are delivered. This is another example of the need for cooperation and coordination in the delivery of public services.

Building local capacity is the application of self help and self reliance into the systems, absolutely critical ingredients for long term success.

Canemark labels the two new issues, water resources and improving sanitation and the urban environment, as “time bombs”.

Water resources management is a time bomb because deteriorating water quality, limited investment in waste management and water reuse, and rapid growth in water competition will lead to increased water scarcity. As a result, the costs of water supply and environmental safeguards will rise dramatically. This will lead to two serious problems: finding ways to expand water supply and waste management services to more people in spite of higher costs, and facing pressures to reallocate water among different consumer groups.

To investigate the policy options, Canemark suggests that we begin to assess water supplies and demands to identify where the problems will be worst, that we evaluate different solution strategies, and find cost-effective and equitable solutions. He believes that we should treat water

as the scarce natural resource it is, emphasize sequential reuse, and see whole systems as integrated networks of interlinked flows including source development, conveyances, water use, return flows, treatment facilities, conveyance to the next user, and final return to the natural system.

The water resource management issue, according to Canemark, will have serious economic and political consequences unless we tackle it successfully. Some countries, such as Jordan will soon reach a ceiling on water they can exploit. Others may have to restructure economies to enable them to supply mega-cities with water. These will be serious issues for the nations to face.

On the waste management side, equally serious management strategies are needed to select the right technologies and institutional options, to apply economic pricing strategies, to implement environmentally sustainable management approaches.

These observations about water and sanitation problems worldwide set the stage for a discussion of the situation in the Hemisphere.

Economic and Social Conditions in the Hemisphere

Clearly, living conditions vary widely in the Hemisphere. One of the attractive goals of economic integration is to bring conditions for all citizens to higher, sustainable levels. One of the primary requirements for this is to provide adequate water and sanitation infrastructure.

If we could take a tour of water infrastructure in the Hemisphere, we might begin with native populations in Alaska or the northern regions of Canada. There, sustainable infrastructure is a public health issue, but population densities are not great. Further down, we reach Canada and the United States, two nations with wide diversity of conditions. In these nations, extensive water and wastewater infrastructure has been installed in cities, but they face problems of decay, high cost, meeting regulatory requirements, and maintaining standards in the face of growth and economic conditions. In the small towns and rural regions of these nations, one finds the *“small system problem”*: a struggle to provide service and meet regulatory rules without adequate financing, infrastructure, or trained personnel.

At the border between the United States and Mexico, we begin to encounter transboundary conditions. These conditions are especially noticeable in today's focus on the North American Free Trade Agreement (NAFTA), and equalizing environmental conditions, including standards for water and sanitation, is a high priority. Mexico, a rapidly growing and developing nation, faces problems that are typical of other Latin American nations: how to meet the pressures of rapid growth in cities and rural areas with appropriate, but still expensive water and sanitation infrastructure?

Central America and many South American nations face great diversity in geography, ethnicity, social conditions, and natural resources. Like Mexico, and rural parts of the US and Canada, they are challenged with providing basic water and sanitation to dispersed populations, and with meeting the immense needs of super cities with rapid urbanization. A good example of a super city is Sao Paulo, a city we will discuss later.

As we travel toward Argentina and Chile, we encounter in some ways the mirror image of

Canada and the U.S. While conditions vary, the same combination of cities and rural regions gives way to colder regions with sparse populations. As we complete our trip we realize what a kaleidoscope the cultures and peoples of the Hemisphere make up, and how varied are the challenges facing our different water industries.

Water and Sanitation Systems in the Hemisphere

As do social and environmental conditions, access to modern water and sanitation systems varies widely in the Hemisphere. Nations and regional assistance organizations are aware of and are seeking solutions to the problems, but are hindered by inadequate finances and a variety of other problems which are illustrated by the case studies.

Although the problems in Latin America are formidable, a great deal of progress has been made since about 1959 when the Inter-American Bank was organized. In fact, the Bank's first loan was to expand a water supply and sewerage system in Peru (Inter-American Development Bank, 1992).

Although a great deal of progress has been made, problems continue to increase due to population growth, urbanization, and industrialization. Although the percentage of people served has increased, the total number without service has actually increased. Another problem is that because safe drinking water is so important and has received priority, sewage systems have been neglected, at the expense of basic sanitation. An estimated 90% of all sewage in the region is still dumped untreated, and adversely affects local populations, especially in urban fringe areas with large, impoverished populations.

While attention to the problems has intensified, investment has not. The 1980's were designated the International Drinking Water and Sanitation Decade, but it turned out that this decade also introduced the worse economic crisis of the century in Latin America. A worldwide economic problem also reduced aid to developing nations.

Unfortunately, in Latin America, a significant proportion of all disease is still attributed to polluted drinking water and untreated sewage, and water-related diarrheal diseases continue as the leading cause of infant mortality in many countries.

The Pan American Health Organization (PAHO) has recently published a regional investment plan for the environment and health. This plan, along with other national and international strategies, constitutes a good base for understanding the problems; and what is now needed is more commitment and collaboration to follow though with the plans (Pan American Health Organization, 1992).

In the wealthier nations, water and wastewater problems are also severe, but the proportion of citizens with access to adequate service is much higher. For example, in the US, safe drinking water is available to almost 100% of the population, and water quality problems have shifted from sewage treatment to non-point sources. These are still significant problems, and financial capacities remain a cause of concern, but at least basic problems have been solved. However, the ability of the US to maintain levels of service is in question due to financial capacity, the strain of new regulations, decaying infrastructure, and social problems caused by, among other things, high rates of immigration.

Management Framework for Water and Sanitation

Regardless of their economic and social contexts, water supply and sanitation systems have similar objectives. They must deliver adequate supplies of safe water to domestic and commercial users, collect wastewater, and return it in safe condition to the environment.

To meet these goals, systems range from the simplest to the most complex. In an attempt to provide a framework for comparison of the systems, a graduate student at Colorado State University developed a paradigm to show that levels of service and management efficiency are determined by the physical and social environments of systems, and by technologies, institutions, and financial capability (Triweko, 1992).

Physical and social environments deal with the diversity of geographic, economic, political and ethnic situations found in the Hemisphere. Technologies range from sophisticated water treatment and delivery systems, to the simplest systems found in some rural areas. Institutions include laws, management agencies, and administrative systems. Financial capabilities are the result of external and internal economic forces. Levels of service that result impact directly on the health, welfare, and economic capability of the people.

The institutional environment of water industries involves service organizations, regulators, government planners and coordinators and support organizations. These are found in unique forms in each country and their effectiveness varies. Technologies and financial practices depend somewhat on the institutional environment, but generic issues are remarkably similar from place to place.

While this framework to explain water and sanitation systems is quite general, it serves as a “model” to compare systems and to identify issues in the case studies.

Case Studies of Water and Sanitation Systems

The case studies are presented to illustrate the variation in the Hemisphere. They do not cover all countries in the Hemisphere, but they do cover a range of conditions that illustrates some of the main issues that could be addressed by the Dialogue.

Case Study 1: United States of America, City of Denver, Colorado

The first case is in the United States, a nation of over 250 million people with a complex water industry characterized by service agencies, regulators, support organizations, and planning agencies. The specific case is the metropolitan region of Denver, Colorado.

Water supply and wastewater agencies are normally city departments, private companies or special purpose districts. According to the Environmental Protection Agency, there were as of 1983, some 58,700 *“community water systems”*, with 11,000 on surface water and 47,700 on groundwater. Another 158,100 *“non-community systems”* serve transients and customers and are regulated for water quality by EPA programs (Wade Miller, 1987). No comparable census is available for sewerage systems, but there are about 30,000 identifiable treatment plants, and probably on the order of 50,000 independent collection systems. The largest number of water supply and wastewater utilities are small, with limited financial and technical capacity, but many utilities have impressive capabilities. The industry is highly regulated for health and environment criteria, but not much by financial agencies.

The main regulatory programs are the Safe Drinking Water Act, first passed in 1974, and the Clean Water Act, first passed in 1972. These laws place stringent standards on water for drinking and water returned to streams, but neither subsidizes services. Under the Clean Water Act, the US provided about $45 billion in capital subsidies for waste treatment plants from about 1972 to 1985, but the program has ended, and now the nation faces high maintenance and renewal costs.

Denver's water supply system. Denver's growth in a semi-arid region was made possible by its water supply. The water supply system began about 1859 when the city was a mining camp (Cox, 1967). From 1859 to 1872 residents relied on individual supplies from private wells or streams. A private Denver City Water Company served surface supplies from 1872 to 1878, but by the 1880's several private water companies were competing, and they were all consolidated into the Denver Union Water Company in 1894, the predecessor of the present Denver Water Board (DWB). It built Cheesman Dam in 1905, still part of the system. The next forty years saw tremendous growth in Denver's water system. In 1936 the Moffat Tunnel was completed bringing into reality the dream of bringing west slope water to Denver.

A proliferation of suburban water agencies began in 1948 when the DWB raised rates. The 1950's drought tested the systems of Denver and the suburbs, and by the early 1960's Denver had completed Dillon Reservoir which holds 254,000 acre-feet. In the 1960's several projects were launched, just before environmental activism began to increase. By the 1970's, environmental opposition to DWB policies had forced a conservation program, agreements to release instream flows, and a citizen's advisory committee.

Part of the environmental concerns of the 1970's was that Denver sought a new surge of growth. This concern led to the Two Forks controversy, probably the most significant water supply battle in the US during the 1980's (Milliken, 1989).

Two Forks was being studied by the DWD's predecessors as early as the 1890's. Denver filed on water rights for the area in 1931. However, it was only in 1982 that 40-odd suburban governments and water districts united to form the Metropolitan Water Providers and to join Denver in the Two Forks Project. In 1986 the DWD filed for a permit to build the Two Forks Dam.

A systemwide environmental impact statement (EIS) was already being prepared by the Corps of Engineers. In 1988 the Corps issued the EIS. In June 1988, after an extensive period of study, Colorado's Governor Roy Romer recommended to the Corps to approve the permit, with a 25-year shelf life. In January of 1989 the Corps announced its intent to permit the dam, but in March 1989, the new EPA Administrator, William Reilly, announced his intention to veto the permit, and it was officially vetoed a year later.

Several aspects of the controversy are noteworthy. The Western Governor's Association identified the following issues for discussion: conflict between traditional water development interests and the environmental community; the existence of reasonable and practicable alternatives within the 404 process; and the forum for decision making which involved municipal water providers with the means to build the project, federal regulatory agencies with the means to permit or deny it, and only a roundtable to coordinate the actions (Western Governor's Association, 1991).

The Two Forks controversy has national implications; it is not just a local water skirmish. Let's look at some things that have happened right after Two Forks. First, there are new organizational initiatives going on. A Front Range Water Authority and a Metropolitan Water Authority have been organized, the City of Thornton announced a “City-Farm Program”, there were meetings of the “Group of 10”, a metro cooperation group that included water supply in its aims, and there are new, statewide initiatives. Private developers have announced numerous proposals for new projects.

A state view of the situation was presented by Governor Roy Romer (1993). Romer noted that in the past few years the state had invested millions of dollars in planning for water projects that had not come about. He said we must “blow the whistle on what has become an unacceptable level of administrative gridlock, litigation, expense and delay whenever water development or transfers are proposed.” He said that after Two Forks water supply planning in the metro Front Range had proceeded piecemeal, with little direction or momentum. He stated that the water wars have focused attention on potential economic and environmental impacts of water transfers. He identified issues of statewide concern: waste of public and private funds; environmental consequences, extensive lead time required to produce new supplies; and impact on future development in other parts of the state. He suggested new directions and alternatives: a regional water coordinating organization led by the state; state incentives such as loans or grants to encourage cooperation; state water project; cooperation with agricultural water users; and enhanced information and decision support systems by state agencies.

METROPOLITAN DENVER WATER SUPPLY EIS - SCHEMATIC ILLUSTRATION

Clearly, many things are still to develop in the wake of Two Forks. The Denver Water Department (DWD) decided not to file suit over the permit veto, and DWD engineers have stated that they learned several things from the affair. One lesson was that they could not think just about their problems; they had to also consider their neighbors. Another lesson is that in water supply planning, they had to study the impacts.

Denver Wastewater Management

Denver's wastewater system. In the Denver region, local water supply and wastewater are provided by numerous different organizations, and a regional organization provides large scale wastewater treatment and disposal. The map shows the general situation.

The wastewater systems grew gradually. Denver built its first sewer in 1881. By the late 1950's 45 different agencies in the region were collecting and disposing of wastewater, and there were 21 treatment plants, mostly small and overloaded. In 1960, enabling state legislation was passed, and in 1961, 13 communities joined to create the Metropolitan Denver Sewage Disposal District No. 1. The District's plant has evolved since it began to operate in 1966, and the District was renamed the Metro Wastewater Reclamation District in 1990. Today, it treats about 150 million gallons of wastewater daily and serves about 1.2 million people in the region.

Conclusions from the Denver case. The Denver case is a snapshot of large city water supply and sanitation systems in the US. The nation has completed two decades since Earth Day 1970, and generally is supplying safe and affordable water and sanitation to its population, but faces problems of cost, capacity, and struggles over social and political issues.

During the past decade, the major water issue in the Denver area has been the struggle over a new supply. In addition, the region faces significant questions of water policy. Wastewater issues have generally been less controversial, but the city faces regulatory burdens and cost increases (Grigg, 1986). In the US, on the water supply side, the main issues are supply adequacy and the safety of drinking water. Severe drought and growth problems have been faced in the last few years. Environmentalism has stopped water supply development in some places. The seven-year California drought illustrated the magnitude of some of the problems.

On the water quality side, the Safe Drinking Water Act and the Clean Water Act are both up for reauthorization this year. An extensive study effort called Water Quality 2000 has just been completed. It recommended programs in preventing pollution, controlling runoff from urban and rural lands, focusing on toxic constituents, protecting aquatic ecosystems, coping with multi-media pollution, protecting groundwater, increasing scientific understanding of water quality issues, promoting wise use of resources, setting priorities, providing safe drinking water, managing growth and development, and financing water resource improvements.

In the political arena, problems to be faced include: local-state-federal relations; roles of state governments in forcing regionalization and consolidation of small entities; financial allocations; and struggles over values of environmentalism versus development.

Wastewater problems in the region seem politically less daunting than water supply issues, but financial implications of the Clean Water Act are worrisome. While this conclusion will apply to parts of the US, the nation is too large and diverse to generalize about these issues.

METROPOLITAN DENVER WATER SYSTEM

FRANCIS L SMITH, JR
APRIL 1972
STUDY TITLE: *THE URBAN WATER SYSTEM - A COMPREHENSIVE ANALYSIS*

Case Study 2: Venezuela, City of Mérida

Much smaller than the United States, Venezuela took a more centralized approach to water and sanitation infrastructure development and management. In 1943, the Venezuelan government created the National Institute of Sanitation Works (INOS). According to its original charter, INOS was responsible for providing water supply and wastewater collection for all the country. This included every aspect of public water service, from the construction of big dams, to the laydown of water distribution networks, to the collection and treatment of water and wastewater, to the billing for water and sewage service. As time passed, INOS gave attention to construction of large water works and neglected rehabilitation, management, and operation of systems and customer services. For more than 40 years, Venezuela's water needs outgrew INOS' capacity to serve its mandate and became one of the largest bureaucracies in the country. Its uncontrolled growth also became one of the largest deficits in the budget. On top of its deficitary problems, union activity became a factor of the operation of INOS while complaints multiplied and the water infrastructure aged without proper operation and maintenance. Lack of planning was evident, with too much crisis management. In recent years, lack of planning was evident, and crisis management occupied most of the agency management efforts.

In lieu of this sequence of events, the Venezuelan government embarked into a national economic program that includes the reorganization of the water sector at the national, regional,

state, and local levels. The objective of this reorganization is to develop a structure that would provide better quality, more coverage, and to achieve financial and administrative health. The specific objectives are: to decentralize service by creating autonomous water companies at regional levels; to reach financial self sufficiency and to equalize the financial operations of the regional companies; and to strengthen institutional aspects of the planning and management of the water systems. This reorganization is the result of a group of recommendations made by prominent policy makers from Venezuela and abroad and which are contained in the VIII National Plan of 1989.

By 1990, the Ministry of Environment and Renewable Natural Resources (MARNR), acting on behalf of the Venezuelan government, signed an agreement with international financing institutions, such as The World Bank (WB) and the Inter-American Development Bank (IDB), in order to scale down INOS' role in the water sector to the construction and maintenance of large waterworks such as dams and reservoirs. The remaining operational and maintenance activities are being decentralized, regionalized and handed over to municipalities, private companies, and/or a combination of both.

By 1991, the Venezuelan Congress passed a bill to shift responsibility of water service to local governments or municipalities. In the meantime, INOS will continue to provide service to urban areas through provisional agreements with the municipalities until the phasing down is completed. Likewise, the Ministry of Health and Social Assistance (MSAS) will continue to provide water service in rural towns with populations below 1000 while regulating health guidelines in those areas.

As part of this reorganization effort, MARNR created a new institutional structure that will place operational and maintenance decisions closer to water problem occurrences. Thus, a regional structure would seek the objectives of decentralizing the service, provide better service and higher quality, increase the coverage while achieving financial self-support and efficiency. This structure is headed by a national water company, C.A. Hidrólogica Venezolana (HIDROVEN), which is charged with the setting of policy and offering of major technical support to ten “Empresas Hidrológicas” or regional water companies, commonly known as “Hidros”. In the long term, HIDROVEN will not have operating functions and the regional companies will be free to sign contracts with private companies to perform specific tasks.

One of these regional water companies is C.A. Hidrológica de los Andes (HIDROANDES), which oversees the operation, maintenance, and management of water systems in the andean states of Mérida and Trujillo in southwestern Venezuela. This region has a combined population of approximately 1.3 million inhabitants. In theory, HIDROANDES will oversee smaller local water companies operated independently by municipalities, private companies, or a combination of both.

Access to loans from World Bank, Inter-American Development Bank and International Monetary Fund (IMF) are conditioned on the achievement of the objectives outlined above. There are deadlines for some specific goals, as for example, the laying off of workers of the old institution (INOS), the time at which HIDROVEN has to be operating at total capacity and the regional water companies or “Hidros” should be self sufficient financially.

In the long run, it is expected that:

1. The city councils will assume total responsibility for the oversight of the services through independent companies called “operators”.

2. The operators can utilize public, private or mixed capital, they will be in charge of service to consumers, and have responsibility for the operation, management, rehabilitation and enlargement of the structures. The Empresas Hidrológicas will be free to contract out work and to select contractors.

3. The revenues should be enough to cover all expenses and investments for future expansion.

4. The “Hidros” will promote the participation of the city councils in the management of the water supply services and the creation of the “operator companies” until they are ready to take control. In the meantime, these Empresas should take charge of the functions of both the operators and the city councils.

5. A legal and regulatory framework will be established for the setting of water prices and establishing conditions of the service.

Mérida's water supply system. The city of Mérida is located at one end of the Andes Cordillera, at 1650 meters of elevation, surrounded by light snow capped mountains. The weather is mild during the whole year (mean annual temperature is 18.5°C; average annual precipitation, 1650 nun). It is one of the main tourist attractions of the country. The city has a very well defined metropolitan area, shaped by the valley of the Rio Chama and is growing with new developments in a path that follows the river.

HIDROANDES, Mérida's new water supply company, is trying now to overcome some of the problems inherited from INOS and to reach the goals set by the restructuring of Venezuela's water supply system At the present time, the company has 141,755 clients in the metropolitan zone, billing practically a 100% of them, but that does not mean that all of them pay their bills. For example, from HIDROANDES reports, for the residential use only 62% of the customers actually pay, for the commercial use only 85% pay for the service, and for industrial use 100% pay the service.

A new nationwide fare was officially approved last year, with nine different rates, depending on the city and the amount of water used (see Figure). Mérida's fare should be calculated by using rate no. 4, but this has not been approved by the council. The company is presently using rate no. 1, with lower prices, expecting to sensitize the people to charges, and to improve efficiency in the hope that a rate increase will be accepted later.

The water supply system covers all the city with no significant problems of raw water availability. The conflict occurs in the central city, where the pipes are old and were not constructed following the original design. Diameters of installed pipes are smaller than specified in the original project, and no one knows the actual layout of the network. At the same time, the city has experienced rapid growth near downtown, mainly because of the closeness with the University of Los Andes main campus. This growth was not anticipated and has created a situation where some zones sometimes do not reach water due to operational problems. Some of these problems could be reduced if trained and experienced personnel were available.

To alleviate this situation, new systems are being constructed to serve zones that are not close

to downtown and to provide more flexibility for the operation of the old network. Also, new pipes are planned to replace old ones, and studies are in progress to determine the layout of the real network.

The operation of the system is run by HIDROANDES, and maintenance is contracted to private companies under direct inspection by the Empresa Hidrológica. From recent studies, the amount of water used in the city varies between 300 and 800 liter/person/day (lpd), which is extremely high in general, and more so for a city like Mérida. In Venezuela, there exist no measures to reduce or control the use of water from a demand standpoint, and in Mérida state the zones with higher water uses are those with greater economic levels. The average rate of water use in Venezuela is 440 lpd, one of the highest in Latin America. The consumption of water is even higher in the capital city, Mérida. This waste of water compels HIDROANDES to look for additional and more expensive sources of water in the future, but at the present does not seem to cause any major problems.

The City of Mérida has a well-designed treatment plant, but lacks sufficient trained personnel. HIDROANDES will have to either pay competitive salaries to hire skilled technicians or invest to prepare their own personnel.

Mérida's wastewater system. The system of collection of wastewater is separated in the whole city, but the county is in charge of the stormwater system and HIDROANDES of the sewerage system. The problem occurs when the county, without contacting HIDROANDES, connects a rainwater conduit to a sewerage one, creating local flooding during intense rainstorms because of the lack of capacity of the sewerage network. The slope of the city, however, helps to avoid larger problems. Around 85% of the city is covered with sewer systems and part of the other 15% is in zones located outside of the city, usually with pit latrines.

The Venezuelan Government has set goals to provide water supply and sewerage service to every city. In general, the water supply goal has been accomplished, but the service must be improved. Sewer coverage goals have not been reached in the whole country, lacking in some small towns, but is on the way. With respect to wastewater, interest in the quality of the environment has not reached the needed levels yet.

In 1991 the Ministry of Environment regulated the quality of the waters to be disposed of in any water body. Basically the regulations follows the ones developed by U.S. Environmental Protection Agency (EPA). However, cities are not complying with the law though some private and government industries are taking measures to avoid penalties. There is not a sense of urgency to care for water bodies. While some authorities recognize the importance of the environment and support the idea of wastewater treatment plants, they have not been constructed. There are always other priorities, and after the water leaves the city that is someone else's problem.

An exception is the Ministry of Sanitation and Social Assistance (MSAS), represented by the Department of Malaria Studies, which is responsible for the water supply of small rural towns with less than 100 inhabitants. Every time they construct a water supply for a town they also construct a wastewater treatment facility.

In Mérida, untreated wastewaters are released to the Chama and Albarregas rivers. There are, however, plans to study the best to wastewater treatment solution produced by the city.

Conclusions from the Venezuela case. Mérida reflects the situation of water supply systems in most of the cities of Venezuela: problems with old systems, losses, high unaccounted-for water, administrative problems, insufficient training, budget problems, and others. In addition, in Mérida, there is a lack of knowledge about the system in detail because the technicians of INOS never registered the changes that were made in the original designs through the years. Much of the information is still transmitted by word of mouth. HIDROANDES is now in the process of recuperating and organizing the information.

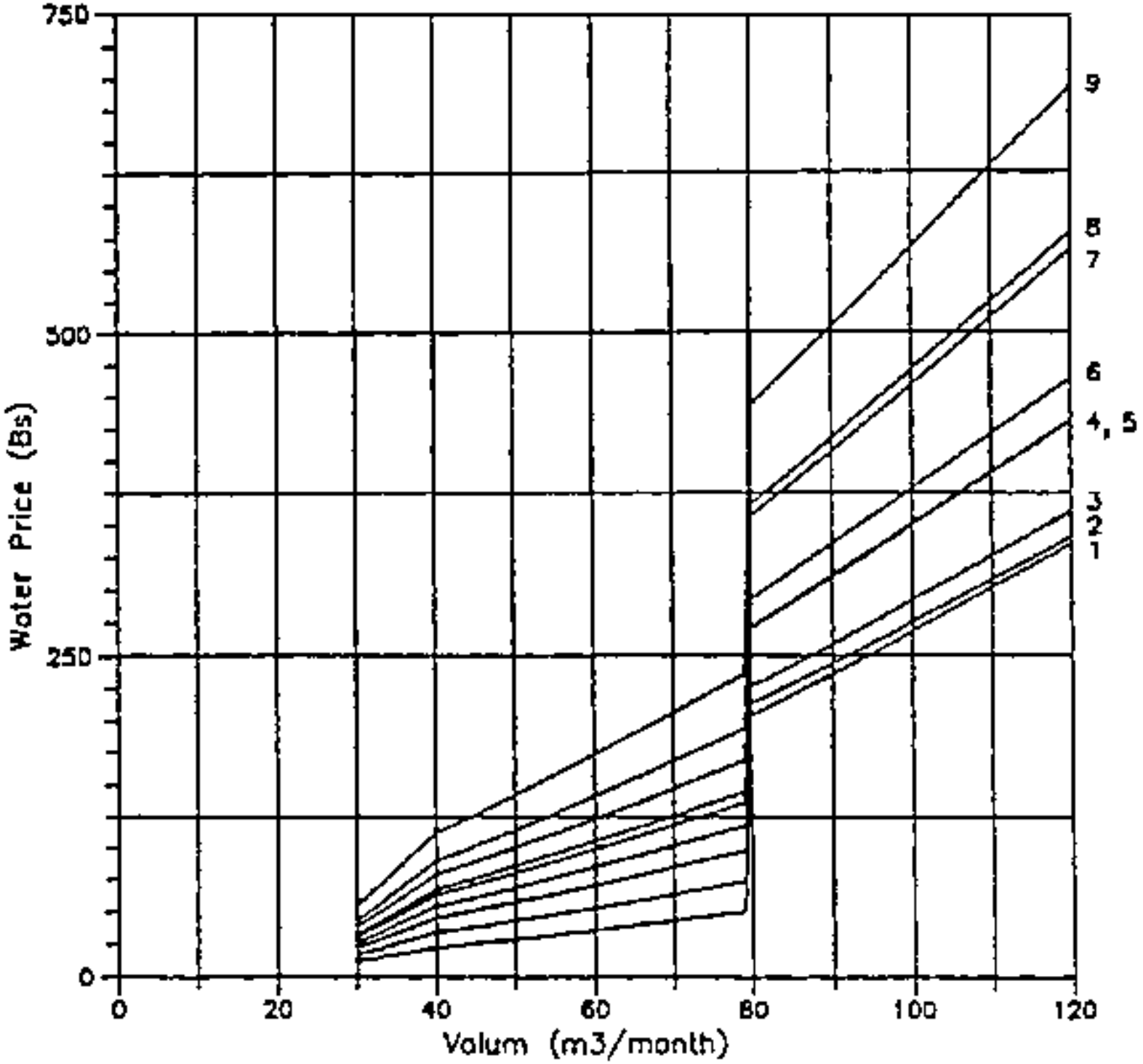
Operation of the networks can be improved with good knowledge of the system and updating it when necessary. It can be improved by having more qualified technicians. Ultimately, to raise the efficiency in the water supply systems and in the treatment plants requires unavoidable investments in the company's human resources.

With respect to wastewater, until a real change occurs in the way of thinking of the authorities and effective pressure on the communities is made, nothing will happen. It is going to take some time, but Venezuela is seeing the beginning of increased awareness by the people. The people perceive that by working in an organized way they can make a difference. In the meantime, water resources and environmental institutions such as CIDIAT must take a position on this issue and others related to the environment.

Venezuela is having new experiences with regional authorities and counties, elected directly by the people, with control over the main decisions. The water companies are learning that sometimes decisions that are technically necessary can be rejected for political reasons. In the case of Mérida, for example, the county is still refusing to approve billing users for the disposal of the wastewaters.

Finally, a great problem is financing. Most of the solutions in the whole nation require financing, and this is a new experience for a country that used to be rich. Fortunately, loans are subject to goal accomplishment, and that will be a positive change.

Water Prices for domestic use



Water Prices vs Volum.

Case Study 3: Brazil, City of São Paulo

Brazil, a vast nation with similarities to both the United States and to Venezuela, also faces a wide diversity of problems related to water and wastewater infrastructure.

Brazil has a large population and is divided into states like the USA, but due to its still-developing status, depends more on central direction and investment than the USA. According to The World Bank, Brazil's 1991 population was 151 million, with a growth rate of 2.2%, in contrast to the 252 million in the USA (0.9% growth rate) and Venezuela's 20 million and 2.7% growth rate (World

Bank, 25th Anniversary Edition).

Brazil's water supply systems cover about 88% of the population, up from about 45% in 1970. Still, there are some 13 million citizens in urban centers without water supply systems. Some 46% of rural residents lack access to water of good quality. Problems of sewage disposal are relatively more severe, with some 73 million Brazilians (65% of the urban inhabitants) lacking access to adequate wastewater infrastructure. Only 10% of the country's sewage receives adequate treatment, with 90% being discharged untreated into the nation's waterways. This results in both inconvenient living and contamination of water, with contamination being especially severe in the large urban centers.

Data from the United Nations (1991), Brazil discharges 95% of its urban sewage without treatment into water bodies closest to where the sewage is generated, a situation not different from developing countries.

Brazil faces different problems in each of the sanitation sectors, water, wastewater, solid wastes and drainage. Problems include excessive centralization, and little participation of states and municipalities in setting priorities. Imbalance and inequity are major problems. On the one hand, state companies are responsible for services to about 3000 municipalities, but there is a problem preventing the extension of services to the poorest citizens. Inefficiencies are a major worry. These include management inefficiency, unaccounted-for-water losses, and inadequate technologies.

The spillover of problems in the sanitation sector affects Brazil's most basic social problems: quality of life for the general population, low-income populations, and infant health, and it portends future misery unless the problems can be fixed. Brazil is quite concerned about its public health problems, especially those related to the water and sanitation sector. They see cities and rural areas as being quite vulnerable to problems of water-borne disease, infant mortality, dysentery, and general problems of low income populations. Especially vulnerable are the *favelas* in large cities where large and poor populations are concentrated.

In 1989, some 26 state companies provided water supply to 78 million citizens, with municipal services providing supply to another 22 million. The per capita use was about 250 lpd, and losses were 30-40% of the water production. The nation recognizes, due to these statistics, the need to modernize the sector, as well as to invest in new facilities.

Brazil recognizes the critical issues involved in the water and sanitation sectors, and is studying ways to reembodied the problems. A conference was held in Brasilia from 26-28 May, 1993 to discuss strategies *(Conferencia Sobre Estrategias em Saneamento Meio Ambiente e Saude)* and the problems are documented on a national scale (*As Deficiencias de Saneamento no Brasil, e as Consequencis para a Saude Publica, O Meio Ambiente e O Desenvolvimento Economica e Social,* unpublished). Brazil's Secretary of Planning, Budgeting and Coordination completed a national study of basic sanitation in 1989, including water supply, sewerage, and solid waste management (*Secretarial de Planejamento, Orcamento e Coordenação, Fundação Instituto Brasileiro de Geografía e Estatística, Pesquisa Nacional de Saneamento Básico,* 1989).

Institutional problems in Brazil include excessive centralization of decisions and little participation of states and municipalities in defining priorities. The inability of the system to provide services to the poorest populations is a serious indicator. Financing system operation and improvements will

be a continuing problem.

With its tremendous size and diversity, Brazil has numerous regional issues to deal with, much as the US does. Its largest city, São Paulo, illustrates the scale of the problems it faces.

City of Sao Paulo's investment program. Sao Paulo plans to undertake through the Sao Paulo State Basic Sanitation Authority a $3-4 billion program to solve sanitation problems in the metropolitan area, while in other parts of the nation rural and urban fringe areas face immense problems of basic sanitation for a rapidly growing population.

Sao Paulo's forthcoming effort to solve sanitation problems will focus on cleaning up the Tiête River, a heavily polluted waterway that drains the city (São Paulo to Launch Massive River Cleanup, The IDB, December 1992). Some 20 million people live in this river basin, illustrating the massive scale of the environmental issued faced there. As is true in other parts of Latin America, public spending has favored water supply over wastewater, and sewage treatment and stream pollution have paid the price.

The financing program, said to be the IDB's largest financing ever at $450 million, will expand the city's sewerage system to serve an additional 1.5 million people, most of them poor. Two new plants will be built, and the proportion of water treated will rise from 19 to 45 % by 1995. Also included will be training and institutional strengthening benefits. The Sao Paulo state agency responsible for pollution control will gain the capability to monitor 1250 industries that are responsible for 90% of the area's industrial pollution, and management capabilities to maintain the plants and to improve financial management.

In addition to the Tiête River project, other IDB-financed projects include sanitation projects valued at more than $1.5 billion in Sao Paulo State, and a nationwide sanitation program being carried out with $350 million in financing to benefit other municipalities.

In summary, Brazil faces tremendous challenges in the water and sanitation sector. Its large population and rapid growth rate challenge the public and private sectors to provide the institutional infrastructure and the financing to provide needed infrastructure services. Unless problems of the sector can be solved, the implications for public health and quality of life in both urban and rural areas are extremely significant.

Analysis of Case Studies

The case studies illustrate only a few of the Hemisphere's water and sanitation issues. Although they vary widely, they can be compared by physical and social environments, technologies, institutions, financial capacities, levels of service, and management efficiencies.

Physical and social environments vary widely, not only north to south, but also within countries. The United States, Venezuela, and Brazil deal with issues ranging from highly urbanized to completely rural. The intensity of the problems differs from socioeconomic factors such as population growth rate and urbanization.

The Hemisphere is experiencing high levels of migration, and inter-regional flows of trade, technologies, financing, and expertise. Economic integration may be a key to solving some of the disparities between regions and nations, both inside of large nations and from nation to nation. Regardless of future progress in equalizing physical and social environments, the wide disparity

of access to safe drinking water and adequate sanitation services is a serious problem needing attention in the Hemisphere.

Technologies also vary widely from region to region, not so much because of technological barriers, but because of lack of access to capital. This is a world-wide problem. The support base of the world's water industry includes international consulting firms, contractors and equipment suppliers who are ready to bring the latest technologies when funding is adequate.

The issue of appropriate technologies is germane to the discussion of equalizing services, because many of the basic technologies needed for water supply and sanitation are not necessarily expensive, but they do require training, expertise and at least a local manufacturing and management capacity.

Management institutions in the Hemisphere vary across the spectrum from purely public to purely private. In the Venezuelan and Brazilian cases, limitations of public authorities are made clear, and the United States is also aware of these limitations, and has given attention to privatization in the water and sanitation sectors. Institutional factors are, no doubt, the most important in equalizing water and sanitation services in the Hemisphere.

Financial capacities constrain national capabilities to invest in each country. External and internal debt structures are such that borrowing will be limited, and the ability of central governments to subsidize regional problems is also quite limited. Improving planning, efficiency and local attention to problems is a critical issue, as is developing effective institutions to address problems without massive financial infusions.

Perhaps the greatest disparity in levels of service is the gap between those who have service and those who lack it. This is made clear in the Brazil case study which provided national data on the percentages of citizens who still lack access to safe drinking water and sanitation. This remains a worldwide problem, as evidenced by the data from the International Drinking Water and Sanitation Decade.

With high rates of growth, migration, and urbanization, every nation in the Hemisphere faces challenges in basic education, governance, training, and institution-building. These problems result in problems with management efficiency in water agencies. Perhaps this is most evident in two symptoms: the small water system problem of the US, mirrored in the rural problems throughout the Hemisphere, and in the inability of large, state-owned companies to provide access to services throughout Latin America. Improving management efficiency is, in the final analysis, another serious institutional problem for all nations.

In the final analysis, there is little generic difference in the problems faced by the nations in the Hemisphere. As shown by the case studies, they include administrative and budget problems, infrastructure issues, inadequate training of personnel, inadequate mapping and information, treatment plants that may have good technology but need improved operation, high levels of needed investments, political problems such as technical decisions being overruled for political reasons, inadequate charging systems, and general financial problems.

Collaboration to Improve Water and Wastewater Infrastructure

The full range of water and wastewater problems facing the nations of the Hemisphere is too

large to address here. However, let us summarize a few from the case studies to focus on how we might all benefit from collaboration:

Access.	Disparity in access to safe drinking water and adequate sanitation services, and in levels of service, need attention throughout the Hemisphere. This is a worldwide problem as evidenced by the International Drinking Water and Sanitation Decade.
Technology.	Modern technologies are not available to those nations and regions lacking investment capital. Appropriate technologies offer help, but they require training, expertise, and local capacity-building.
Management.	Improving management efficiency, especially at local levels, is a critical issue. One of the most urgent issues is obtaining qualified and trained personnel.
Finance.	All nations in the Hemisphere are struggling with issues related to financial capacity. As economic integration proceeds, ways are needed to upgrade and equalize water and sanitation as a basic issue in trade and political cooperation.
Institutions.	In all nations, institutional factors are the most important in upgrading and equalizing water and sanitation services.

How can the water and sanitation sectors in nations and institutions in the Hemisphere collaborate to improve our joint approaches to solving these problems?

Possible areas of collaboration include technology transfer, improving access to information and innovations, and formation of alliances. This might be facilitated by mechanisms of cooperation such as a collaborative network of research and training institutes.

Such a network might be linked to water management agencies with the interest and capability to share training and experiences. It could promote water supply and sanitation education and technology exchange, and would coordinate with existing networks, such as AIDIS (Asociación Interamericana de Ingeniería Sanitaria y Ambiental) and others such as national and international water supply and environmental associations.

A network could organize a clearing house for cooperation in training and the exchange of educational materials. It could link up with existing assistance organizations and associations to organize regional meetings and periodic international congresses. Also, it might work with financing organizations to develop packages of self-study materials for water and sanitation officials.

While there is a wide variety in the nature of the problems faced at local levels, there certainly exists a potential to help each other solve problems in the Hemisphere through cooperation and sharing of experiences and knowledge.

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(Special acknowledgements to HIDROANDES and specially to Eng. Sara Morales).

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Rubem Porto, Director, Fundação Centro Technologico Hidráulica, Av. Prof. Lucio Martins Rodriques, 120, 005508-900, São Paulo, Brasil.

(Special acknowledgements to the Asociação Brasileira de Recursos Hídricos).

Part IV - Plenary Presentations and Keynote Addresses

Text of Keynote Address by the Honorable Rodrigo Carazo[1]

Former President of Costa Rica

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The contemporary world is in debate over the consumption-conservation alternative.

Developed countries have destroyed their natural resources and this is the price they have paid to achieve what we commonly know as “wealth.” The operation of the industrial complex continues to damage what little green space is left in the rich countries. Pollution is further exacerbated by automobiles and enormous urban development.

The damage suffered by our Planet intensifies and the dangers of the hole in the ozone layer and the greenhouse effect are common knowledge, just to mention only two examples.

The wealthy nations continue their harmful practices without curtailing their exorbitant resource consumption, which is well above the per capita average of the world. They refuse to regulate or change their customs and their waste. However, the dangers of a polluted environment grows everyday and the popular conscience in those rich and developed nations gives warning as to what is happening.

The curious part of the issue is that rich countries see the speck of dust in the others' eye but overlook the log in their own. The ecologists tend to point to the destruction of natural resources in the developing world as the sole cause of global environmental evils. Although experts acknowledge that contamination is contributed by the rich world, they specialize in blaming

poorer nations for the difficulties that are now beginning to preoccupy them. They point fingers at others before “restraining themselves” and massively reducing the problems caused by their own societies.

One of the subjects of their preoccupation is the voracious destruction of tropical rain forests. The fact that poor countries are following the model of growth that the industrialized nations have followed for centuries is ignored. The international financial institutions make the poor nations “adjust themselves” to formulas that will permit them to live according to the practices in force in the rich world. The “foreign investment” - among other things - is oriented towards the use and abuse of natural resources in developing countries, who accept these practices in order to obtain the degree of growth and development that would allow them to be more equal with the rich.

Today's contemporary civilization has instilled the belief that to be rich is to have money. There are relatively few who think that true wealth is represented today by the Earth's green resources, which are capable of contributing to the absorption of carbon dioxide (CO_2) that contaminates the air; to maintain the temperature at normal levels; and to give oxygen (O_2) to all living creatures.

The rulers and the people of the poor nations ignore the fact that they are owners of real wealth (natural resources), whose existence and benefits freely provide all the inhabitants of the earth, including, of course, the owners of money (volatile wealth). The poor nations also ignore the fact that the rich countries are adopting a conscience which requires a conservationism that they refuse to practice, but which increases their responsibility towards our poor world.

For centuries, the zeal for conquest and dominion of the strong over the weak has been to obtain volatile wealth. We might then conclude that control over territories could prove threatening to those who are considered guilty of the destruction of natural resources - our true wealth - which affects the survival of the entire human race.

In not taking care of ourselves, we, as poor nations of the world, will fall victim to the pressure and action of the powerful countries who wish to impose their ways and policies upon our people. We must, therefore, dedicate specific efforts to the conservation of resources, specializing and dedicating our designated forest lands for this purpose.

It is urgent that we make our intentions and actions known internationally and that we counteract the information that discredits us. It is also urgent for us to speak up and let it be known that our countries demand that the planet - of which we are all a part - not continue to be polluted by the industrialized world.

It is urgent that we make known around the world that contributing to the survival of humankind demands personal sacrifices and significant financial obligations. It should be obvious that to maintain a national park, to protect an area and create a wildlife refuge, and, at the same time, to enact protection laws for the natural resources, costs a lot of money.

The rich nations cannot be indifferent towards this effort if they wish the human race to survive. Such countries need to contribute financially; they should help pay for that conservation.

We also need to contribute - by conserving our natural resources - for the well-being of mankind. The countries that have already destroyed their green resources should restore where they are

able, conserve what little is left, and help pay so that the nations who still have them might maintain them.

It would be impossible to pretend that the rich purify their air, maintain the level of their oceans and moderate the temperature to which they are accustomed... all at the expense of the poor.

It is imperative to adopt a new attitude towards global justice. Let us, developing countries, provide of real wealth for the usufruct of all nations, demanding in return instruments that would facilitate our own development. This development is nothing else but the growth imposed upon us by the rich world of our time.

Population growth would not be such a problem if the riches of the earth were infinite. But our ecosystem is limited, and this presents an obstacle for the expansion of the human species. Obviously, the resources will not last forever and it is urgent to design new methods for their use, a design that needs to take into account the creativity of the new generations.

The resources which we usually exploit grow out of the evolution of the planet. Indiscriminate use by our generation can cause a very desperate situation for future generations. Although the known reserves will increase five times, a glimpse of total destruction can be seen on a short-term basis. Recognition of this danger should compel governments to be the keepers of natural resources. I feel the need to reenforce this concept and to extend it to the relationship between the human species and planet Earth... to put mankind in the perspective of guardian over its inheritance, which has been transmitted over and over for millions of years.

Let us make an effort so that the era of exorbitant consumption that we live in today will, in the future, be considered as a period of transition between the stable era of slow economy (past centuries) and a future recycled economy, which may again be stable and highly technological. This recycled economy will not be spontaneous. It will require research and development, as well as a considerable investment. Its development requires an adaptable philosophy that can be offered to all cultures, notwithstanding the actual basic premises as conditions for “a new way of life.”

The study of the earth's resources and the quality of life of the inhabitants of our planet must be considered integrally. We believe that an individual can live a healthy life in a pleasant environment; can maintain an active cultural life; and can have access to the beauty of nature. Quality of life constitutes mankind's enjoyment of satisfactory conditions, and the way to achieve that is through the satisfaction of his basic needs. It has been proven that a rich and diverse environment can guarantee the fulfillment of such needs.

The conceptual framework that has oriented the establishment and management of protected wildlife refuges in Latin America, and particularly in Costa Rica, has been guided by the principles defined by Kenton Miller (1980), for protected wildlife refuges planning. The objectives of these principles are:

- maintain large tracts of land as representative samples of the country's important biological regions in their unaltered state to assure continuity of the evolutionary process, including wildlife migration and genetic flow;

- maintain models of the various characteristics of all the types of natural habitat, physiographic form and landscape in order to protect the unique and representative

diversity of the country, particularly to ensure the function of natural biodiversity in the regulation of the natural environment;

- maintain all genetic materials as elements of the natural habitat and prevent the extinction of species of plants and animals;

- provide the means and opportunities in the wildlife areas for formal or informal educational purposes, for investigation and for the study and regulation of the environment;

- maintain and operate watersheds in order to ensure the flow and purity of freshwater;

- control and prevent erosion and sedimentation, especially in those places related directly with the investments that will be made at the lower end of the river basins which depend on water for transportation, irrigation, agriculture, fishing and recreation; and for protection of the natural areas;

- maintain and operate fishing and wildlife resources for the production of proteins and as a base for industrial, sport and recreational activities, always taking into account the vital function that they play in regulating the environment;

- provide constructive and healthy opportunities for outdoor recreation for local residents and for visitors from the different parts of the country and abroad, in order to allow for tourist development based on the natural and cultural characteristics of the country;

- manage and improve the timber resources to fulfill their role in regulating the environment and providing a stable production of lumber products for the construction of homes and for other important uses within the country;

- protect and make objects, places and cultural, historic and archeological structures accessible for the purpose of public use and scientific research as elements of the country's cultural heritage;

- protect and manage the landscape to ensure the environmental quality near cities and towns, roads, rivers and recreational and tourist areas;

- maintain and manage extensive tracts of land under flexible methods of land use, in order to conserve the natural processes which ensure the freedom of options in case of future changes.

The global goals of such objectives are:

- sustainable use of the natural resources (water, land, forests, wildlife, etc.);

- conservation of the biodiversity (which includes the diversity of the species and the diversity of the ecosystems);

- maintenance of the essential ecologic processes and vital support systems such as recycling of nutrients, quality protection of water sources, as well as conservation

and rehabilitation of soils;

• improve the quality of life by profiting from environmental, industrial, technological, administrative and legal opportunities that favor the sustainable use of natural resources, and yield environmental quality that offers greater options for satisfying basic, recreational, aesthetic and spiritual needs;

• achieve a more equitable balance between rural and urban development through strategic plans that promote an integral cultural and socio-economic development in the rural environment making it attractive, and at the same time, improving the quality of life of the marginal sectors in the urban environment;

• profit from the nation's non-renewable resources and the country's tourist potential, in order to contribute to a long-term sustainable economy for the benefit of the majority of its citizens and in harmony with the environment;

• define immigration and population policies with a long-term vision, considering the limitations of our basic natural resources;

• raise the citizens' consciousness towards issues that empower mankind - social justice, austerity, a healthy economy, high moral ethics in private and public functions; and the conservation and rational use of natural resources. These are essential to obtain long-term sustainable development and to prevent reduction in the quality of life that could jeopardize the country's civil peace and traditions;

• promote individual and collective responsibilities towards nature, environmental and economic stability, and human solidarity to ensure material progress and a greater harmony among humans, as well as between man and nature.

To conserve is the obligation of every human being. Such action must be founded on the fulfillment of every nation's responsibility. Our generation, as no other, is under the obligation to watch over the survival of humanity.

When dedicating a national park I always say, as President of the Costa Ricans, that we do it in order to fulfill our obligation before God and also as a contribution in benefit of all humanity.

I congratulate you for this extraordinary assembly and express my sincere wishes for the success of its deliberations. Thank you.

Text of Luncheon Address by Sandra Postel[1]

Author of *Last Oasis: Facing Water Scarcity*

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I would first like to thank the South Florida Water Management District for inviting me to speak to you today. It's really a great pleasure for me to be here. I believe that the multiplier effect we can achieve by better communicating and sharing our experiences with water problems and solutions is potentially very great. And in that spirit, I'd like to share with you some of the thoughts and

findings of my book, *Last Oasis.*

In many people's minds, the term “water scarcity” conjures up visions of drought - the impression that nature hasn't delivered what it was supposed to, and as a result, people end up short of water. But in fact the most disturbing signs of water scarcity are actually being caused more by human activities than by nature, and in many pans of the world, conditions of scarcity are rapidly becoming chronic.

There are now 26 countries that have more people than their water supplies can adequately support. This is based on a rule of thumb hydrologists use that countries need at least 1,000 cubic meters of water per person per year to meet food, industrial, household, and ecological needs. This 1000 cubic meters per year, which translates to about 725 gallons per person per day, is son of a minimum benchmark. When per capita supplies drop below this amount, a country is considered water scarce.

Africa currently has 11 water-scarce countries, the most of any continent. Given current rates of population growth, 4 others will join this list by the end of the nineties (Malawi, Morocco, South Africa, and Sudan), and the total number of Africans living in water-scarce countries will climb to 300 million - that's a third of the continent's projected population for the year 2000.

The Middle East is the most concentrated region of scarcity in the world today, with 9 out of 14 countries already in the water-scarce category. Tensions over water are high in all three of the Middle East's major river basins - the Jordan, the Nile, and the Tigris-Euphrates. The situation is particularly acute in the Jordan basin, which supplies Israel, Jordan, the West Bank, and part of Syria. Israel is already in a water deficit situation and about a third of its supply comes from sources within the occupied territories. So you can see how any ideas of trading land for peace are tightly linked to the issue of water security. Water scarcity issues will increasingly shape the political landscapes and economic futures of the countries in this region. It's my feeling that by the end of this decade, water problems will lead either to an unprecedented degree of cooperation in the Middle East, or a combustible level of conflict.

Besides this population-water equation, many physical signs of water scarcity are now evident around the world. Falling water tables from the overpumping of groundwater are now widespread in parts of China, India, Mexico, Thailand, the western United States, north Africa, and the Middle East. Water tables under Beijing, China's capital, for instance, have been dropping 1-2 meters per year.

We can point to whole economies that are now dependent on the mining of fossil groundwater - underground water reserves that are hundreds or even thousands of years old and which get very little replenishment from rainfall today. Saudi Arabia, for instance, is mining fossil groundwater to meet 75 percent of its current water needs. The Saudis use desalination for drinking water, but virtually the entire agricultural economy of the country is based on a groundwater supply that is projected to be depleted in less than 50 years. Clearly, the 4 million tons of wheat the Saudi's produce with this water are not a reliable part of the food supply.

We have a somewhat similar situation in the U.S. with the Ogallala aquifer in the Great Plains. Texas has depleted its portion of the Ogallala by a fourth, and irrigated area in the region is declining. In Northwest Texas, which overlies the Ogallala, irrigated area has fallen by a third since 1974.

In fact, when we look at irrigated area on a global basis, we now see a very disturbing trend. For most of modern history, the world's irrigated area grew faster than population did. This helped food production stay ahead of population growth. But in 1978, this trend turned around. Per capita irrigated land peaked that year, and it has dropped nearly 6 percent since then. Remember that irrigated lands give us a disproportionate share of our food - they make up only 16 percent of the world's cropland, but they account for a third of the global harvest. So this trend of declining irrigated land per person raises some red flags for food security. It's historically new, and, from my reading of things, our political leaders and policy makers have not yet fully grasped its consequences.

Finally, we also now see a host of ecological consequences from our overuse and mismanagement of water. As most of you well know, our basic approach has been to keep reaching out for more water and to gain ever more control over nature's water cycle. Global water use has more than tripled since 1950, and the answer to this rising demand has been to build more and bigger dams, river diversions, and other water supply projects.

The toll on the environment has been severe. We've heard quite a bit about some of the dramatic examples - like the Aral Sea in the central Asian republics, an ecosystem the size of Ireland virtually destroyed by excessive water use in the region.

Of course we have one of the premier examples in the world right here in south Florida. As we heard this morning, the Everglades are threatened by a range of activities that have greatly damaged the hydrological system that is the lifeblood of the Everglades. Only half of the original Everglades area remains. The population of nesting wading birds - herons, egrets, wood storks and so forth - has plummeted 90 percent since the 1930's.

Just about this time of year three years ago, I had the pleasure of seeing the Everglades system by helicopter thanks to the South Florida Water Management District. What I saw made a powerful impression on me - both the extraordinary beauty and wildness of the Everglades themselves, but also the relentless encroachment of more and more people and human activity into this fragile area. I couldn't help but think to myself afterward that if we in the United States, among the wealthiest countries in the world, should fail to save this treasure of an ecosystem, what realistic hope is there for wild places elsewhere - whether it's the Pantanal, the Sudd wetlands of Sudan, the Okavango Delta in Botswana, or the Donona wetlands in Spain - all of which are threatened by existing or planned water development projects.

There are many subtle signs of ecological damage as well. The American Fisheries Society, for instance, now lists 364 species of fish in North America as endangered, threatened, or of special concern - the vast majority of them at risk because of habitat destruction. Some of the prized salmon species in the western U.S. are on the brink of extinction. The winter run of Chinook salmon in California's Sacramento River, for example, has dropped from 120,000 in the sixties to just 400 today. And in 1992, just one adult Snake River Sockeye salmon made it to Redfish Lake, its primordial spawning ground in Idaho.

Putting water use on a sustainable footing and protecting the integrity of the aquatic environment is going to take, I think, a fundamental shift in our whole approach to managing water. Instead of constantly looking to expand the supply, as we've traditionally done for decades, the challenge is to focus much more directly on reducing our demand for water. We've been nibbling at the edges

with conservation, but it can and should now be a centerpiece of water planning.

In most cases, measures to conserve and recycle water and to use it more efficiently are now the most cost-effective and environmentally sound ways of meeting water needs. Based on numerous examples, which I've documented in *Last Oasis,* it's safe to say that with technologies and methods already up and running, many farmers could cut their water demands by 10-50 percent, industries by 40-90 percent, and cities by a third. And these savings could be achieved cost-effectively. I'd like to quickly run through some examples.

Improving irrigation efficiency is a top priority, since agriculture accounts for two-thirds of global water use. Worldwide, irrigation efficiency averages less than 40 percent, so there's tremendous room for improvement. The savings possible in irrigation constitute a large, new supply. Just consider, for instance, that reducing irrigation needs by a tenth would free up enough water to roughly double domestic water use worldwide.

Technologies and methods that can do that and more already exist. Farmers in the Texas High Plains, where, as I mentioned the Ogallala aquifer is diminishing, have adapted their old-fashioned furrow irrigation systems to a new “surge” method that distributes water more uniformly and reduces waste. Their water savings have averaged 25 percent, and they've recouped their initial investment of about $30 per hectare within the first year.

We've seen expanding use of drip irrigation, a very efficient method that uses porous or perforated piping to deliver water directly to the crops' roots. It can achieve efficiencies as high as 95 percent. Worldwide, use of drip irrigation has expanded 28-fold since the mid-seventies, but it still accounts for less than 1 percent of world irrigated area.

In much of Asia, where there are very large canal systems, the challenge of increasing irrigation efficiency is as much an institutional one as a technical one. It's been estimated for instance, that in India, improving the infrastructure and operation of its large canal systems could allow the area under irrigation to expand by nearly a fifth without building any new dams.

The savings possible in industry are particularly striking. Pollution control laws have turned out to be terrific incentives to save water because they make it more economical to recycle water inside a factory than to release it to the environment. So in industry, more than any other sector, we've already seen some really big gains.

For instance, in 1965, Japan was getting $21 worth of output from each cubic meter of water supplied to industry; by 1989, it was getting $77 worth of output from each cubic meter supplied to industry - and that's in real terms (adjusted for inflation). So Japan's industrial water productivity more than tripled in just over two decades. Some of this, of course, is due to some shifting away from heavy industry, but much of it is due to greatly increased recycling rates in the major water-using industries like chemicals, iron & steel, and pulp & paper manufacturing. We see similar trends when we look at Germany and the U.S.

Here, again, I would add that we've seen just the tip of the iceberg. In California, the recent 6-year drought pushed industries to go well beyond the usual level of conservation and recycling out of fear that their supplies could get cut back. And so what we've seen in California are some really impressive reductions in water use among a wide range of industries. For instance, one study of a number of companies in the San Jose area - including IBM, Hewlett Packard, and

Tandem Computers - showed savings of 30 percent all the way up to 90 percent, and with paybacks of less than a year in nearly every case.

Municipalities - cities, suburbs, and towns - account for less than a tenth of the world's water use, but their demands are concentrated geographically and so they put a lot of strain on local water bodies. And, as we all know, it takes a lot of money to build, operate, and maintain a modern water and wastewater system.

There are a number of cities around the world now that have made conservation an integral part of long-term water planning. We'll be hearing about Winnipeg's efforts later this morning. In my book, I talk about Boston, Jerusalem, Singapore, Los Angeles, Mexico City, and Waterloo, Canada as being among the metropolitan areas that have benefited from investing in conservation instead of the usual approach of expanding supplies. I found Boston's program particularly impressive. It was planned and implemented by the Massachusetts Water Resources Authority and through a combination of measures - including retrofitting residences, industrial water audits, and finding and fixing leaks in the distribution network - the program cut total water demand in the greater Boston area by about 20 percent in about 5 years. That brought water use back to the level of the late sixties, which has allowed the city to put off building an expensive and environmentally damaging new water project. And, again, the program was very cost-effective. Meeting water needs through conservation cost half as much as it would have to build a new river diversion project.

We'll be hearing more about conservation efforts in all these areas - agriculture, industry, and cities-during this conference. The key to bringing about these savings is replacing policies that promote profligacy and waste with ones that promote conservation and efficiency. In most countries, for instance, farmers pay less than 15 percent of the true cost of their irrigation water. That's been true of federal projects in the United States as well as in Mexico, Indonesia, Pakistan, and Egypt. Obviously new irrigation technologies are not going to spread as long as water is priced so cheaply.

It's my feeling that pricing, marketing, and regulations all have a role to play in bringing about sustainable water use. Which turns out to be the best and most appropriate policy instrument will vary, I think, from case to case. The thing we most need now is leadership - We need governments at the federal, state, provincial, and local levels to start making conservation a top priority and to start putting in place those policies that will enable the water efficiency revolution to unfold. The United States has taken a couple of important steps in this direction. In late 1992, a law was enacted that overhauls the Central Valley Project in California. This is the huge federal project that supplies irrigation water to 3 million acres in the agricultural heartland of California. Among other things, it calls for the establishment of a tiered pricing system that charges more for high levels of consumption, which should encourage farmers to conserve. It also allows Central Valley farmers to sell water to other water users in the state, including cities. And, finally, the new law dedicates 800,000 acre-feet of water each year to the aquatic environment. This water comes off the top of the project's deliveries, which means that rivers, wetlands, and fisheries will be assured a minimum amount of water even in times of drought. This is a pathbreaking new law that I hope will set a precedent for broader reforms in the western U.S. and elsewhere. And you can see that it combines the three major policy instruments - pricing, marketing, and regulations - to promote more sustainable water use overall.

In the area of urban conservation, we've seen strong moves in recent years toward the establishment of efficiency standards for common plumbing fixtures. In Canada, Ontario has adopted province-wide efficiency standards to help meet its goal of zero growth in water use for the next 20 years. Mexico was one of the first countries to adopt national standards, in part to help deal with the intractable water problems of Mexico City. And in late 1992, the U.S. established national efficiency standards as well. They are supposed to take effect in January 1994-though the federal government has been slow in coming up with regulations to enforce the law. These standards are important, since they will gradually cut indoor water use by 30 percent, helping lower water and wastewater costs nationwide.

Regulations also have an important role to play in the protection of watersheds and groundwater recharge zones. Careful land-use planning and zoning is about the only way I know of to ensure that land development does not destroy the integrity of the natural water system. A county on Long Island, New York, recently acquired 3,400 hectares of open space in order to preclude any development in a critical groundwater recharge zone. The county is paying for the land by way of a quarter-cent increase in the county sales tax, which was approved by the voters.

These policy tools cannot be fully effective, however, without education. It was Baba Dioum, a Senegalese conservationist, who said, “In the end we will conserve only what we love, we will love only what we understand, and we will understand only what we are taught.”

Historically, we have been quick to assume rights to use water, but slow to recognize obligations to preserve and protect it. What we need now, I think, is a new water ethic-one that makes the protection of water ecosystems a central goal in all that we do. We've heard it so often that it begins to sound trite, but water is, after all, the basis of life, and our stewardship of it will determine not only the quality but the staying power of human societies.

As I see it, the challenge now is to put as much human ingenuity into learning to live in balance with water, as we have put historically into controlling and manipulating it. And in the end, the time available to make this shift may prove as precious as water itself.

Thank you for your attention.

The Role of Environmental Education in Watershed Management

John H. Baldwin[1]

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The times are a-changing. Old development (cold war) paradigms of mutually assured destruction (MAD) are being replaced by the United Nations Conference on Environment and Development (UNCED) policy of mutually assured development (MAD-2). The goals of development have changed from development versus the environment to development and environment. This change in philosophy and policy has not been reflected in education programs. Thus, the knowledge and information systems “on the ground” reflect old policies and realities - and are resistant to change. Knowledge is power, and the development of modern

information and education systems that foster new development policies, programs and practices are essential for successful transformation to the new “mutually assured development” paradigm. For example, the UNCED Agenda 21 addresses issues of science (eg. carrying capacity, assimilative capacity and system resiliency), economics (eg. efficiency and equity), and society (eg. information, participation and justice). Information is generally available on the impacts of development on physical systems (through the sciences); however, less is known about the economics, and even less on the social consequences of old versus new development paradigms.

Alicia Barcena, the Executive Director of the Earth Council of Costa Rica, previously stated that, “the key to action is access to information.” She is referring to information that is accurate, appropriate, in the local language, in the right place and to a receptive audience. To foster change in water management policy, new and improved education and information systems are necessary. In closing, the development of new Inter-American Water Management Policy involves a fundamental change in development thinking. Modern systems of education and information are needed to inform the public to foster community and regional support for water management projects. Education is a strong proponent of change. It is through change that real progress will be made in water resource management. H.G. Wells expressed my sentiments years ago by stating: Civilization is a race between education and disaster. Thank you.

Water Resources as Eyewitness to the Health and Future of the Planet

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Note of the Editor: Dr. Goldman made a thorough presentation including a number of audiovisuals. The following text is a summary of his presentation. The full presentation was videotaped and requests for the full presentation transcript will be available soon.

At no time in our relatively short history on earth has the value of maintaining adequate clean water supplies for agriculture, industry, and domestic consumption been more important to the earth's rapidly increasing human population. Demographic predictions are that ninety-five percent of this growth will occur in the southern hemisphere. The importance of water restoration projects ranging from improved erosion control to lake, river and wetland management, rehabilitation, and pollution control can scarcely be over emphasized. In fact, the quality of life in many pans of the world is already seriously impacted by inadequate quantity and/or quality of available water. The droughts in the west and recent floods in the Midwest and Europe and hurricanes all serve as painful reminders of the power of climatic forces. It has become increasingly evident that we need to maintain the more natural order of entire watersheds and their associated wetlands to reduce the damage of these events.

This conference includes reports on restoration and conservation planning for the enormous 140,000 km^2 Pantanal in the upper Paraguay River Basin in western Brazil, eastern Bolivia, and northeastern Paraguay, the Florida Everglades, the Upper St. John's River Basin, as well as the

Upper Mississippi. Although these projects are individually very different, they have the common objective of providing for multiple water use while at the same time rehabilitating river and wetland systems damaged by water diversion, development or pollution. Since important human, plant, and animal populations will all ultimately be affected by the design, execution and performance of these costly projects they are of great importance to this and future generations.

Lake Tahoe, USA, for more than thirty years has been a microcosm for the study and resolution of environmental conflict. Lessons from the Tahoe consensus building are already being exported to Lake Baikal in Russian Siberia. This is the world's oldest and deepest lake soon to be designated as an International Heritage Site by UNESCO. Research on environmental conditions in Tahoe, Honduras, Costa Rica, Ecuador, Brazil, Argentina, and Africa will highlight the importance of understanding ecosystem structure and function for management. It is important to monitor the impacts of existing conditions and have an adequately flexible long-term research program to take advantage of new knowledge and technology. Only then can we move beyond the conflict, and through active consensus building avoid endless litigation while the values of the resource continues to decline.

Hydrometeorological Advances in Flood Forecasting in View of Lessons Learned from The Great Mississippi Basin Flood of 1993

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INTRODUCTION

The Great Flood of 1993 was a hydrometeorological event without precedent since the United States started providing weather services over a century ago. In terms of precipitation amounts, record river stages, areal extent of flooding, persons displaced, crop and property damages, and flood duration, this event surpassed all floods in the United States during modern times. There were 500 counties in nine states devastated by The Great Flood of 1993. Record and near-record precipitation in the spring of 1993 on soil saturated from previous seasonal precipitation resulted in flooding along many river systems and their tributaries. Figure 1 shows the general area impacted by heavy rainfall and flooding.

In the Mississippi and Missouri River main stem systems alone, a total of 93 record river stages were broken. The duration of The Great Flood of 1993 was as overwhelming as the areal extent of flooding and the number of new record stages established.

ANTECEDENT CONDITIONS

The hydrological and meteorological conditions that lead to the flood were unique, complex, and extreme in many respects. An extended wet period in the fall of 1992 moistened soils to near saturation and raised many stream levels to bankfull or flood levels. This set the stage for rapid runoff and record flooding that followed excessive June and July rainfall.

During The Great Flood of 1993, a persistent atmospheric pattern produced excessive rainfall across much of the upper Mississippi River Valley and the northern and central Great Plains during June, July, and the first half of August 1993. Much of the major river flooding originated from several synoptic scale copious rainfall events from mid-June through late July. During the summer (June-August 1993), rainfall totals surpassed 12 inches across the eastern Dakotas, southern Minnesota, eastern Nebraska, and most of Wisconsin, Kansas, Iowa, Missouri, Illinois, and Indiana. Over 24 inches of rain fell on central and northeastern Kansas, northern and central Missouri, most of Iowa, southern Minnesota, and southeastern Nebraska, with up to 38.4 inches in east-central Iowa. These amounts were approximately 200-350 percent of normal from the northern plains southeastward into the central Corn Belt. Since the start of the growing season (April 1), precipitation amounts through August 31 were even more impressive: totals approached 48 inches in east-central Iowa, easily surpassing the area's normal annual precipitation of 30-36 inches. (From a seasonal standpoint, above- to much above-average rainfall fell over the entire Upper Midwest from May through August 1993. The May-August 1993 rainfall amount is unmatched in the historical records of the central United States.) In July, there were broad areas in North Dakota, Kansas, and Nebraska, as well as a smaller pocket in Iowa, that experienced over four times normal precipitation. The April-July precipitation amounts are remarkable not only in magnitude but also in their broad regional extent. Record wetness existed over 260,000 square miles. The Missouri July values were somewhat tempered by below-normal rainfall in the extreme south, although some areas of northwestern Missouri had over 30 inches of rain in July alone. Seasonal rainfall records were shattered in the affected areas.

HYDROLOGIC ANALYSIS

Extreme flooding of major river systems, like the Mississippi and Missouri Rivers, typically does not occur in the summer because of the highly variable nature (in space and time) of convective rainfall in the Midwest coupled with high rates of evapotranspiration. Typical midwestern summers experience a few localized heavy rains of as much as 6-12 inches in 1-2 days that extend over a few thousand square miles. These heavy rains are usually found randomly distributed, producing localized flash floods on streams and tributaries, but are not usually sufficient to produce major flooding on larger river systems of any consequence.

Figure 1

Another common aspect of the precipitation climate of the midwestern summer involves atmospheric conditions capable of producing above-average rainfall over sizable (state-scale) areas in random parts of the Midwest. When these conditions do not occur, the Midwest has summer droughts like that of 1988. These “wet periods” typically persist for 2-5 weeks and sometimes last up to 8 weeks creating the “wet summers” found in the climatic record. However, excessively heavy rain extending over wide multi-state areas and lasting more than 8 weeks is a rare event. These long-lasting and spatially extensive wet conditions, along with exceptionally wet antecedent hydrologic conditions, were necessary hydrometeorological conditions required to produce the massive flooding in the Midwest during the summer of 1993.

HUMAN AND ECONOMIC FACTORS

When measured in terms of economic and human impacts. The Great Flood of 1993 clear will be recorded in twentieth century history as this Nation's most devastating flood. Initial assessments

of the economic impact of The Great Flood of 1993 indicate that losses will range between $15-20 billion. This will rival Hurricane Andrew in overall losses.

During The Great Flood of 1993, the Missouri Basin River Forecast Center (MBRFC) and the North Central River Forecast Center (NCRFC) were the two offices within the nine-state area impacted that were responsible for the preparation of the river forecasts. During normal operations, the MBRFC and NCRFC basically operate day-time schedules during the week and provide an on-call coverage during the night hours with only skeleton service on weekends. Naturally, when a “normal” flood event does occur, the hours of operation at the RFCs are extended to meet the needs of the occasion. Around-the-clock operations do occur but usually only for a day or two. Within days, or even a week in some unusual instances, the RFC reverts to its normal hours of operation.

Not enough can be said about the quality of the performance of the National Weather Service (NWS) employees during The Great Flood of 1993. The extraordinary effort exerted under extremely stressful conditions, which persisted for literally months, is unprecedented. The devotion to quality services and protection of life and property was extraordinary. The human judgment and expertise in many cases compensated for serious deficiencies in the current capabilities of the forecast and warning system. The services provided during this historical event were a major team effort by 2 RFCs, 9 Weather Service Forecast Offices, and 20 Weather Service Offices with support from national centers. This team effort was momentous, and the collaborative effort by all offices was outstanding.

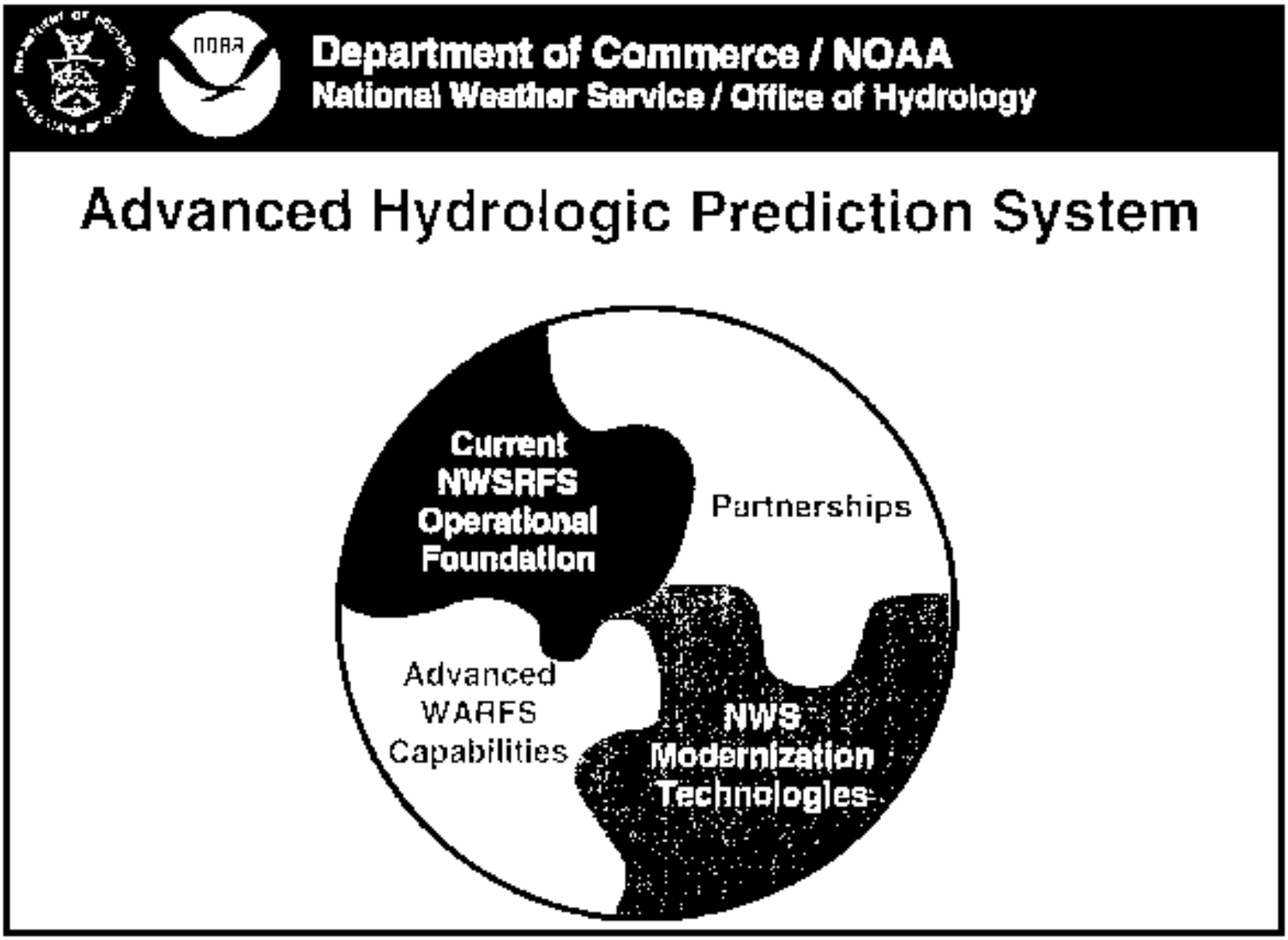
ADVANCED HYDROLOGIC PREDICTION SYSTEM

It is clear that in view of the magnitude of the losses, every effort must be taken to reduce potential future losses. It is also clear that many questions raised during the flood were similar to questions raised during the 1988 drought. For example, “When will barge traffic resume?” and “When will this flood/drought end?”

Many lessons have already been learned from The Great Flood of 1993. Foremost among these is the need to accelerate the implementation of an Advanced Hydrologic Prediction System (AHPS). The major components of this advanced prediction system are as follows (see Figure 2):

1. Current River Forecast System (NWSRFS) operational foundation;
2. National Oceanic and Atmospheric Administration (NOAA) partnerships;
3. NWS modernization technologies;
4. Advanced Water Resources Forecasting System (WARFS) capabilities.

Figure 2



The first component of the AHPS is the NWSRFS. It is the mainline river forecast system of the United States NWS. This computerized system was developed through a team effort by the Office of Hydrology at the national level and the RFCs at the field level. Development of the system has evolved to the current Version V which has been implemented at RFCs across the United States. The NWSRFS allows for the automated input of data from a number of sources and provides maximum flexibility to the forecaster in selecting and using the procedures that will do the best job for a specific river basin. The system also provides the opportunity for each RFC to include its own unique procedures and allows other offices to use them. With the NWSRFS on-line, the RFCs will be able to effectively implement the latest technology in a timely manner as it becomes available.

The second component is NOAA's partnerships. The NWS regularly interacts with its many partners in data and information exchange. Partners include Federal agencies (Corps of Engineers, Geological Survey, and Soil Conservation Service), Regional Commission (Salt River Project, Denver Water), the private sector, universities, and state and local agencies involved with hydrological and water resources. The AHPS is geared to decision making for flood preparation and management. During The Great Flood of 1993, these partnerships proved invaluable.

The third AHPS component is NWS modernization technologies which involves new sources of information about the atmosphere, powerful new information and processing systems, reconstruction of NWS into an interactive scientific work station environment, and a new organizational structure. The overriding goal of the modernization is to improve the quality and reliability of NOAA services.

Implementation of the major NWS modernization technologies, principally the Next Generation Weather Radar (NEXRAD) and the Advanced Weather Information Processing System (AWIPS), will (1) substantially improve the availability of higher resolution meteorological and hydrological data and information, especially radar-based precipitation estimates, and (2) provide powerful interactive-processing capabilities. The modernization technologies allow forecast operations to be better tailored to each RFC's needs.

WARFS, the fourth AHPS component, is essential for major advances required to provide an improved national hydrologic prediction system for floods and droughts; for operations on large lakes; and for better overall water management through advanced hydrologic/hydraulic modeling, improved data integration techniques, enhanced real-time and historical databases and optimal incorporation of meteorological and climate forecast information (see Figure 3). During crises, WARFS will greatly improve the Nation's capability to take timely and effective actions that will significantly mitigate the impact of major flood and drought situations.

Figure 3

LESSONS LEARNED DURING THE GREAT FLOOD OF 1993

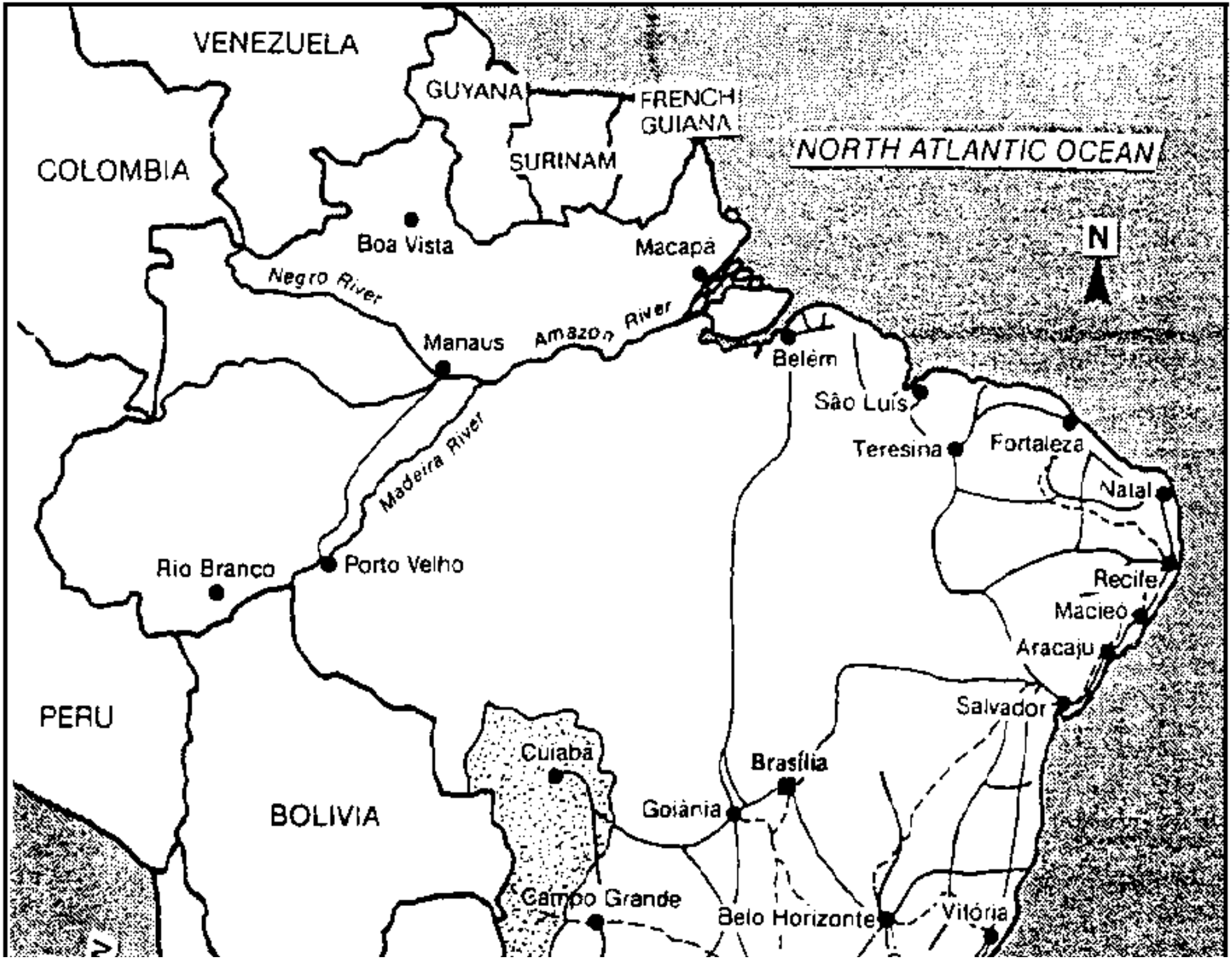
A NOAA disaster survey team was formed to identify opportunities to improve NOAA's weather and flood forecast and warning systems, not only for the effected region but also throughout the Nation. Those improvements to NOAA's environmental prediction capabilities will: (1) advance the agency's overall contributions to environmental services; (2) expand the payback on current investments, and improve and/or extend the benefits to many more segments of the public. An enhanced, modernized hydrologic forecast and warning system will help:

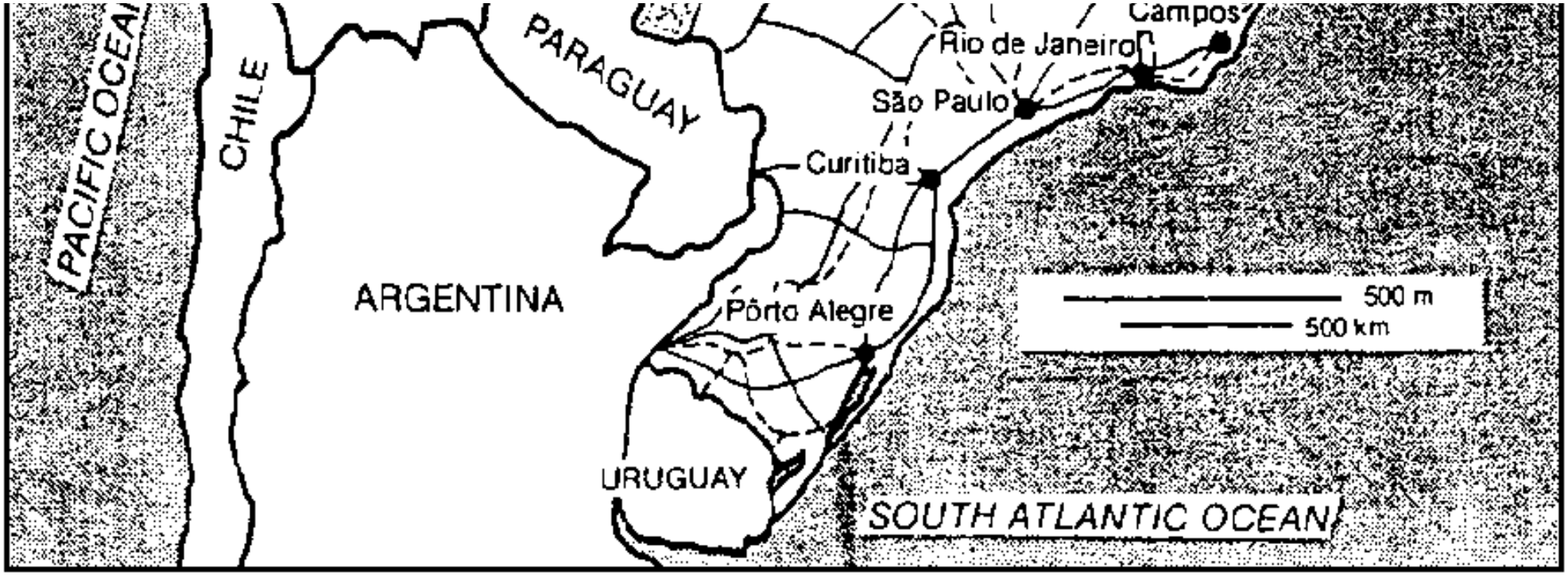
1. Reduce fatalities and injuries due to hazards from weather and floods;
2. Improve the flow of more accurate environmental data and predictions to the public;
3. Enhance the ability of planners to use hydrologic forecasts in the range of days to months;
4. Provide better information for management of fresh water resources;
5. Prevent avoidable damage to private, public, and industrial property over land, in coastal areas, and along rivers; and
6. Improve efficiency, reliability, and savings in industry, transportation, agriculture, and hydro-energy systems.

The survey team found that a major need existed to provide the type of advanced products and services that are possible with the implementation of WARFS. The essential scientific and technological ingredients needed to build WARFS are ready for integration and implementation.

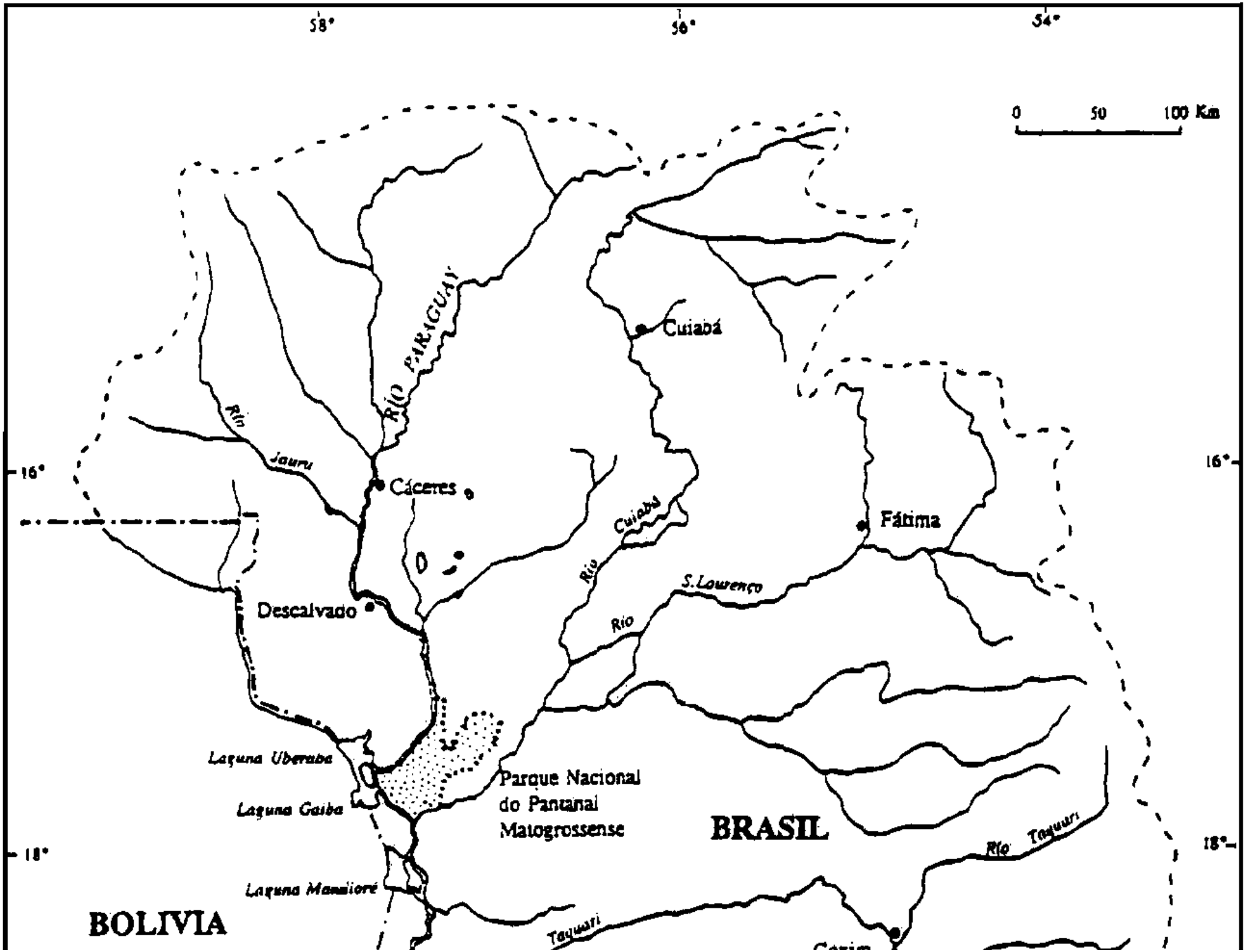
These ingredients include advanced data and modeling procedures which, for example, will more effectively represent the physical processes that produced The Great Flood of 1993 in the Mississippi and Missouri Basins. This involves more accurate modeling of water that has fallen over the river basins as well as the coupling of information from the meteorological, climatological, and hydrological forecast systems to account for future rainfall events. Such coupling will allow river forecast procedures to not only account for water already on the ground but also to account for estimates of future additional rainfall that will magnify flood crests. Inability to adequately incorporate precipitation forecasts was the single largest source of error for the longer-term hydrologic forecasts during The Great Flood of 1993. The ability to consider future rainfall will provide longer hydrologic forecast lead times which will allow for more effective flood mitigation measures. Also, these advanced hydrologic/hydraulic capabilities will allow for modeling of the status of levee over-toppings and their effect on the flood wave.

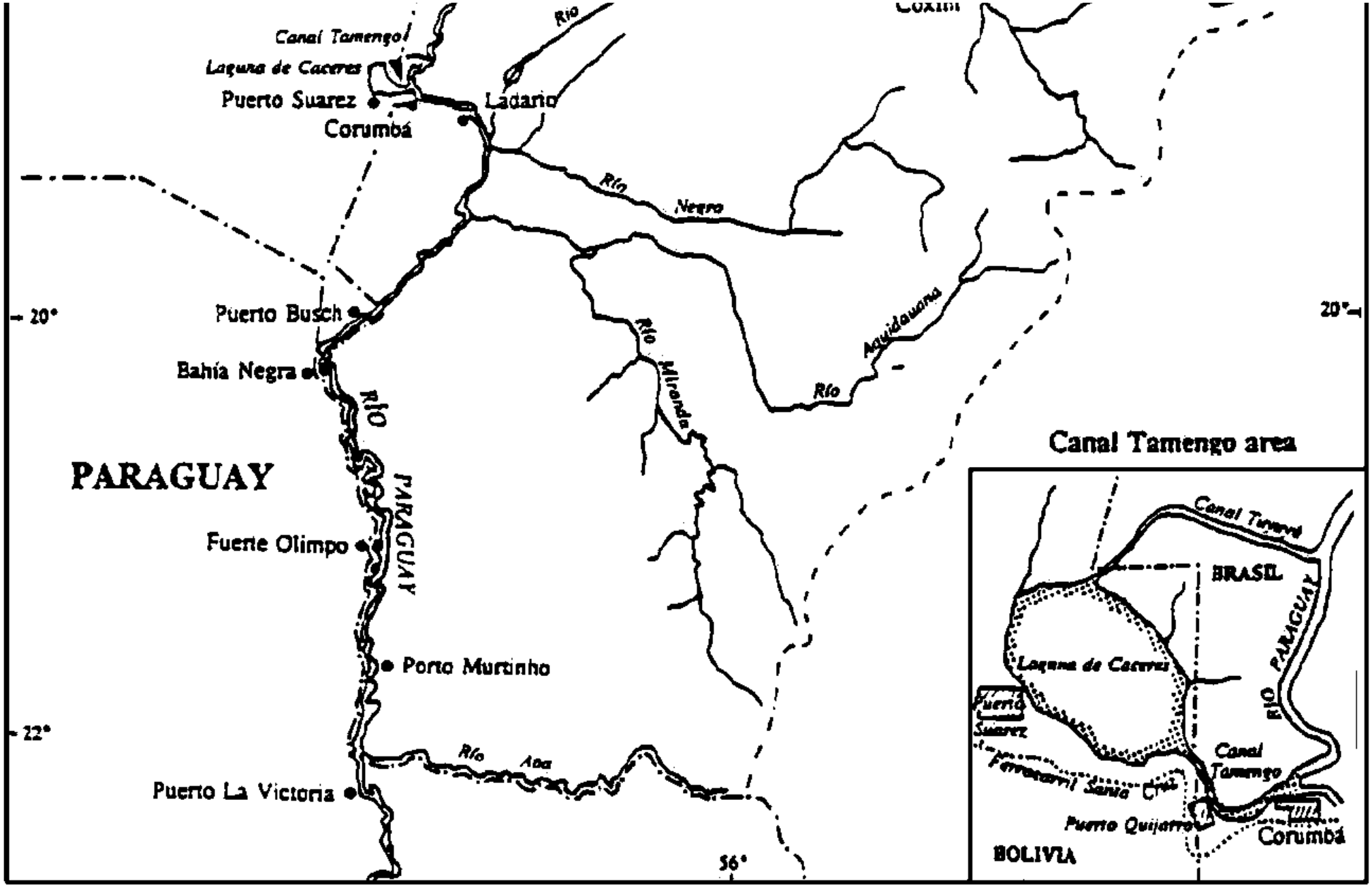
Although The Great Flood of 1993 has caused devastating human, environmental, and economic impacts, the lessons learned will guide us in providing improved services and benefits to the Nation in the future.

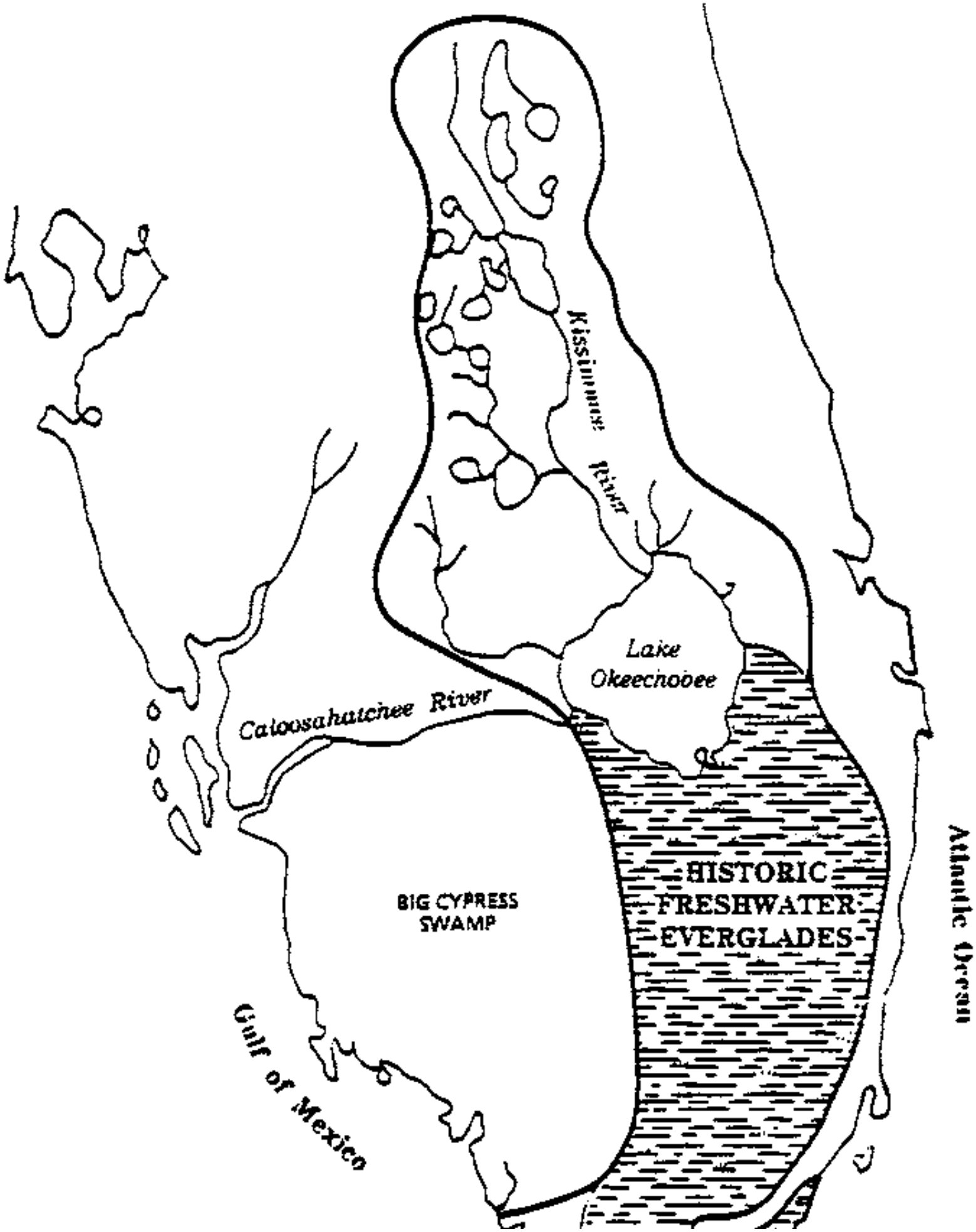

VENEZUELA
GUYANA
FRENCH GUIANA
NORTH ATLANTIC OCEAN
COLOMBIA
SURINAM
N
Boa Vista
Macapá
Negro River
Amazon River
Manaus
Belém
São Luís
Madeira River
Teresina
Fortaleza
Natal
Rio Branco
Porto Velho
Recife
Maceió
Aracaju
Salvador
PERU
Cuiabá
Brasília
BOLIVIA
Goiânia
Campo Grande
Belo Horizonte
Vitória

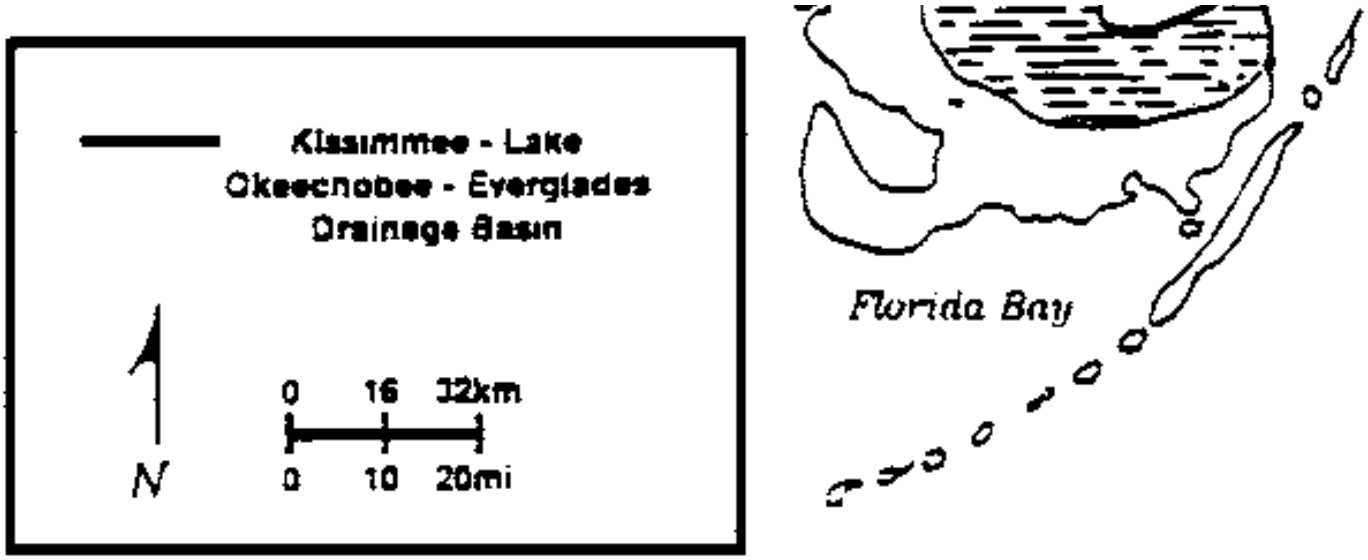


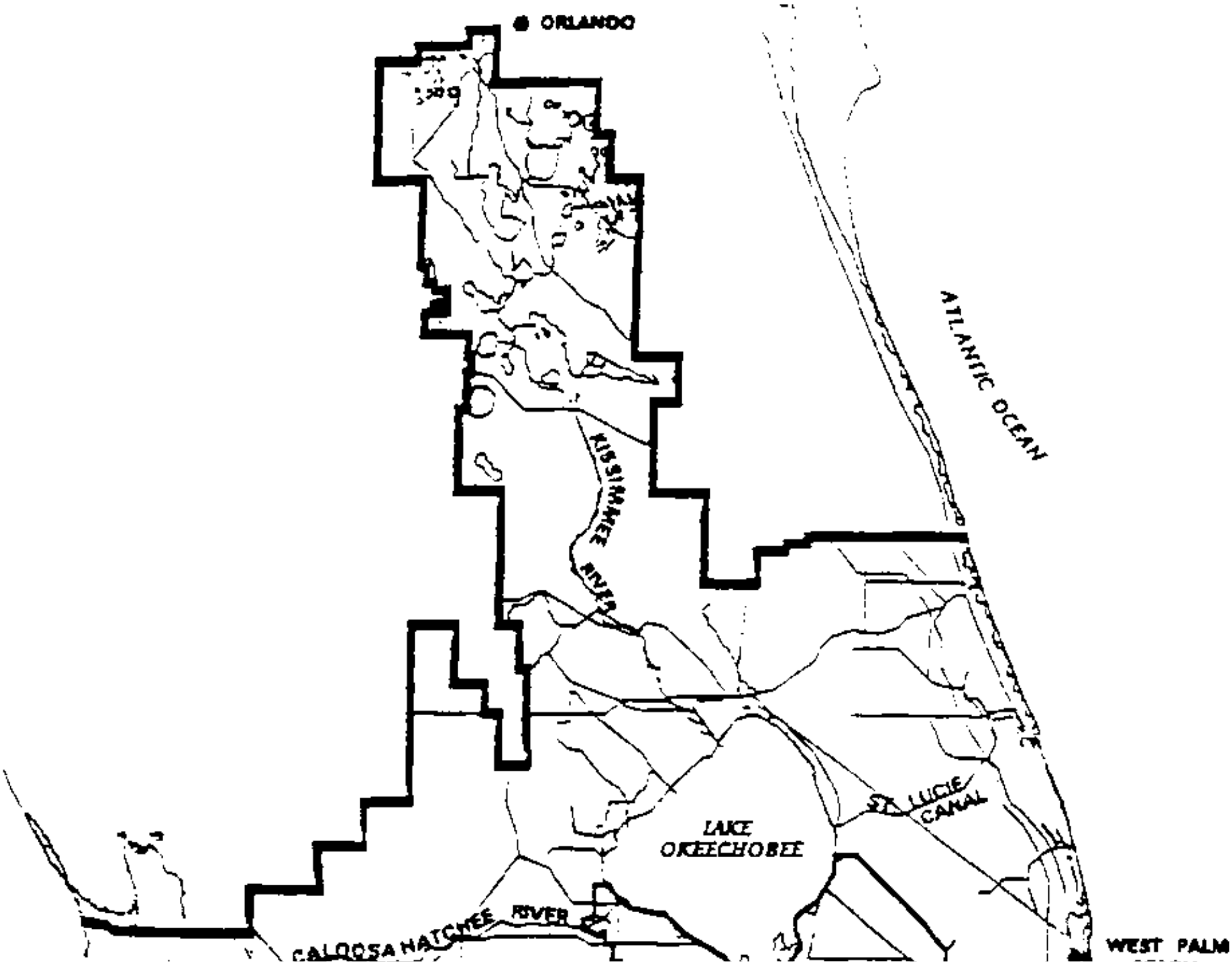
Pantanal Watershed

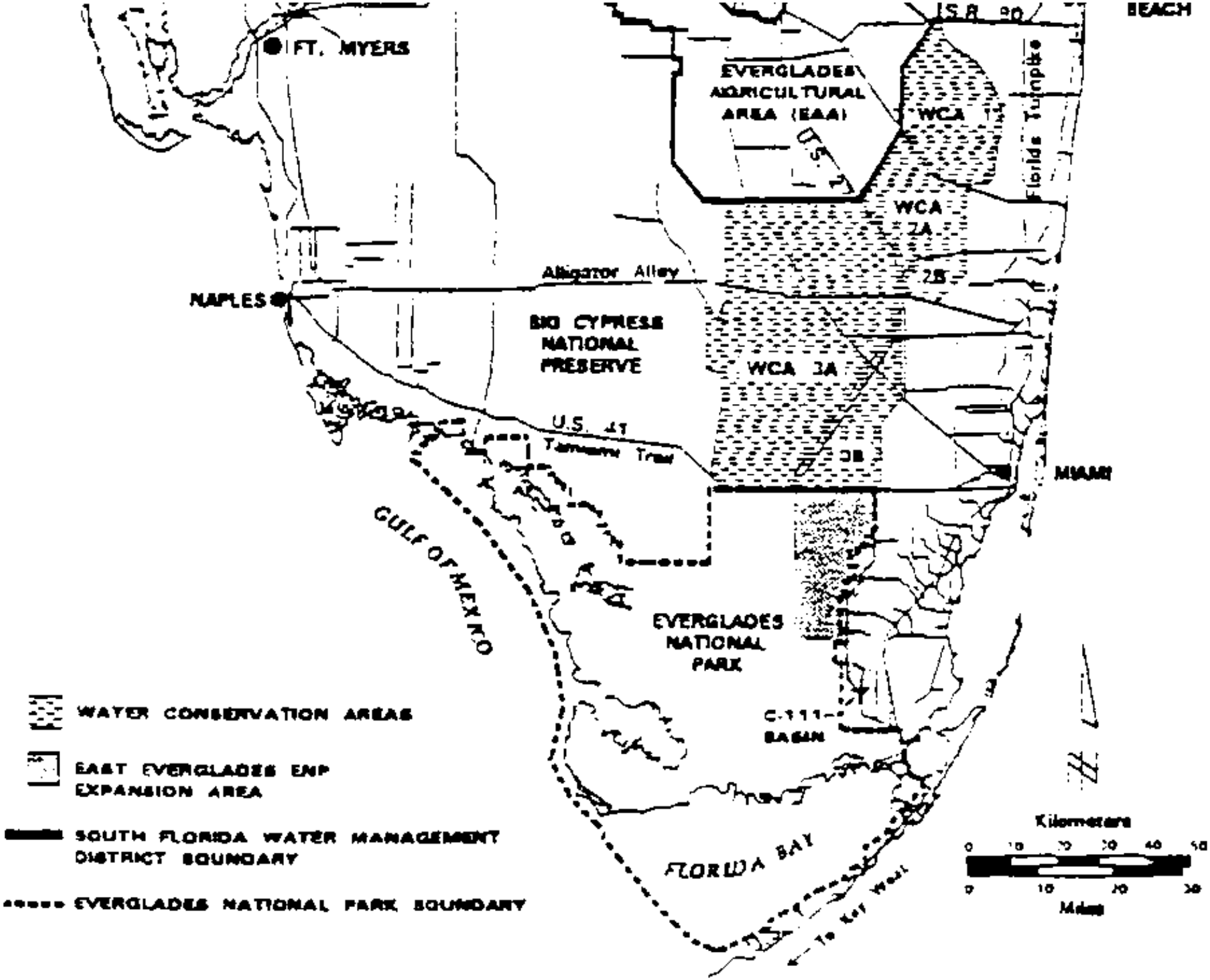

58°
56°
54°
0 50 100 Km
16°
18°
Río Paraguay
Río Jauru
Cáceres
Cuiabá
Río Cuiabá
Fátima
S. Lourenço
Rio
Descalvado
Laguna Uberaba
Laguna Gaiba
Laguna Mandioré
Parque Nacional
do Pantanal
Matogrossense
BRASIL
BOLIVIA
Río Taquari
Taquari

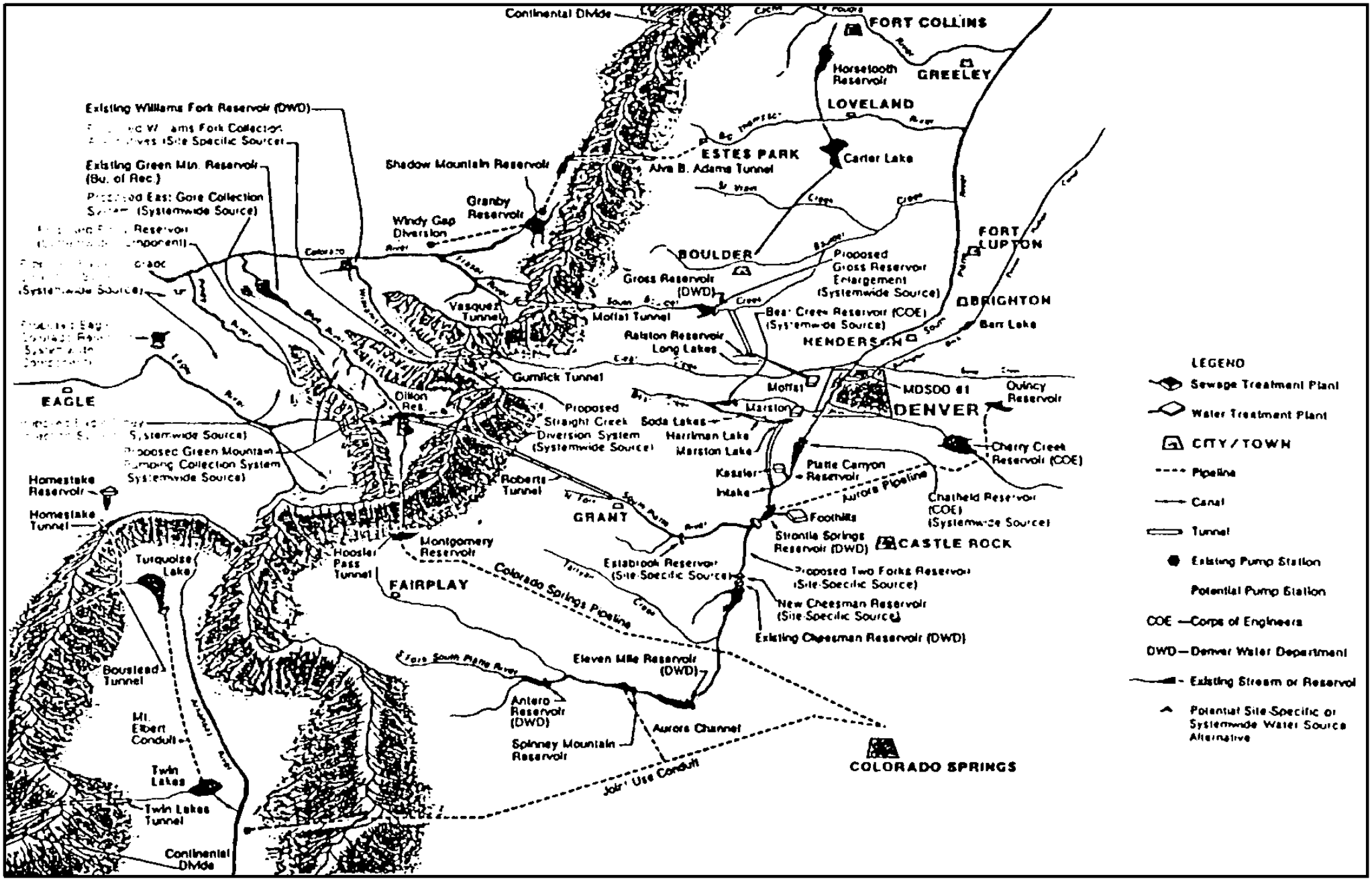

Canal Tamengo
Laguna de Caceres
Puerto Suarez
Corumbá
Ladario
Río Negro
Coxim
Puerto Busch
Bahía Negra
Río Paraguay
PARAGUAY
Fuerte Olimpo
Porto Murtinho
Río Apa
Puerto La Victoria
Río Miranda
Aquidauana
Río
20°
22°
56°
Canal Tamengo area
Canal Tamengo
BRASIL
Laguna de Caceres
Puerto Suarez
Ferrocarril Santa Cruz
Puerto Quijarro
Canal Tamengo
Corumbá
BOLIVIA

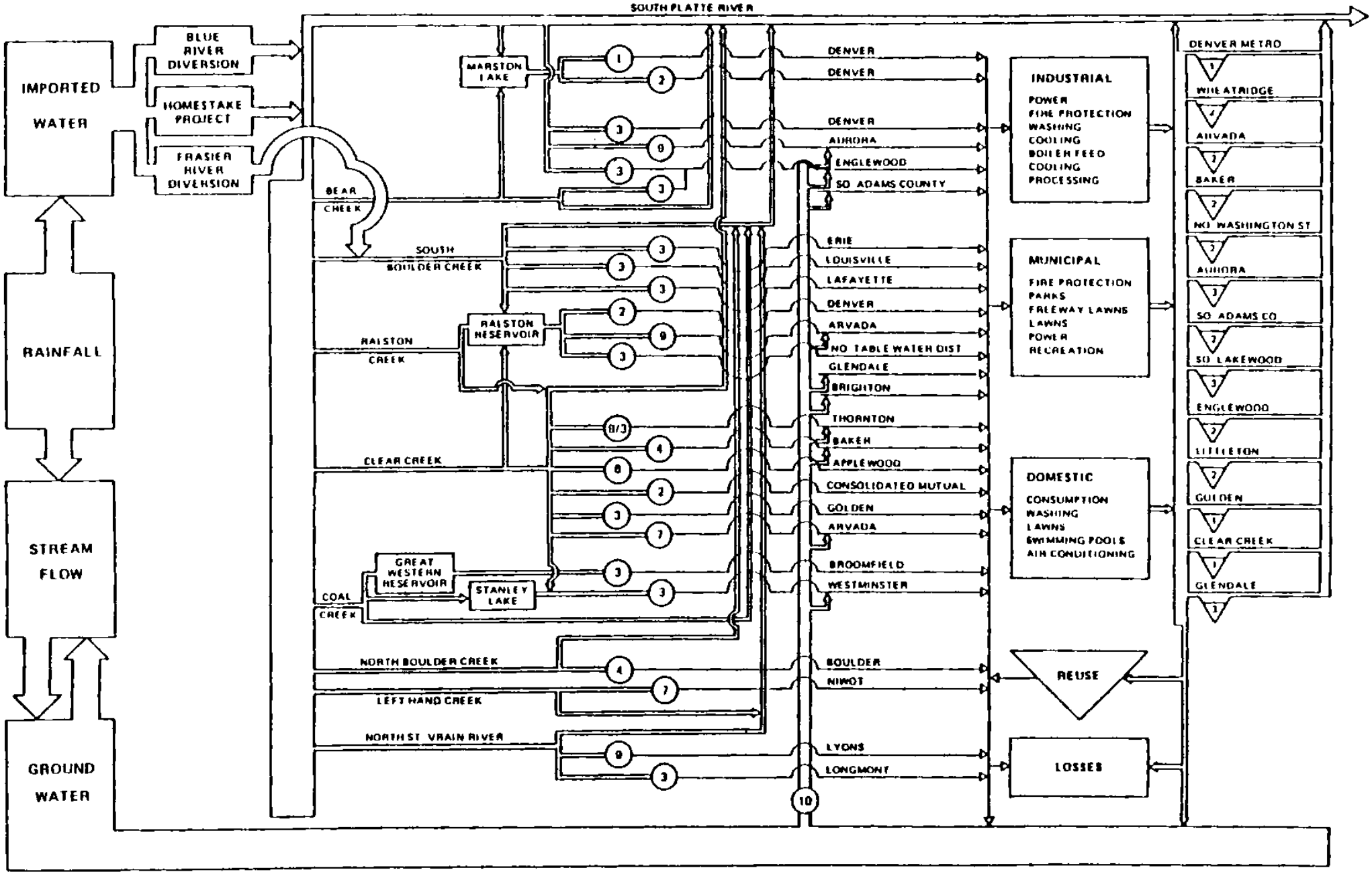

Kissimmee River
Lake Okeechobee
Caloosahatchee River
BIG CYPRESS SWAMP
HISTORIC FRESHWATER EVERGLADES
Gulf of Mexico
Atlantic Ocean


Kissimmee - Lake
Okeechobee - Everglades
Drainage Basin
N
0 16 32km
0 10 20mi
Florida Bay


ORLANDO
ATLANTIC OCEAN
KISSIMMEE RIVER
ST. LUCIE CANAL
LAKE OKEECHOBEE
CALOOSAHATCHEE RIVER
WEST PALM


FT. MYERS
EVERGLADES AGRICULTURAL AREA (EAA)
WCA 1
WCA 2A
2B
WCA 3A
3B
Florida Turnpike
Alligator Alley
NAPLES
BIG CYPRESS NATIONAL PRESERVE
U.S. 41
Tamiami Trail
MIAMI
GULF OF MEXICO
EVERGLADES NATIONAL PARK
C-111 BASIN
FLORIDA BAY
WATER CONSERVATION AREAS
EAST EVERGLADES ENP EXPANSION AREA
SOUTH FLORIDA WATER MANAGEMENT DISTRICT BOUNDARY
EVERGLADES NATIONAL PARK BOUNDARY
Kilometers
Miles


Continental Divide
FORT COLLINS
Horsetooth Reservoir
GREELEY
LOVELAND
Existing Williams Fork Reservoir (DWD)
Existing Green Mtn. Reservoir (Bu. of Rec.)
Shadow Mountain Reservoir
ESTES PARK
Alva B. Adams Tunnel
Carter Lake
Granby Reservoir
Windy Gap Diversion
FORT LUPTON
BOULDER
Proposed Gross Reservoir Enlargement (Systemwide Source)
Gross Reservoir (DWD)
Vasquez Tunnel
Moffat Tunnel
Bear Creek Reservoir (COE) (Systemwide Source)
BRIGHTON
Barr Lake
Ralston Reservoir
Long Lakes
HENDERSON
Gumlick Tunnel
EAGLE
Dillon Res.
Moffat
MDSDD #1
Quincy Reservoir
Proposed Straight Creek Diversion System (Systemwide Source)
Soda Lakes
Harriman Lake
Marston Lake
DENVER
Proposed Green Mountain Pumping Collection System (Systemwide Source)
Cherry Creek Reservoir (COE)
Homestake Reservoir
Roberts Tunnel
Kassler
Intake
Platte Canyon Reservoir
Aurora Pipeline
Chatfield Reservoir (COE) (Systemwide Source)
Homestake Tunnel
GRANT
Foothills
Strontia Springs Reservoir (DWD)
CASTLE ROCK
Turquoise Lake
Hoosier Pass Tunnel
Montgomery Reservoir
Colorado Springs Pipeline
Elbiblock Reservoir (Site-Specific Source)
Proposed Two Forks Reservoir (Site-Specific Source)
FAIRPLAY
New Cheesman Reservoir (Site-Specific Source)
Existing Cheesman Reservoir (DWD)
Eleven Mile Reservoir (DWD)
Boustead Tunnel
Antero Reservoir (DWD)
Mt. Elbert Conduit
Aurora Channel
Spinney Mountain Reservoir
COLORADO SPRINGS
Twin Lakes
Joint Use Conduit
Twin Lakes Tunnel
Continental Divide
LEGEND
Sewage Treatment Plant
Water Treatment Plant
CITY/TOWN
Pipeline
Canal
Tunnel
Existing Pump Station
Potential Pump Station
COE — Corps of Engineers
DWD — Denver Water Department
Existing Stream or Reservoir
Potential Site-Specific or Systemwide Water Source Alternative


SOUTH PLATTE RIVER
IMPORTED WATER
BLUE RIVER DIVERSION
HOMESTAKE PROJECT
FRASER RIVER DIVERSION
RAINFALL
STREAM FLOW
GROUND WATER
MARSTON LAKE
BEAR CREEK
SOUTH BOULDER CREEK
RALSTON CREEK
RALSTON RESERVOIR
CLEAR CREEK
GREAT WESTERN RESERVOIR
STANLEY LAKE
COAL CREEK
NORTH BOULDER CREEK
LEFT HAND CREEK
NORTH ST. VRAIN RIVER
DENVER
DENVER
DENVER
AURORA
ENGLEWOOD
SO. ADAMS COUNTY
ERIE
LOUISVILLE
LAFAYETTE
DENVER
ARVADA
NO. TABLE WATER DIST
GLENDALE
BRIGHTON
THORNTON
BAKER
APPLEWOOD
CONSOLIDATED MUTUAL
GOLDEN
ARVADA
BROOMFIELD
WESTMINSTER
BOULDER
NIWOT
LYONS
LONGMONT
INDUSTRIAL
POWER
FIRE PROTECTION
WASHING
COOLING
BOILER FEED
COOLING
PROCESSING
MUNICIPAL
FIRE PROTECTION
PARKS
FREEWAY LAWNS
LAWNS
POWER
RECREATION
DOMESTIC
CONSUMPTION
WASHING
LAWNS
SWIMMING POOLS
AIR CONDITIONING
REUSE
LOSSES
DENVER METRO
WHEATRIDGE
ARVADA
BAKER
NO. WASHINGTON ST.
AURORA
SO. ADAMS CO.
SO. LAKEWOOD
ENGLEWOOD
LITTLETON
GOLDEN
CLEAR CREEK
GLENDALE
KEY
1 RAPID FILTER (ANTHAFILT)
2 RAPID SAND FILTERS
3 SLOW SAND FILTERS
4 SAND FILTERS, MICRO STRAINERS
5 CHLORINATION, SAND FILTERS
6 SAND PRESSURE FILTERS
7 SAND FILTERS
8 ZEOLITE FILTERS
9 MICRO-FLOC
10 CHLORINATION
1 ACTIVATED SLUDGE
2 TRICKLING FILTER
3 EXTENDED AERATION

Report of the Interamerican Dialogue on Water Management

Compiled by Alberto J. Palombo[1]

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The Interamerican Dialogue on Water Management was held at the Inter-Continental Hotel in Miami, Florida, USA on October 27-30, 1993. The Dialogue was held in conjunction with the Annual Meeting of the Interstate Council on Water Policy and the XVI Annual Conference on Water Management in Florida.

Every international water resource conference in the past twenty years has confronted these challenges and made recommendations to meet them. Consistent themes have been the need to advance water resource technology, improve the exchange of information, and institute environmentally sound policies and practices throughout the hemisphere.

The South Florida Water Management District became a catalyst in moving these concepts from discussion to action. The District is undertaking a multi-faceted restoration project in the Florida Everglades that embodies the best principles of integrated watershed management. This project and other District activities have attracted inquiries and visits from around the world, and especially from Latin America, underlining the need for a new mechanism to facilitate communication, training, and technology transfer. Many other water management authorities have had similar experiences.

Such experiences focused attention on the fact that water management agencies and support organizations must improve their capacity to communicate, cooperate on technology transfer and information exchange, and coordinate water and environmental policies. To this end, support grew for the establishment of an *Interamerican Water Resource Network* that would focus first on water resource issues in the Western Hemisphere.

The Dialogue was an intrinsic step to the launching of this Network. Participants from 19 countries and many multi-lateral and international institutions assessed plans and priorities; review the results of an international survey of water managers, policy makers, educators, and

related user groups; and confirm the policies and structures for the operation of the Network.

Separate caucuses during the first day served as fora to discuss particular issues and positions of the diverse groups and institutions who gathered at the Dialogue. Also, the dialogue served as the setting for conducting a Non-Governmental Organization (NGO) Forum and a separate roundtable to discuss technical aspects of the San Juan River dispute between Costa Rica and Nicaragua.

The NGO Forum took place during the first day of the event. The Forum, facilitated by the Global Tomorrow Coalition and the National Audubon Society, provided a unique and valuable opportunity to continue the NGO dialogue that preceded the 1992 U.N. Conference on the Environment and Development (Rio Earth Summit), and that has continued since the Earth Summit, especially as it relates to water management and policy issues in the Western Hemisphere. NGO networking is a positive and an irreversible process that needs continuous strengthening and that is benefited from such fora as the Interamerican Dialogue on Water Management.

The Dialogue also provided an opportunity to evaluate ongoing efforts and develop new approaches to the binational management of the San Juan River Basin. Under the auspices of the North-South Center of the University of Miami, a balanced group of Nicaraguans and Costa Ricans was invited to participate in a roundtable discussion facilitated by the University of Florida's Center for Governmental Responsibility.

After extensive discussion of the facts and issues, the San Juan River roundtable participants came to several conclusions. Greatly enhanced cooperation in management of the basin was strongly supported by the group. There was recognition of the need to establish an institutional basis for such cooperation. Rather than seeking to establish new institutional structures, it was agreed that development of cooperative basin management should be pursued through the processes established for management of the Si-A-Paz agreement. To this end, the Costa Rican and Nicaraguan Parliamentary Commissions are planning a joint meeting, with part of the meeting to be held in Los Chiles, Costa Rica and part in San Carlos, Nicaragua.

The Interstate Council on Water Policy held its annual business meeting and provided a forum for presentations on water policy issues. As part of the Dialogue, ICWP organized a special session on Aquatic Ecosystem Restoration, depicting the role of different federal and state agencies in aquatic restoration efforts and projects to forge partnerships, overcoming obstacles, and reaching for the opportunities in the United States. ICWP brought a wide perspective on water issues that was extremely useful to the overall theme of establishing a *true dialogue* - an effort to outreach for new and innovative ways for establishing partnerships and exchange of information at all levels of government.

The XVIII Annual Water Management Conference in Florida, which served as the seed for the multi-faceted and international Dialogue, provided the participants an excellent opportunity for the sharing very actual water policy issues particular to Florida. For example, the issue of Permit Streamlining was a model of inter-agency cooperation that attracted the attention of many international participants. Since 1990, the Annual Water Management Conferences in Florida have attracted many international participants, due to the strategic location in reference to Latin America and the Caribbean, Florida's sub-tropical climate, and the state's unique institutional

framework comprised by the water management districts.

In preparation for the Dialogue, two case studies were commissioned to compare and contrast water resource management problems from North and South America, and to highlight and elaborate on common goals and strategies. One analogue, developed by the University of Florida's Center for Governmental Responsibility, focused on semitropical wetland systems and provided an in-depth look at the Everglades and the Pantanal. This case study compared the unique and shared characteristics of these great marshland regions, one which has been substantially altered by development and one which is facing similar pressures. A second case study, developed by Colorado State University in conjunction with the Interamerican Center for Environmental and Land Research (CIDIAT, Mérida, Venezuela), featured a comparison of water supply development projects in several cities throughout the hemisphere: Denver, (USA), Sao Paulo (Brazil), and Mérida (Venezuela). These cities, diverse in size, environmental conditions and problems, illustrate the main issues addressed in the roundtable discussions.

The case studies, while examining relevant water resource challenges, underscored the macrocosm of issues inherent in a comprehensive and integrated approach to water management. Beyond the environmental components - the water resource itself, related land issues, habitat and ecosystem concerns - the studies attempted to portray and investigate social, cultural, political, institutional and economic considerations which arc inextricably tied to water management policy and practice. As such, they served to crystallize the need for integrated and watershed-based approaches to water management throughout the hemisphere.

In addition to presenting the case studies, the Interamerican Dialogue on Water Management provided a forum for the advancement of technical and institutional knowledge and promotion of sound and sustainable water management practices throughout the western hemisphere. Over 40 papers were presented during the 4-day conference emphasizing the diversity of water resource problems and solutions, emerging problem areas, and financial resource scarcity, many papers were presented under three main roundtable tracks: 1) Management of Aquatic Ecosystems; 2) Water Supply and Sanitation Infrastructure in a Sustainable Development Context; and 3) Water Governance and Policy. The roundtables discussions, professionally facilitated with the help of process design experts, led participants to a pragmatic address of many of the theoretical concerns outlined in Agenda 21 at the Rio Earth Summit:

- Cross-comparisons of water management problems: How do we manage the alteration and use of freshwater systems without degradation or abuse?

- Institutional capacity-building: What are the principles, customs, regulations, training and education needs, laws and values that will enable people to manage water resources in ways that sustain both human needs and natural systems?

- Cross-scale threats: How do we resolve water resource problems when some have their source locally and others a half world away (e.g. global warming, threats to biodiversity, rival trading blocs, transboundary issues involving human and wildlife migrations, regional water competitions and conflicts)?

- Organizational dimension of global change: How do we organize institutionally for cooperative and participatory resource management to ensure sustainable water resources in the future in light of profound world change?

Roundtable participants were challenged to work out an agreed set of principles and priorities for an interamerican partnership that would focus on sustainable development, taking into account the basic tenets that:

- Water is a finite resource that is essential for life on earth.
- Water issues have often been the limiting factors for sustainable development.
- Water is an indispensable integrating component of natural systems management and protection.
- The availability of reasonably priced, high-quality freshwater is a fundamental building block of a competitive and healthy society.
- Water is a “linchpin” product and a renewable resource. It repays for its wise management over and over again in the sheer variety and quality of other goods and services it enhances.
- Water policy and management by their very nature are challenges of multiple use and intergovernmental relations.

Substantive discussions of issues such as these helped participants to identify priorities for the proposed Interamerican Water Resource Network, to define how it can most effectively serve the needs of water resource managers and water policy makers in a wide diversity of countries and regions, and to discuss how it will relate to non-governmental organizations as well as for-profit corporations.

The remainder of the Dialogue was composed of plenary speeches and panels by dignitaries and panelists from non-government organizations, multi-lateral financing institutions, international organizations, foreign governments, and federal, state, and local officials who presented their perspectives on the issue of water resource management, sustainable development and empowerment. Among the keynote speakers were Governor Lawton Chiles of Florida; Rodrigo Carazo, Former President of Costa Rica; Alicia Bárcena, Executive Director of the Earth Council; Thomas Lovejoy, Assistant Secretary for External Affairs of the Smithsonian Institution; Adalberto Gabaldón, Minister of Environment of Venezuela; OAS Ambassador Heraldo Muñoz from Chile; Mario De Marco Naón, President of the National Institute of Water Science and Technology of Argentina; U.S. Representative Carrie Meek of Miami, Florida; Sandra Postel, Vice-President of Research of the Worldwatch Institute; Peter A.A. Berle, President of the National Audubon Society; and Charles Goldman, a renowned limnologist from the University of California, Davis.

President Carazo offered a very interesting perspective on global justice and equity issues as they relate to the environment. Sandra Postel, of Worldwatch, spoke on the issue of water scarcity, pointing out that 40% of the world's people live in river basin shared by more than two countries. She went on to say that in Mexico City, groundwater pumping exceeds natural recharge by 50-80 percent with disastrous consequences. Postel's address highlighted once more the need to share information leading to a sustainable management of the water resource. Thomas Lovejoy spoke on the need share technical information and know-how, but in a sensible manner that would recognize cultural and social peculiarities of the different regions of the Western Hemisphere. In addition, traditional topics such as hydrological and wetlands research,

environmental impact assessments, water supply modelling, and water policy were discussed.

The culmination of everyone's effort - the Statement of Miami - was drafted from the discussions in the roundtables and shared with the audience during the final session. Read with eloquence and enthusiasm by Evan Vlachos and responded by Ambassador Heraldo Muñoz and Representative Carrie Meek, the Dialogue ended on a bright Saturday morning, with a room full of people - an audience of more than 200. The participants were given their charge: *If we are truly following the lead of the Earth Summit and wish to achieve the principles set forth in Agenda 21, we must see to it that this interamerican water resource network becomes a reality.* The Statement of Miami clarifies some of the goals of the proposed network and establishes action steps to accomplish them.

This Interamerican Water Resource Network is conceived as a consortium to facilitate the exchange of information, promotion of cooperation and training among water resource professionals and institutions between North, Central, South America and the Caribbean. Most importantly, the Network will built on existing groups and exchanges - it has been described as a *network of networks* - taking advantage of existing institutional and technological infrastructures. Under this parameters, the organizers researched existing networks and platforms to build on. One of those systems is called *TogetherNet,* which is managed and maintained by the Together Foundation for Global Unity. This non-governmental organization headed by Ella Cisneros of Venezuela, has offered a platform for a pilot network called WATERDIALOGUE. TogetherNet has a number of sites scattered throughout the United States, Venezuela, Brazil, and Switzerland. Among the strengths of this particular system is its ease of use and low cost to end users. By the time of publication of these proceedings, a prototype system will be on-line.

Without doubt, the Dialogue allowed participants from diverse latitudes to hear and understand the water problems of each other in this hemisphere. Participants have come to realize with increasing anxiety that the mistakes made and the water management decisions that now are so desperately wished have been made differently, are in danger of being repeated in other areas of the country or elsewhere in the world. In order to prevent this vicious circle, we must act promptly to make water knowledge available and accessible. The lessons, successes, and failures experienced in this sector must be in the public domain if we are to survive as a global community.

Major Conclusions and Recommendations from the Interamerican Dialogue on Water Management

At the windup of the Interamerican Dialogue on Water Management, the Policy Council convened for the second time to assess and provide their first impressions on the outcome of the meeting. Also, the Council provided directions for future activities related to the follow-up of the conference and the consolidation of an interamerican partnership named the Interamerican Water Resource Network. Details of their conclusions and recommendations are outlined below.

1. Positive Assessment of the Dialogue

Members of the Policy Council generally concurred in a highly positive assessment of the Interamerican Dialogue on Water Management, and the opportunities for future progress created

by the forum. Among the comments made in this regard were:

- a focus was maintained on the highest priorities of clean drinking water and sanitation;
- able execution of the Interamerican Dialogue opened the possibility for a network that is both “high-tech” and “high-touch”;
- the readiness on all sides to share experience and technology was encouraging;
- superior staffwork and breadth of representation were impressive;
- the Interamerican Dialogue achieved more of its stated expectations than any conference previously attended;
- the outstanding level of representation from Central and South America was a great strength;
- the NGO Forum held on the opening day made a strong contribution, and it will be valuable to keep NGO perspectives involved;
- information flowed in both directions, and it was clear that North Americans already were learning form Latin Americans;
- the round table discussions led to a greater awareness of the number of existing networks already in place;
- good organization and strength of participation reinforced high expectations for the future;
- a sense of trust and mutual respect was established as a foundation for future practical cooperation; and
- the hallmarks if the Interamerican Dialogue were communication, cooperation, and implementation.

2. <u>Criticism and Proposed Guidelines and Directions</u>

A number of Policy Council members also offered constructive criticisms of the Interamerican Dialogue, and suggested guidelines to be observed in taking the next steps. Among these were:

- there is still need for greater clarity in defining the intended *clients* of the proposed new network, and for close attention to their needs and desires in the shaping of future plans *(Note: see related addendum at end of this section for definition of clients)*;
- the Interamerican Dialogue included too many formal presentations, and did not allow enough time for informal discussions;
- to achieve the desired goal of better communication and information exchange, precision is needed in defining the levels, components, and subjects of the proposed network;

- some self-segregation was still evident at the Interamerican Dialogue among those most interested in development and those most interested in ecosystem protection;
- communication channels for the new network must include mail, telephone, fax, and personal contacts as well as computer-controlled electronic systems;
- it will be extremely important at all times to keep the needs of local people in mind;
- follow-up actions should be quick and demonstrative, emphasizing “high-touch” rather than “high-tech” processes;
- clients of the network can contribute many forms of support, and those resources should be explored before seeking major outside funding;
- the goal should always be to start building on existing networks and institutions, rather than trying to create new ones;
- the frustration in Latin America over access to information is very real, but the information is usually available - the challenge is to find ways to translate and deliver it most effectively, whenever possible working through official channels; and
- the survey of water resource professionals should continue to be used as an ongoing and expanding “inventory” of hemispheric Water resource needs.

3. Scope of Proposed Networks

One viewpoint expressed was that the proposed Interamerican Water Resource Network should immediately provide for the involvement of water resource professionals from around the world, especially from Africa and the Middle East, where water-related issues are already of acute importance. The consensus, however, was that the network must be able to “crawl before it walks,” and that it would therefore be most practical to focus first on the Western Hemisphere. Expansion toward involvement of other world areas could follow as the structures, systems, policies, services, and funding of the network became better established.

4. Opportunities for Future Review and Assessment

Among the suggestions of potential opportunities to expand communication, and enable those interested in the new network to come together and assess progress, were;

- the annual meeting of Florida Water Management Districts in the fall of 1994 in Tampa, to be hosted by the Southwest Florida Water Management District, which could include a track related to the International Water Resource Network;
- the triennial Watershed Conservation Conference planned for November 1994 in Mérida, Venezuela;
- ongoing collaborative efforts on the San Juan River project;
- the continuing translation and information services of the Economic Commission for Latin America and the Caribbean (ECLAC);
- national or regional projects such as the Plata Basin, with intergovernmental

collaboration encouraged and facilitated through the Organization of American States; and

- the upcoming Summit of the Americas, a meeting of the Heads of State from throughout the Hemisphere to be held in Miami at the end of 1994.

5. Proposal of the Together Foundation for Global Unity

A presentation was made by Ms. Ella Cisneros, Founder and President of The Together Foundation for Global Unity, and Mr. James MacIntyre, Director of The Together Foundation, for the immediate activation of a hemispheric computer-based communication system dedicated to water managers, by building on the established structures and systems of TogetherNet. TogetherNet has offices in the United States in New York, Burlington, Vermont, and Boulder, Colorado, and in Latin America in Caracas, Venezuela, with prospects for new communication centers opening soon elsewhere in Latin America. Sources of funding include not only the contributions of the Cisneros family but financial and in-kind donations from Apple Computers, Motorola, Bell South, Pepsi-Cola, and others, as well as modest monthly fees received from users.

This computer network could begin immediately to help meet the needs of information-sharing on water resource issues, while other aspects of the International Water Resource Network (named WATERDIALOGUE) are being developed. Access for users in low-income areas, especially in Latin America, would be encouraged through free hook-ups for up to a total of 30 subscribers initially.

6. Actions by the Policy Council

After discussion, the Policy Council unanimously agreed:

1. To extend the life of the Policy Council as the focal point for next steps in follow-up to the Interamerican Dialogue on Water Management, inviting all current members to continue to serve, with the understanding that broadened participation will be encouraged as efforts progress;

2. To meet again at a date to be specified within roughly six months, probably in March/April 1994, and at a site to be specified, probably in Washington, DC, or Miami Florida, USA;

3. To accept the generous undertaking by Mr. Tilford C. Creel on behalf of the South Florida Water Management District that the District will continue to serve as a point of coordination and staff support for the ongoing work of the Policy Council for approximately six months, through the next meeting of the Policy Council; and

4. To accept the forthcoming and constructive proposal of The Together Foundation for the launching of the pilot network system as an immediate next step.

The Policy Council moved by acclamation to commend the South Florida Water Management District for its outstanding leadership in initiating the Interamerican Dialogue on Water Management, and requested that Mr. Donald R. Lesh of the Global Tomorrow Coalition prepare and send a letter on behalf of the Policy Council to Mr. Creel, the members of the Governing Board of the District, and Governor Lawton Chiles expressing gratitude and appreciation.

Several members of the Policy Council also urged that the Global Tomorrow Coalition continue its valuable organizational and convening functions during the next phase. Mr. Lesh confirmed that the GTC would very much look forward to doing so, but would be dependent on the availability of funding.

Addendum

With reference to the definition of the *"clients"* of the proposed International Water Resource Network, the agreement of the Policy Council, in its first meeting on May 14-15, 1993, in Miami, Florida, was summarized in this way:

3. Definitions of Clients

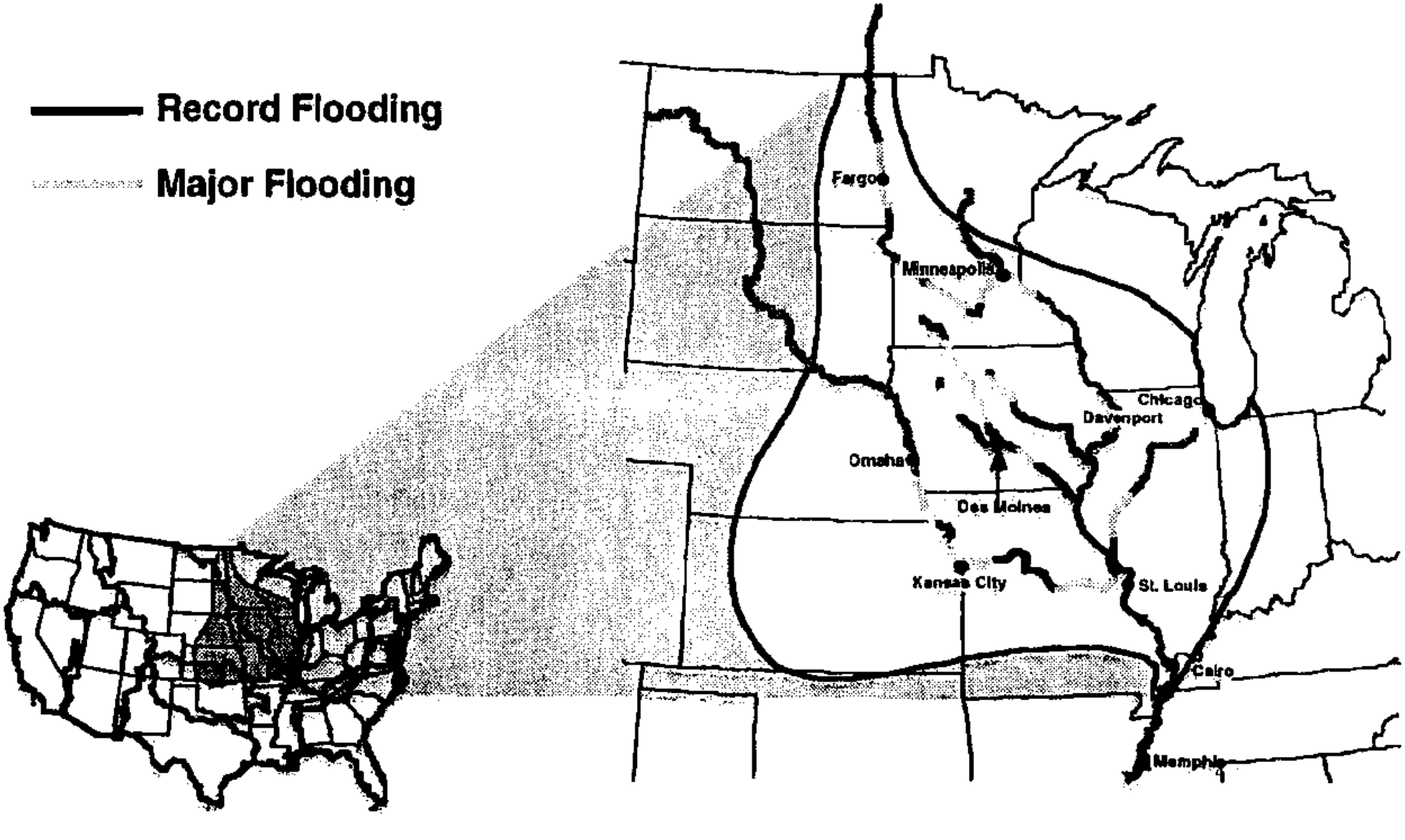
To provide focus for the Network, its, *"clients"* should be understood as water management practitioners, specified in Mr. Henry J. Hatch's formulation as follows:

> *The principal client base is the array of public and private entities who influence water resource development - to include use, regulation, protection, and conservation. Those entities would include the research, technical, and managerial support base that plans, designs, executes, and operates water resource related activities, as well as the public and private decision makers whose decisions impact on the water aspects of sustainable development.*

By this definition, the clients - existing networks, national ministries and agencies, regional/state/local management authorities, and other private institutions - are the principal beneficiaries or users of the services of the Network. Among other valuable resources of the Network will be the continuing input of universities and research institutions, nongovernmental organizations, regional and international authorities (Organization of American States, United Nations agencies, etc.), and other stakeholders with important interests in water-related issues.

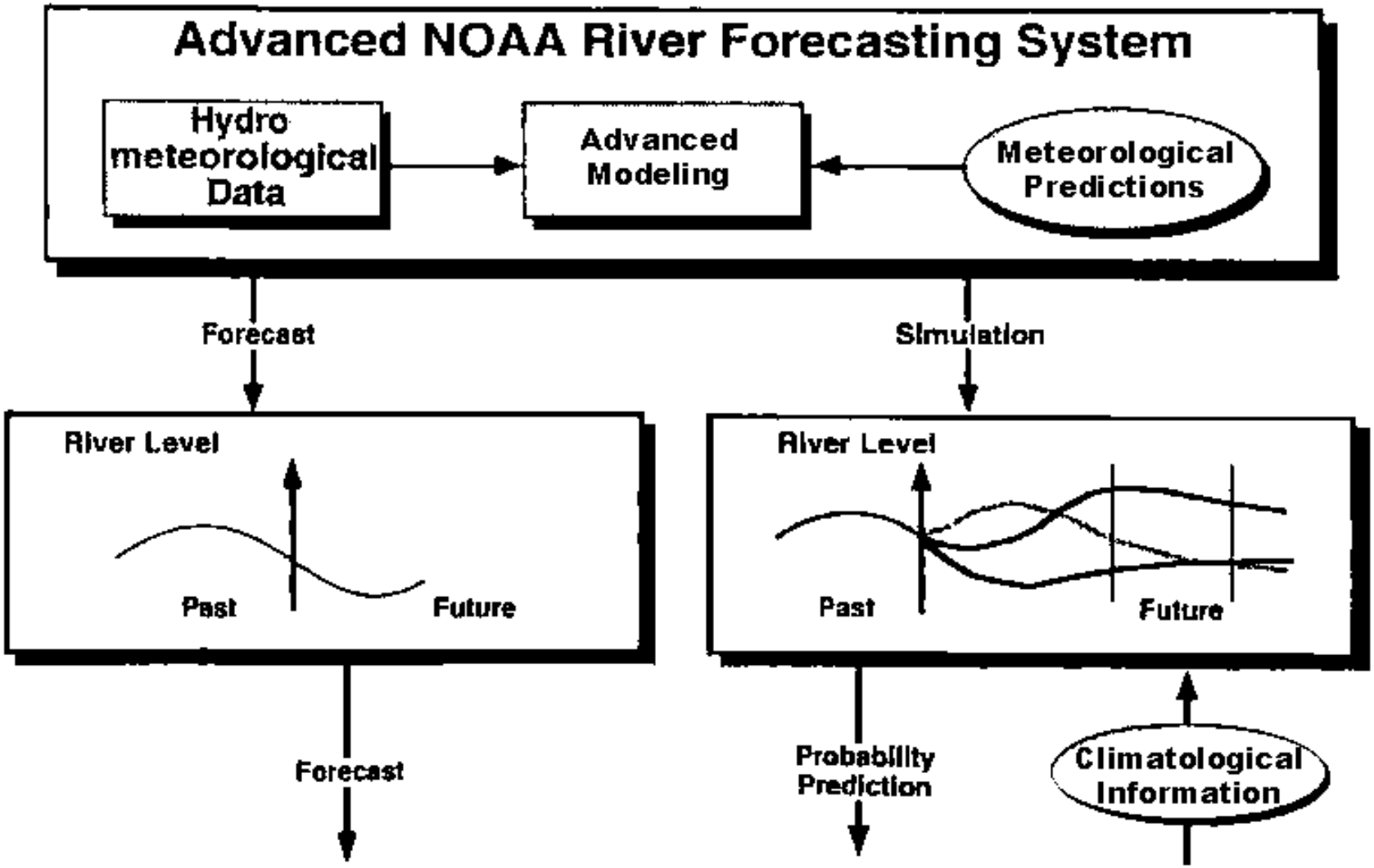
Department of Commerce / NOAA
National Weather Service / Office of Hydrology

General Area Impacted by Flooding



Department of Commerce / NOAA
National Weather Service / Office of Hydrology

Water Resources Forecasting System



Roundtable I - Management of Aquatic Ecosystems

Co-Chairs

Joseph B. Browder, Partner, Dunlap & Browder, Inc., Washington, D.C., USA

Dr. Emiko Kawakami de Resende, Secretary of the Environment, State of Mato Grosso do Sul, Brazil

Moderators

Sub-Track: **Environmental Problems and Assessment**

Dr. Thomas Lodge, Principal Environmental Scientist, Law Environmental, Inc., Fort Lauderdale, Florida, USA

Miguel Monserrat, National Director of Water Pollution Control, Water and Environment Advisor, Secretary of the Presidency, Argentina

Sub-Track: **Protection and Restoration Strategies**

John Kusler, Executive Director, Association of State Wetlands Manager, Berne, New York, USA

Dr. Gonzalo Castro, Executive Director, Wetlands for the Americas, Manomet, Massachusetts, USA

Coordinator

Dr. Jorge A. Marban, Senior Professional, Department of Planning, South Florida Water Management District, West Palm Beach, Florida, USA

Background Papers

Management of Aquatic Ecosystems, by Joseph Browder, Dunlap and Browder, Washington, DC, USA

The Environmental Conditions in Latin America - A Brief Overview, by Jaime Incer,

Minister of Environment and Natural Resources, Managua, Nicaragua

Papers and Authors

Sub-Track: **Environmental Problems and Assessment**

1. *Nutrient and Sediment Retention in Andrew Raised-Field Agriculture,* by **Heath J. Carney, Ph.D.,** Research Associate, Division of Environmental Studies, University of California, USA

2. *Environmental Assessment and Restoration Planning for Sensitive Coastal Resources in Isla Vieques, Puerto Rico,* by **Gerard A. Gallagher, III,** Geographer, Assistant Regional Manager, ecology & environment, inc., Tallahassee, Florida *USA*

3. *Adaptively Assessing and Communicating Complex Resources Issues,* by **Lance G. Gunderson,** Department of Zoology, University of Florida, USA

4. *Environmentally Compatible Watershed Management in Venezuela,* by **Freddy Hermoso,** General Director, National Service of Basin Conservation, Ministry of the Environment and Renewable Natural Resources, Venezuela

5. *Lake Chapala and Rio Blanco: Two Cases of Environmental Problems in Western México,* by **Fernando Montes de Oca,** Executive Director, Fundacion Chapala, Guadalajara, México

6. *Environmental Sustainability and the Role of Stewardship,* by **D. W. Moody** and **E. T. Smith,** U.S. Geological Survey, Reston, Virginia, USA

7. *Washington State Marine Waters Environmental Program: A Practical Use of Environmental Assessment Science,* by **Maria Victoria Peeler,** Supervisor, Permit Coordination Unit, Department of Ecology, State of Washington-Environmental Review and Sediment Management Section, Olympia, Washington, USA

8. *Aquatic Weed Control in the Yarinacocha Pucallpa Lagoon,* by **Olga Rios Del Aguila,** Regional Agricultural Director, Pucallpa, Ucayali, Perú

Sub-Track: **Protection and Restoration Strategies**

9. *The Role of Non-Governmental Organizations in Environmental Assessment in the Pantanal Region,* by **Joaquim Rondon Rocha Azevedo,** Executive Director, Sociedade de Defesa do Pantanal (SODEPAN), Campo Grande, MS, Brazil

10. *Conserving Aquatic Ecosystems for Sustainable Development,* by **Gonzalo Castro,** Executive Director, Wetlands for the Americas, Manomet, Massachussetts, USA

11. *Management of Aquatic Ecosystems - The Pantanal Case,* by **Agostinho Carlos Catella,** Researcher, Empresa Brasileira de Pesquisa Agropecuária - Centro de Pesquisa Agropecuária do Pantanal (EMBRAPA/CPAP), Corumbá, MS, Brazil

12. *The Everglades Nutrient Removal Project,* by **Mariano Guardo,** Senior Civil Engineer, Research-Everglades System Research Division, SFWMD, West Palm Beach, Florida, USA

13. *Lessons Learned from Five Decades of Wetlands Restoration and Creation in North America,* by **Robin Lewis,** President, Lewis Environmental Services, Inc., Tampa, Florida, USA

14. *The Role of Wetland Filters in Ecosystem Restoration,* by **David L. Stites,** Supervising Environmental Specialist, St. Johns River Water Management District, Palatka, Florida, USA

15. *Development of the Kissimmee River Restoration Plan: Lessons Learned and Recommendations for Comprehensive Restoration Projects,* by **Louis A. Toth,** Senior Environmental Scientist, Division of Kissimmee & Okeechobee Systems Research, South Florida Water Management District, West Palm Beach, Florida, USA

Background Paper: Management of Aquatic Ecosystems

Joseph B. Browder[1]

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A Background Paper prepared for discussion in the Roundtable I: Management of Aquatic Ecosystems

Water brings us together as neighbors, cultures and communities on Earth, and binds us to the rest of nature. Conflicts about water divide us, and lead us to degrade nature and ourselves.

This gathering presents us with a challenge: to search for ways to help each other reconcile the management of water for human health and commerce with the management of water for the protection of nature. We do so out of respect for the diversity and mystery of the natural wold, and from the certain knowledge that nature and humankind inevitably bear the wounds of each other's neglect.

The urgency of this reconciliation stems from immediate public health, water supply and economic development needs in much of the world, and from our increased understanding that even small changes in the water regimes of natural systems can cause profound and costly damage, to nature and to society.

Today's resource management decisions are more complicated because water, as an asset that flows through the global economy, is now subject to more sophisticated social and political inputs. For decades, the world-wide reach of capital and engineering have changed little-known mountain streams on small tropical islands, and re-made some of the Earth's largest rivers and estuaries. Now, local environmental protection campaigns, integrated with local economic and cultural interests, are capable of global outreach to change the plans of capital and engineering. Only recently have scientists and citizens throughout much of the world developed communications to link local critics of resource development projects with international groups able to influence the financing and design of water projects and other major infrastructure development and resource management programs. As a result, local interests that have felt disenfranchised from decisions about water resources now enjoy opportunities to use global resources to achieve more political influence in their own communities.

Major changes in a natural water regime often redistribute economic benefits away from those local communities which, however imperfectly when measured against the ambitions of regional

or national enterprises, have accommodated to the natural system. For example, local fishing communities economically damaged by water management programs that increase benefits to other enterprises richer in both political and financial capital are, in isolation, sometimes treated as marginal assets, to be written off in the search for higher yielding activities. But today the concept of the global village is becoming reality. When the integrity of a specific local economy can be linked to the integrity of a natural system, formerly marginalized interests can establish influential global relations with scientists, non-governmental organizations, multi-lateral agencies, and other institutions capable of modifying or even halting proposed water resource projects and other development programs.

For many local interests, the advocacy of environmental responsibility has thus become an instrument for more general participation in politics. Where people feel stronger kinship in defense of a forest or river than in yielding to the advice of a province or state, when government response may seem less meaningful than the responsiveness of peoples from different cultures who share similar interests in the protection of nature, a new political economy is evolving. In a world where our nation-states are learning to live with the benefits and difficulties of multi-national investments and multi-lateral organizations, we should not be surprised at the emergency of global citizens.

For the professional women and men who, from every perspective, seek to understand and better administer our relations with natural resources, this challenging new policy environment offers great opportunity. Much conflict about water resources development is based on concern about nature, but also relates to the needs of people. Productive, sustainable local social and economic activities based on less capital intensive use of natural resources are sometimes incorrectly dismissed as without value in a national balance sheet. We frequently look at today's needs and limitations, and rationalize natural resources damage that will cause lost opportunity and higher costs for our children. Yet those whose principle interest is the preservation of natural systems are equally capable of marginalizing and rationalizing. Agony and disease caused by contaminated community water supplies, loss of soils, water and wildlife to destructive farming methods that appear to be the only economy for many, rural peoples, and cities throughout the world without the social structure to provide water, sanitation, shelter and food to millions of men, women and children, represent environmental crises as real as the threatened loss of a species or an ecosystem.

Precisely because more people can speak and be heard, more of us can learn, from each other and from the world outside our professional circles. It has become pointless to think of protecting the Earth's great resources without planning to deal with the demands of human settlement and economic development. It is equally futile to think of using water, or any other natural resource, without planning to protect the ability of ecosystems and biological resources to renew and sustain themselves.

This does not mean there will be no winners and losers. Resources of great economic value will remain undeveloped, to preserve unique and irreplaceable wild places and creatures, or will be less than fully exploited in order to protect the interests of local communities. In other cases, species, biological communities and human cultures will be lost forever to satisfy economic demands. But we are capable of making even those choices with greater wisdom, and are more capable of finding ways to keep humanity living in a living Earth. When water resource managers learn enough about the social and economic values of natural systems, science and engineering

will better reveal to us the opportunities for meeting human needs while protecting nature.

When defenders of nature learn enough about the ways in which water flows through our economy, environmental science and engineering will participate more effectively in decisions that, in the end, are made by economically organized human societies.

If this mutual understanding is accompanied by commitment to respect the legitimacy and urgency of both missions, we can, in ways small and large, personal and institutional, help discover the real meaning of sustainable development, for our human communities and for the natural world that nourishes us all.

Background Paper: The Environmental Conditions in Latin America - A Brief Overview

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A Background Paper prepared for discussion in the Roundtable I: Management of Aquatic Ecosystems

The intensive use of the natural resources in Latin America has resulted in an undesirable transformation of the aquatic ecosystems in the region. It can be said that this transformation started when the early civilizations started using fire, plants, and animals for their preservation and survival. The impact on the environment became more severe with the advent of the Industrial Revolution and the intensification of agricultural production.

It is important to point out that the abuse of the natural resources is not a natural consequence of the human process, but rather a consequence of the models of economic growth, poorly chosen in the past, which have not taken into consideration the concept of ecological sustainability.

There are a number of issues that contribute to the reduction of natural resources in the hemisphere. The most significant ones are:

- Intensive use of the land
- Environmental impact of human settlements
- Utilization of fresh water and coastal resources
- Continuous deforestation
- Exploitation of mineral resources
- Increasing need for energy related
- Industrial development
- Lost of biodiversity

Intensive Use of Land: This is a very serious problem throughout Latin America. The intensive use of land in many areas has produced a high degree of erosion, salinization and alkalinization of soils and decertification. Erosion has reduced the amount of usable land by 30% in Central America and 10% in South America. About 70% of the productive arid lands in South America and Mexico have been through some type of decertification. Latin America has between 693 and

736 million of hectares of potentially cultivated lands.

Environmental Impact of Human Settlements: The majority of the Latin American nations have urbanized quite rapidly during the last half of the century.

The main problems caused by the rapid urbanization of major cities in Latin American such as Rio de Janeiro, Buenos Aires, Quito, Mexico City, Guayaquil, Managua, Guatemala City, Tegucigalpa, La Paz, Medellin and others have caused domestic and industrial contamination of lakes, rivers and coastal environments which have affected public health and sanitation.

Utilization of Fresh Water and Coastal Resources: The contamination of aquatic ecosystems throughout Latin America has significantly reduced the value of natural resources throughout this hemisphere. Important resources such as Lake Amatitlan (Guatemala), Lake Ilopango (El Salvador), Lake Managua (Nicaragua), Yohoa Reservoir (Honduras), Panama Bay (Panama), Lake Valencia (Venezuela), Rio La Plata (Argentina), Habana Bay (Cuba), Bluefield Bay (Nicaragua), Tarcoles River (Costa Rica), Choluteca River (Honduras), Amazonas and Orinoco River, and San Juan River (Nicaragua), among others, have been impacted by the industrial, agricultural and urban development.

Latin America can potentially produce 22% of the world hydroelectric energy but only 22% of the energy consumed in Latin America is of hydroelectric origin. There are several major waterways that contribute to economic development in Latin America but it also represents a threat to the natural resources of the region. The Amazonas River, the Parana and La Plata Rivers and the Apure/Orinoco system are important elements of the economy of South America. The planning and management of the water resources should be a basic activity in the promotion of sustainable development in the region.

Continuous Deforestation: The problem of deforestation in Latin America is very serious. It is estimated that deforestation have been responsible for 40% of the CO_2 emissions in the region. Brazil (20%), Columbia 7%, Peru and Ecuador (3%), and Mexico (2%) are the most impacted countries in the region.

The burning of tropical forests have serious ecological consequences both at the local, regional and global scale. In Latin America 80 million people use firewood for cooking purposes with an annual per capita consumption of 350 to 370 kilograms. This implies a significant degree of deforestation.

Other ecological consequences attributed to deforestation are high use of biomass, increased soil erosion, lack of groundwater recharge, atmospheric contamination and global warming.

Exploitation of Mineral Resources: The mineral extraction in Latin America is very intensive and is closely associated with some of the environmental problems in the region, particularly air and water contamination and destruction of habitats adjacent to the mines and processing plants. Lack of treatment of the effluents that are discharged from the mineral processing plants results in water contamination of chemical deviating of sulfur. A typical case of degradation occurs in the Amazon jungle with the exploitation of gold and diamonds which contribute significant concentrations of mercury to the rivers of the region. A similar situation exists in the jungles of the Orinoco region. The countries more affected are those near the Andes Mountains such as Chile and Peru. Among the rivers more affected by mineral activities are the Mantaro

and Rimac rivers of Peru and the Mico River of Nicaragua.

Increasing Use of Energy Related Resources: The production transfer and use of energy have produced negative and positive effects in the quality of life in Latin America The principal environmental impacts due to energy production and use in Latin America are: extension of valuable tropical ecosystems, air and water contamination related with transport of energy related products such as petroleum, sedimentation and erosion of river basins, thermal contamination of water, increased deforestation due to the use of firewood and local climate changes. The most important sources were petroleum and natural gas (17.1%), hydroelectric energy (13.6%) and biomass (12.4%). Others in minor scale are coal, geothermic energy and nuclear energy.

Past experiences have shown that the reservoirs required for energy production have produced ecological changes that should be taken in consideration in future development of hydroelectric projects. The use of non-conventional systems such as biomass, wind and solar energy is very limited and should be expanded. Energy conservation efforts should be promoted.

Industrial Development: Industrial development as well as the use of mineral and energy related resources have provided significant impact to the environment particularly to the aquatic ecosystems. Chemical contamination of lakes, rivers, estuaries, and wetlands prevails in most countries of Latin America and Caribbean islands.

The main industries that have contributed to water and air pollution are the food, chemical and health industries, and petroleum and gas refineries. Air pollution caused by industrial plants and the transportation industry have produced significant health problems in many important cities of the region such as Mexico, Rio de Janeiro and many others.

It is estimated that in Latin America 41,000 tons of toxic residues are produced every day without adequate treatment facilities. These products are responsible for numerous diseases and deaths.

In the cotton region of Central America, the extensive use of insecticides has reached 80 kilograms per hectare. Frequently, the products employed as herbicides, insecticides and pesticides have been prohibited in the developed countries. About 75% of these products have been prohibited in the United States of America. During 1986 and 1987, 27% of the deaths in El Salvador were caused by intoxication from pesticides. According to a Greenpeace report, more than 2000 kilograms of products prohibited in the United States arrived in Central America every day. In the industrial city of Cubato in Brazil, 40 of every 1000 children were born dead in 1980 and 40 others were deformed due to severe industrial waste and pollution.

These are opportunities for industries in the Latin American region to become more environmentally aware, by using environmentally acceptable materials, developing pollution free processes, cleaning gas and liquid effluents prior to discharging to the receiving bodies, and by the use of recycling whenever is feasible. All these measures can be done in an economically efficient basis.

The lack of government controls and environmental policies related to industrial development have contributed to a status quo contrary to the principles of sustainable development.

Lost of Biodiversity: The lost of biodiversity due to the effects of unsustainable development has increased significantly in recent years.

Latin America accounts for 90,000 of the 250,000 species of tropical plants in the world. Some of these species are used for medical purposes (10%), for industrial purposes (10%), and for food (15%). In general more than 31,000 species are usable.

Recent projections indicate that 10% or more of the plant species will be extinguished by the year 2000 in the tropical jungles of Latin America.

The fauna of the region, in addition to be very diversified, present opportunities for economic development. Species such as the guano producing seabirds of Chile and Peru, the Vicuna of the Andes region, the Guanaco of Chile and Argentina, the alligator and capybara of the Amazon, Orinoco and Pantanal regions have great economic potential.

The rehabilitation of the impacted ecosystems will benefit the biodiversity of the region and well increase the productions of wood and food related products strategy for sustainable development in Latin America.

The historic role of the region as supplies of materials and resources required to keep high standard of living in the developed nations resulted in overexploitation of the natural resources, thus causing significant degradation of the environment throughout Latin America. Natural resources are depleted or extinguished before they can be regenerated.

The principal factors contributing to the crisis are:

- The disorderly growth of the nations in the region
- The lack of scientific and technical capabilities
- The political and economical instability whatever development strategy is formulated in the future it will need to consider the protection and sustainability of the natural resources of the region. The formulation of aggressive policies of protection of environmentally sensitive areas similar to the one used in national parks, ecological refuges and sanctuaries needs to be considered as priority in order preserve biodiversity in the region.

A series of socio-economic principles needs to be followed in order to promote sustainable development in the region. It is important that a solidarity between society and government be established with multiple participation of non governmental organizations and other interest groups.

It is important to promote:

- The sustainable use of natural resource in each county
- The use of appropriate technology
- A more efficient use of energy
- Development of products that satisfy the basic needs of the population

It is imperative that agriculture and industry embrace goals for the improvement of quality of life through specialization, efficiency and productivity. At the same time, it is necessary to reduce production costs in industry and agriculture through the use of more efficient technology, to give

special consideration to energy saving technologies, and to promote recycling and re-use of materials and products.

Government and conscious citizens in Latin America must avoid the use of technologies and products banned in developed countries.

The international collaboration in the achievement of sustainable development in Latin America not only can reduce potential tension, but can contribute to a new era of progress in a global scale, that will allow for a superior quality of life. This collaboration will tighten the ties between the north and south nations in a common effort to promote sustainable development and ecological integrity in this hemisphere. This challenge must be met in order to preserve the survival of the human and natural resources in the planet.

Sub-track: Environmental Problems and Assessment

Nutrient and Sediment Retention in Andean Raised-Field Agriculture

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Note of the Editor: At the time of the publication of these proceedings, only the abstract of the presentation was available. Further details or the complete paper may be available by contacting the author at the specified address.

ABSTRACT

Raised-field agriculture was widespread throughout Central and South America in prehispanic times. In this system of agriculture, crops are cultivated on a series of raised beds, which are separated from one another by large and deep water-filled canals. In some regions, rehabilitation of raised fields is now underway. In some cases, it is expanding rapidly because of substantially higher yields. These are due largely to fertile soils, adequate water supply, and protection from frost. As part of a MAB/UNESCO program, we have been studying nutrient and sediment dynamics and retention along transects which include raised fields and canals in the vicinity of Tiwanaku, on the Bolivian side of the Lake Titicaca basin. We have found that high concentrations of nitrate, available phosphorus and turbidity in water decline dramatically as it flows through canals between raised fields. Retention of these nutrients and suspended sediments in canals help maintain soil fertility and reduces pollution of downstream waters and wetlands. Thus there are environmental benefits in the expanding rehabilitation of raised-field agriculture which complements and help sustain the previously demonstrated economic benefits. This appears applicable to a broad range of environments in the Western Hemisphere and other pans of the world.

Environmental Assessment and Restoration Planning for Sensitive Coastal Resources in Isla Vieques, Puerto Rico

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Note of the Editor: At the time of the publication of these proceedings, only the abstract of the presentation was available. Further details or the complete paper may be available by contacting the author at the specified address.

ABSTRACT

Vieques is an island located approximately seven miles east of Puerto Rico in the Caribbean Sea. Of the island's total 33,000 acres, approximately 23,000 acres are owned and used by the United States Navy for conducting training exercises and storing ammunition. The remainder of the island is privately owned. Prior to Navy land acquisition on Vieques in 1943, the island was largely deforested and used for sugar cane and pasture. Over the past 50 years, large areas of Navy-owned lands on Vieques have remained undeveloped and in various stages of reforestation. Remote locations and restricted access of lands under Navy stewardship have afforded an opportunity to preserve significant and highly sensitive natural resources that include extensive mangrove forest, bioluminescent bays, tidal fed and freshwater lagoons, turtle beaches, near shore coral reefs and reef fish associations, sea grass beds, and threatened/endangered species.

In conjunction with a broad-scope environmental assessment of the island, land and watershed management planning activities were conducted that targeted important coastal areas in need of restoration and protection while considering island resident population economic concerns and Navy mission requirements. For approximately 45 drainage basins, detailed analyses were

conducted to assess the condition of upland areas, drainages and coastal features. Of particular concern was the accelerated erosion/sedimentation brought on by cattle grazing lease activities, unimproved roads, altered drainages, periodic military training activities, and the resulting adverse impacts imposed upon sensitive coastal resources.

In addition to the above, remnants of several unimproved coastal roads were blocking the ephemeral lagoon openings to the sea, thus eliminating natural tidal flushing of the system. In several locations, mangrove forests were in rapid decline due to increased upland sediment deposition, physical damage by cattle, and hypersalinity brought on by blocked tidal connections.

To assist the Navy's efforts to restore and protect the unique natural resources of Vieques, erosion control and land use management plans were developed and implemented. These plans included improved cattle grazing lease management measures, road improvements, drainage improvements, lagoon tidal access improvements, and establishment of limited-access conservation areas and buffer zones.

Adaptively Assessing and Communicating Complex Resources Issues

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Note of the Editor: At the time of the publication of these proceedings, only the abstract of the presentation was available. Further details or the complete paper may be available by contacting the author at the specified address.

ABSTRACT

The techniques and practice of adaptive environmental assessment and management (AEAM) as developed by Holling (1978) and Walters (1985) have been applied to resource issues around the world for over two decades. The AEAM approach focuses on uncertainties of resource issues through the identification of key gaps in understanding and knowledge. Computer models provide one means of communication among a diverse set of scientists, engineers, and resource practitioners involved in complex resource issues. Recent advances in computer hardware and software have led to dramatic improvements in visualization techniques. Computer animations of space-time dynamics of key ecosystem functions allows for rapid communication of large amounts of complex information in widely available formats. Computer modelling is limited by scaling issues and the various trade-offs involved with model construction. The AEAM approach has been successfully used to synthesize and integrate information for the Everglades ecosystem, as part of ongoing restoration efforts.

Environmentally Compatible Watershed Management in Venezuela: The Rio Tocuyo Case

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Note of the Editor: At the time of the publication of these proceedings, only the abstract of the presentation was available. Further details or the complete paper in Spanish is available by contacting the authors at the specified address.

ABSTRACT

In Venezuela, most of the major cities are located in northern central coastal corridor. This area contains only 15% of the total water resources in the country and 70% of its population. Clearly, this situation stimulates water use conflicts between the urban and agricultural sectors. Also, there is a progressive decay of water quality and quantity due to unfit management of the land resources near streams and lakes, thus accelerating the erosion and sedimentation processes. In addition, there is an increasing discharge of pesticides, insecticides and other industrial and organic residuals in the water bodies of the region.

In lieu of this situation, it is necessary to take an integrated approach in the management of watersheds in an environmentally compatible national program. The community participation is an integral part of the basin under study. The Venezuelan government, taking into consideration a technical basis for the design of the watershed conservation projects, has taken a sequence of steps to guarantee a sustainable way of promoting a sound basin conservation methodology. A few steps taken include:

- the establishment of the National Autonomous Service of Watershed and Land Conservation under the auspices of the Ministry of Environment and Renewable Natural Resources;
- the development of a methodological approach for integrated watershed planning;
- the implementation of funding mechanisms for adequate watershed management, such as water concession fees, impact fees, and multi-lateral financing.

The Rio Tocuyo case in western Venezuela illustrates the outcome of this integrated effort. It contains a demonstration value based on a scientific basis that would yield appropriate economic development levels while protecting the very same land and water necessary for sustaining life in that watershed.

Lake Chapala and Rio Blanco: Two Case of Environmental Restoration in Western México

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Note of the Editor: At the time of the publication of these proceedings, only the abstract of the presentation was available. Further details or the complete paper may be available by contacting the author at the specified address.

ABSTRACT

Lake Chapala, located in western México, is the largest natural reservoir in México, second in altitude in the American continent, and third in size in Latin America. It is also the main source of water supply for a population of 300,000 in Guadalajara. México is divided in 37 hydrological regions, and the Lerma-Chapala-Santiago basin, with 32,500 square kilometers, houses one of every eleven mexicans, and irrigates one eighth of the total agricultural land of the country. Also, this basin contains a third of the industrial infrastructure and 9% of large dams of México.

The most imminent problems of Lake Chapala are water quantity and quality, lack of efficiency in water use, and water hyacinth infestation on 200 of a total surface of 1,200 square kilometers. This study depicts the restoration efforts made at national, state, municipal, and private level in order to restore and perform integrated watershed management in this hydrological unit.

The Rio Blanco Hydrological Basin, located in the municipality of Zapopao, Jalisco, includes 7200 hectares of urban area of Metropolitan Guadalajara and some 8500 hectares of agricultural uses, and the three small dams of La Peñita.

A joint commission of municipal authorities, environmental organizations and citizens groups have developed an integrated management plan for those water bodies and their corresponding basins. Natural and international funds have been sought in order to implement the plans and guarantee the ecological survival of those areas.

The restoration of the Rio Blanco will protect the few natural resources left in the valley of Atemajac and will promote ecotourism in the region.

Environmental Sustainability and the Role of Stewardship

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The concepts of sustainability and stewardship are receiving much attention in the environmental and renewable natural resources literature and in the media. Biodiversity, ecosystem management, watershed management, and sustainability, as applied to renewable natural resources, ecosystems and society in general, are terms that have entered the vocabularies of policymakers, elected officials, and the public. In doing so, these terms have lost some of their precision and meaning (Viederman, 1993) and in the worst cases, they have become buzz words. In fact, different groups - environmentalists, resource managers, economists, and so on - use these words to mean different things, leading to false expectations and misunderstandings between these groups.

Definition of Sustainability

The meaning of sustainability has been and continues to be the subject of much debate. As many as 60 different definitions of sustainability have appeared in the recent literature (Cross, 1992). The traditional notion of sustainability in resource management has generally meant the production of a renewable commodity resource at a rate equal to or greater than its rate of use or harvest. This is the concept of sustained-yield management, as successfully practiced in forestry and agriculture.

In its 1987 report, “Our Common Future,” commonly referred to as the Brundtland Commission report, the United Nations Commission on Environment and Development defined sustainable development as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs (United Nations, 1987).” Economists, on the other hand, have proposed that sustainable development involves “maximizing the net benefits of economic development, subject to maintaining the services and quality of natural resources over time (Cross, 1992).” The quality of resources, in this context, is the use of renewable resources at a rate that is equal to or less than the rate at which they can be regenerated. Thus, the concept of sustainability can be treated either as an ethical question of what is right or as an economic question. As with most issues, there is a middle ground.

At one time the concept of sustainability was not much more than a poorly defined index of concern about environmental ills. However, this concept may be moving toward more concrete definition. For example, work is now underway on how to expand the national income and product accounts to include measures of nonrenewable resource consumption and related environmental impacts. However, important questions remain:

- Is it really necessary to assign monetary values to everything in the accounts? How can this be done?
- Why is there only one accounting system, and what imperfections does its use engender?
- If we do not carry out such monetization, how can the concept of sustainability be included in national and international planning?

The problem is made more intractable by many uncertainties in the information. We are unsure about the size of potentially recoverable stocks of key resources. It is not certain whether technology for recovering materials will continue to have its historic success. Also, we do not know if technology will continue to find effective and less costly substitutes for scarce materials. We are uncertain about levels of depletion beyond which supposedly renewable resources - forests, fisheries, soils, and perhaps even entire ecosystems - may fail to renew themselves. In an overall sense, we simply do not know to what extent our own and the natural world's capacity for resilience and adaptation can withstand the severe rates of change caused by human actions, especially those actions that employ the technologies of the developed nations.

Each of these uncertainties has a range of possible estimates which leads to impacts that extend from trivial to overwhelming in their implications. Furthermore, if one considers a conceptual model in which many of these estimates are inputs to the system, the combined uncertainties can become so great as to defeat any reasonable estimation process.

Because environmental and natural resource variables are defined as “external diseconomies,” values to represent them are very hard to assign when compared to the well known stocks and flows of economic goods that are now in the national accounts. Our present analytical capabilities limit us to a few methods of analysis. We can use a scenario approach, in which several plausible alternatives are analyzed, each one using different values of environmental variables. The strength of such an approach is the consistency of the picture created by the scenario; it is unlikely that variables will take on values radically inconsistent with the entire picture. Scenarios have the weakness that none of them is a predictor of future conditions; they

only represent the results of certain “what if” conditions carried to their logical conclusion.

At present we cannot quantitatively define a permanent state of sustainability. We can, however, make repeated estimates of outcomes based on the playing out alternative scenarios, and attempt to correct our course through time as the future becomes the present.

Ecosystem management approach

Like sustainability, ecosystem management has a variety of meanings. The traditional sustained-yield approach to resource management focused attention on maximizing production constraints imposed by the resource base of soil and water, other uses of the land and water, or environmental issues. Resource managers have given little attention to the other non-commodity products and environmental services provided by the ecosystem.

In contrast, ecosystem management is an ecologically-based approach to the management of natural resources. It makes use of the understanding gained by ecology and related disciplines to make management decisions. It includes the development and implementation of management strategies to maintain the health and productivity of an entire ecosystem or set of ecosystems over long periods of time. By definition, the ecosystem includes humans and their activities. The health of the ecosystem may be measured by its biodiversity, changes in habitat, and productivity. Most importantly, ecosystem management recognizes, and explicitly considers as part of the management strategy, the link between land uses and water resources. The products and services of the ecosystem, upon which the welfare of society depends, are viewed as the outputs of a sustainable ecosystem.

An example of the linkage between human economic welfare and biodiversity is provided by the salmon fisheries of the Pacific Northwest (Nehlsen and others, 1992). The value of these fisheries may be on the order of $1 billion per year in personal income and more than 60,000 jobs. Recent surveys of salmon stocks have revealed 214 stocks at either high risk or moderate risk of extinction or of special concern. Ninety percent of these stocks of salmon are affected by habitat damage from hydropower development, logging, mining, agriculture, and urbanization. Impassable dams, which blocked of upstream spawning grounds and habitat, have led to the extinction of 106 stocks.

The Pacific salmon fisheries cannot be managed on the basis of an individual species. The health of the salmon are too closely tied to the health and condition of entire river basins. Managers and the public must see the fisheries as a component of land and water ecosystems whose health and productivity are tied directly to the productivity of a larger watershed system.

Nehlsen and others (1992), propose that an approach that views ecosystems at a landscape scale and emphasizes conserving the biological diversity of ecosystems, rather than a single species alone, will benefit all animal and plant communities in the system. By looking at the system as a whole, “weak links” and their causes may be found and repaired. To do this the scientific understanding of how large ecosystems function must be improved. Most research has focused on commodity-based resource management systems with little attention given to the sustainability of natural systems whose goods and services lack a market value. An exception is the Ecological Society of America's Sustainable Biosphere Initiative (Lubchenco, 1991), which is aimed at directing ecological research to three major areas: global change, biological diversity, and sustainable ecological systems.

A middle ground between ecologically- and economically-based approaches to resource management has been suggested which is termed eco-development. Managers and planners who apply eco-development (ecologic/economic development) design and organize human activities to allow ecosystems to continue to produce the products and services on which humans depend. In this paradigm, human activities are seen as part of ecological system, and economic and social concerns are considered part of a larger system, rather than as separate and distinct issues.

In August of 1992, the Renewable Natural Resources Foundation (RNRF) sponsored a Congress on Renewable Natural Resource Issues in the 21st Century (Morrisette, 1992). High on the list of issues, for this Congress, was obtaining consensus on the meaning of sustainability and its operational implementation by resource managers, many of whom were trained in the sustainable yield tradition of resource management. Of particular concern to the delegates to the Congress was the need to integrate better the disciplines of ecology and related sciences and economics. Delegates further emphasized the need for better techniques to place value on the non-commodities and environmental services provided by ecosystems so that they can be incorporated into economic analyses. For example, at present we have no way standard method of valuing the environmental uses of water, such as instream flows for habitat or wetland maintenance.

Role of Stewardship

A significant conclusion of the RNRF Congress participants was the need to develop a stewardship ethic to guide the use and development of natural resources. Stewardship implies the caring for or nurturing of something that is entrusted to an individual. This is a philosophical area which goes beyond scientific principles, information, and understanding. If it is accepted that we have a moral responsibility to care for and nurture the land (and water) through practices that maintain or enhance its integrity, value, and beauty for future generations, then this ethic deserves to be widely discussed and debated.

The need for this debate stems from the desirability to involve all the human inhabitants of an ecosystem or watershed in its management. Regulation alone is unlikely to achieve the degree of pollution prevention, water conservation, and environmental protection needed to preserve sustainable ecosystems. To participate in the debates, citizens must be adequately informed about the impacts of their actions on land and water resources. Acquisition of information and understanding is not enough. It must be disseminated to be used. This in turn suggests that interaction between resource scientists, the public, and the media must increase to enhance public understanding of the issues and knowledge of linkages between ecosystem functions and the economy. Non-governmental organizations play an important role in communicating this information to the public and governments as do professional societies.

Professional societies have begun to formulate codes of ethics that are consistent with an ecological approach to resource management. The Society of American Foresters in 1992 adopted the following language as part of their code of ethics (Marshall, 1993):

> *"A member will advocate and practice land management consistent with ecologically sound principles."*

Other resource-based professional organizations are incorporating similar ideas into their codes

of professional ethics.

It seems clear that sustainability must avoid polar opposites; we cannot either “use up” renewable resources as though they were infinite, nor can we leave them undiminished and inviolate. Instead, sustainability may more realistically aim for the preservation and enhancement of the productive potential of the environment. Also, the range of choices available to succeeding generations should not be diminished. This principle might be implemented in many ways:

- Investment in new technologies that will reduce waste an improve production.
- Changing to new economic activities that will provide employment and be less disruptive to long-term environmental quality.
- Improvements in health that will increase productivity and quality of life.
- Education that will increase capability to manage and conserve resources as well as better understand the philosophical principles and values of stewardship.
- Provision of stable institutions that will enable us to live without imminent risk to health, safety, and welfare.

Many tradeoffs exist. For example, it is difficult to define the extent and rate at which one generation is justified in drawing on an existing set of natural resource endowments in order to meet immediate needs, and simultaneously to invest in the changes needed to sustain or enhance future productive potential.

A crucial balance exists between the need for long-term intergenerational sustainability and a concern for intragenerational equity. The desire for a universal standard of living like that in the developed nations will imply attendant resource consumption and pollutant generation. Yet, it is hard to imagine any succeeding generation that will meet our expectations, if it does not spring from a present generation that sees hope in the future. The model must be one that “bootstraps up” our approach to the world, not one that “spirals down” into global hopelessness and poverty.

The first steps now being taken to grapple with the concept of sustainability are limited and tentative. Much work is needed to define and improve the base of information, to improve analytical capabilities, and to create institutional mechanisms that will permit negotiations, tradeoffs, and compromises. We may be at the start of a process of discovery that will benefit not only ourselves but generations yet to come.

Aldo Leopold captured many of these philosophical issues 45 years ago (Leopold, 1966) in his often cited Sand County Almanac essays that he wrote in 1949:

> *“That land is a community is the basic concept of ecology, but that land is to be loved and respected is an extension of ethics.... We abuse land because we regard it as a commodity belonging to us. When we see land as a community to which we belong, we may begin to use it with love and respect.”*

As we enter the 21st century, perhaps society will adopt Leopold's philosophy.

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Washington State's Marine Waters Environmental Program: A Practical Use of Environmental Assessment Science

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Washington State, located at the Northwest corner of the United States, bordering British Columbia, Canada, is divided by two mountain ranges, the Olympics and the Cascades. Puget Sound, a large body of water created by deep glacial cuts into narrow channels, lies between these two ranges, providing ideal temperate climate, deep harbors, very productive marine waters, and plentiful surface and ground water supplies. Many consider Puget Sound an unusual fjord, where “flushing”, or movement of marine sediments (and therefore contaminants) is small, even though tides can vary as much as ten feet.

Years of industrial and residential development have increased many rivers and streams' natural depositional rate of sediments into the shallower urban bays, carrying increased contamination to the bays, and routinely clogging commercial shipping lanes. Destruction of natural wetlands and marshes reduced nature's ability to reduce stormwater discharges. Washington is dependent on shipping, marine commerce, and naval facilities to maintain a healthy economy. This requires that routine, maintenance dredging be conducted along Puget Sound, Greys Harbor and the Columbia River by the U.S. Army Corps of Engineers.

However, increased concern for Washington's shoreline by local and state government agencies, citizens and scientists, reduced the dredging and disposal activities in the early 1980s.

In 1982 the State legislature created the Puget Sound Water Quality Authority, giving them the mandate of developing an environmental protection plan for Puget Sound. The Plan includes sediment management elements, requiring source control and education as primary tools to implement water and sediment quality improvements in the Sound.

Two state natural resources agencies have primary responsibility for marine sediment management in Washington State: the Department of Natural Resources (DNR), which manages state lands and issues leases to entities who propose development for water dependent uses; and the Department of Ecology (Ecology), which is responsible for regulatory oversight of Washington's environment.

After several attempts at managing these resources independently, coordinating poorly with the federal agencies, and receiving continued data from environmental samples revealing that contamination in some areas of Puget Sound, such as Eagle Harbor and Commencement Bay, had reached critical levels, Ecology and DNR decided to join expertise and resources. In 1984 the State of Washington entered into an agreement with the Federal EPA Region X (Seattle) office and the Corps of Engineers Seattle District to provide consistent scientific review and management of sediment quality in Puget Sound, naming it the Puget Sound Dredged and Disposal Analysis (PSDDA) program.

The PSDDA program is unique because it operates completely in a cooperative, non-regulatory atmosphere. It is also unique in several other ways: 1) although three of the four agencies have independent regulatory authority under the Federal Clean Water Act to manage water and sediment quality, and the fourth has final say on the use of the state aquatic lands, all four agencies share responsibility for expenses, studies, review of projects, management of the program and communication with the public; 2) consensus is always reached before an action is taken; 3) all decisions are based on a carefully laid out plan that includes years of scientific research and development, pre-approved disposal areas, and commitment to conduct long-term monitoring of all actions and take corrective action, if necessary; 4) all proposed changes to the program are subject to public review, allowing the public to propose revisions, and committing to the public to review and, if possible, implement their requests; and, finally, 5) the program operates under the philosophy that to maintain good water quality, management of sediments is critical.

Quality of the sediment is assessed by testing the material for 57 “chemicals of concern” (with an option to add more if historic practices warrant it). “Trigger” levels of contamination were established in 1984 by conducting extensive chemical analysis of local sediments, then conducting bioassay studies on five selected native marine organisms to determine what level of contamination in the sediments triggered a negative response on all five species. Statistical calculations were used to determine which levels of contamination most consistently triggered negative effects on all suites of bioassays, and on individual species. Reliability and predictability of effects were measured to determine if responses were statistically valid. This technique is commonly referred to as the Apparent Effects Thresholds (AETs).

The AETs allowed the PSDDA agencies to establish numerical regulatory levels to determine whether sediments passed or failed suitability for disposal. An exceedance of “maximum levels” (MLs) of contamination immediately determine the sediments are not suitable for disposal in open water. The full environmental assessment process also allows further testing of sediments

if exceedance of “screening levels” (SLs) occurs.

This tiered testing approach allows results from bioassays, bioaccumulation and benthic studies to be used to make the determination whether the sediments are suitable for dredging and disposal in Puget Sound. Sediments that fail the tests can still be dredged, but must be placed in confined disposal sites, mostly upland (although near-shore sites can be proposed if appropriately managed). This approach allows the applicant to decide whether they wish to spend minimum funds and efforts by exclusively testing for chemistry (the most inexpensive of options), and abiding by its established trigger levels; or, following through with biological testing to determine whether the sediments will or will not affect marine populations.

The PSDDA program manages, on average, 8 million cubic yards of sediments per year, and tests over 10 million. Testing is conducted by taking surficial samples (generally collected with a Van Veen grab sampler) and core samples (generally using a Vibracore), allowing compositing of several adjacent samples to obtain “dredged material management units” (DMMUs) - or prisms that can be dredged in one cut. Enough sediments are always collected to also run bioassay tests and bioaccumulation tests, if tier 2 testing becomes necessary.

PSDDA program policy does not allow dredging projects to leave exposed materials which test more contaminated than prior to dredging, thus ensuring that the dredging site will, at a minimum, have the same water and sediment quality conditions found prior to dredging.

Every year extensive physical and chemical monitoring is conducted by the Corps and DNR, respectively, and the data entered by Ecology into a multi-task relational database called SEDQUAL. Comparison of historical data and new data is conducted to determine trends. Monitoring results at the end of each dredging year cycle have shown continued improvement in the quality of the sediments and waters in the disposal areas.

In 1991 Washington State adopted the majority of PSDDA's procedures in regulatory form as the Sediment Management Standards (SMS), under the State's water quality and waste clean-up regulations. EPA Region X approved the SMS as water quality standards in accordance with the Federal Clean Water Act, and as part of Washington's Comprehensive Conservation and Management Plan (CCMP) - the first in the Nation.

The two programs are consistent with each other primarily because both use an established sediment sampling protocol originally developed for the Puget Sound area, but now used in all of Washington's marine sediments. We refer to these as the Puget Sound Estuary Program (PSEP) protocols.

The SMS provide an additional dimension to the management of sediments in Washington marine waters. A portion of the regulation requires “remediation” of sediments at a certain level of contamination. This trigger level is referred to as “minimum clean-up level” (MCULs), and essentially match with PSDDA's MLs (see attached relational graph). Because the SMS are primarily concerned with the quality of the sediments in the “biological active zone”, or the first 10 centimeters, compositing of these samples is not allowed, making sampling a bit more complicated. This practice is not necessary if preliminary review of historical records indicate the area is pristine or not heavily affected by human activities.

Three portions of the SMS are not complete: 1) determination of how human health effects will

be factored into the current chemical standards; 2) development and implementation of fresh water sediment standards; and, 3) interpretive regulatory guidelines for assessment of benthic community populations. PSDDA will use and incorporate both the information obtained for development of human health criteria, and assessment of benthic populations.

The PSDDA program is working on refinements to the suite of bioassays, and bioassay protocol updates. Studies have been completed on the 20-day *Neanthes arenaceodentata* chronic-sublethal bioassay, and the larval toxicity bioassays. Under study is the Microtox toxicity bioassay (including the new solid phase test), and the possibility that sensitivity of the amphipod bioassay may be jeopardized if species substitution is used. The SMS science advisory board will review this information to determine if revision of the standards is warranted.

These scientific improvements are incorporated into PSDDA by conducting continuing research, proposing the improvement to the public in an annual report and public notice, and obtaining public comment and proposals in an annual review meeting held every spring. The SMS will incorporate improvements during triennial modifications. As an example, last year PSDDA incorporated the 20-day chronic/sublethal *Neanthes arenaceodentata* bioassay test as part of the suite of bioassays. Washington State is the first in the nation to use this regulatory interpretation tool. The *Neanthes* bioassay was studied for more than six years before the PSDDA program decided the test increased the overall accuracy of the suite of bioassays.

Can shortcuts be taken and costs of testing be reduced further without jeopardizing the hard-won improvement of water and sediment quality in Puget Sound?

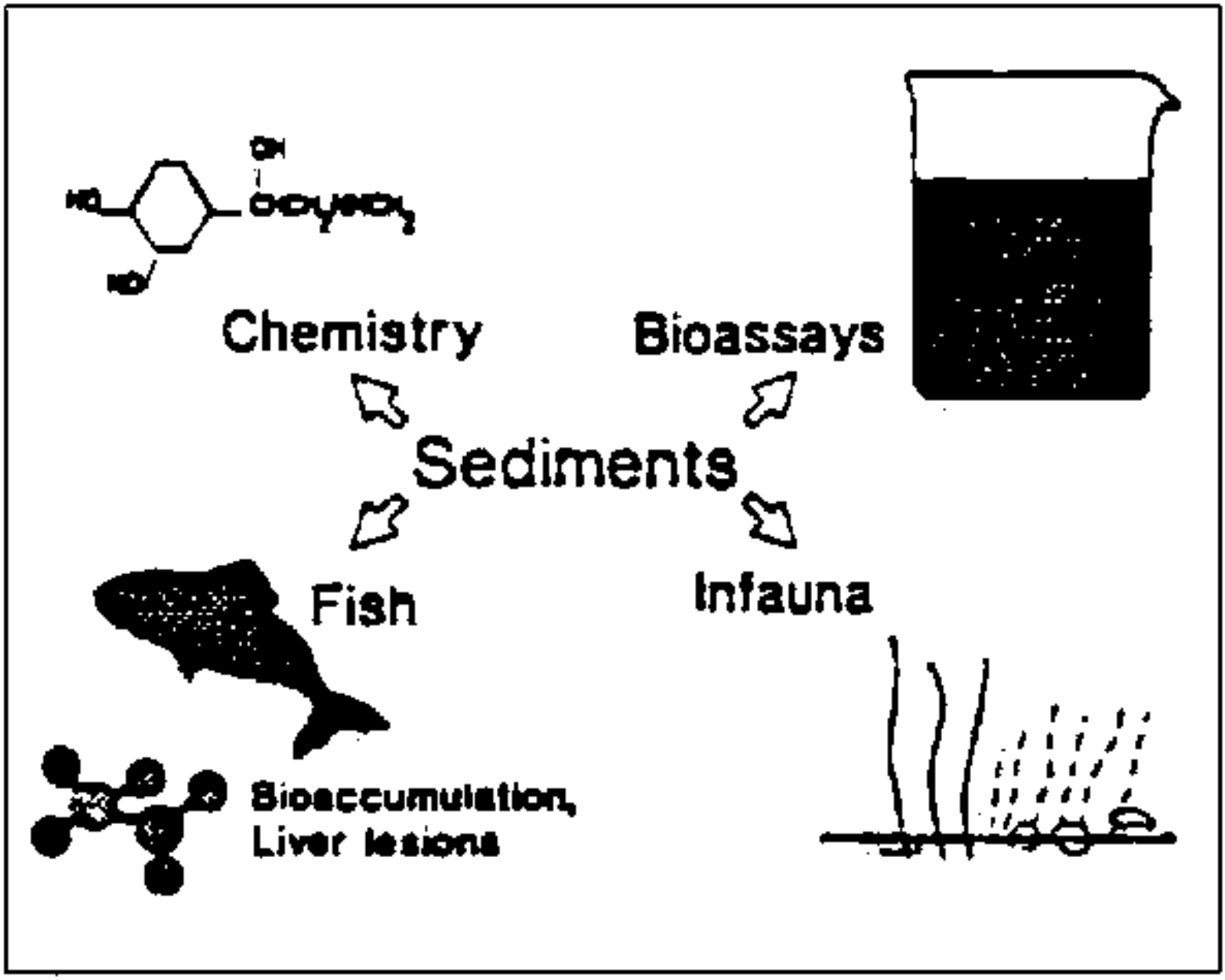
The PSDDA program believes that as the program matures and experience is gained, regulatory tools will become cheaper and easier to use. Right now, Ecology is using the SEDQUAL database, with a data bank that has increased one-hundred-fold, to recalculate the AETs. Preliminary results indicate the new trigger levels in some chemicals will more accurately predict sublethal and lethal effects to biota.

Can the rest of the U.S. and Americas benefit from our states' knowledge and experience?

The PSDDA agencies have presented the program to Oregon, Alaska, San Francisco, and British Columbia governments. Oregon and San Francisco are proceeding to implement this model. Alaska and British Columbia already use large portions of the PSEP and PSDDA protocols and regulatory interpretations. A presentation in France last year precipitated queries from the Netherlands and a visit from New Zealand scientists. New Zealand is in the process of adopting a scaled down version of the PSDDA program.

The knowledge we have gained can be used easily by any government in need of managing their water and sediment quality, by adapting Washington's process to their own needs. We consider it an honor to provide our information to others, and look forward to a closer partnership with other governments that can provide us their experiences and studies, thus enhancing our knowledge as well.

OVERVIEW OF KEY SEDIMENT MANAGEMENT FEATURES



Environmental Effects of Contaminated Sediments

- Sediments with elevated concentrations of chemical contaminants
- Adverse effects to laboratory test animals
- Fewer animals living on and in contaminated sediments
- Bottomfish fin rot, gill lesions, reproductive failure and liver tumors
- Local health department fishery advisories warning against human consumption

Administrative	Environmental
• Permit Information	• Physical
• Costs	• Bioassays
• Dredged Volumes	• Infauna
• Compliance Inspections	• Bioaccumulation
• Quality Assurance	• Chemistry

⇓ **Outputs**	⇓ **Outputs**
• Compliance Reports (DNR, Corps, ECOLOGY)	• Permits/Certifications (Corps, ECOLOGY)
• Annual Reviews (DNR, Corps)	• Annual Reports (Corps, ECOLOGY, DNR)
	• Disposal Guidelines (ECOLOGY)
	• Data Transfers (ECOLOGY)

PSDDA is an Interagency Consensus Regulatory Program

- Corps issues a federal permit for projects involving dredging and disposal of dredged material; EPA promulgates the national dredging rules and has veto authority over the Corps' permits

- DNR owns the PSDDA disposal sites - they maintain the shoreline permit for the sites and issue site use permits to dredgers

- Ecology issues the State response, water quality certification and CZM consistency determination for the Corps permit

- Ecology is also responsible for:
  - → annual monitoring and program assessment reports
  - → data management and disposal guidelines
  - → dredging site compliance inspections

Sediment/Discharge Liability
Regulatory Control? - or - Trespass and Taking?
• **No landowner approval or indemnification** • **Rule avoids proprietary implications** • **Align standards/provide accountability** • **Integrate regulatory and proprietary**

Discharge and Sediment Liabilities

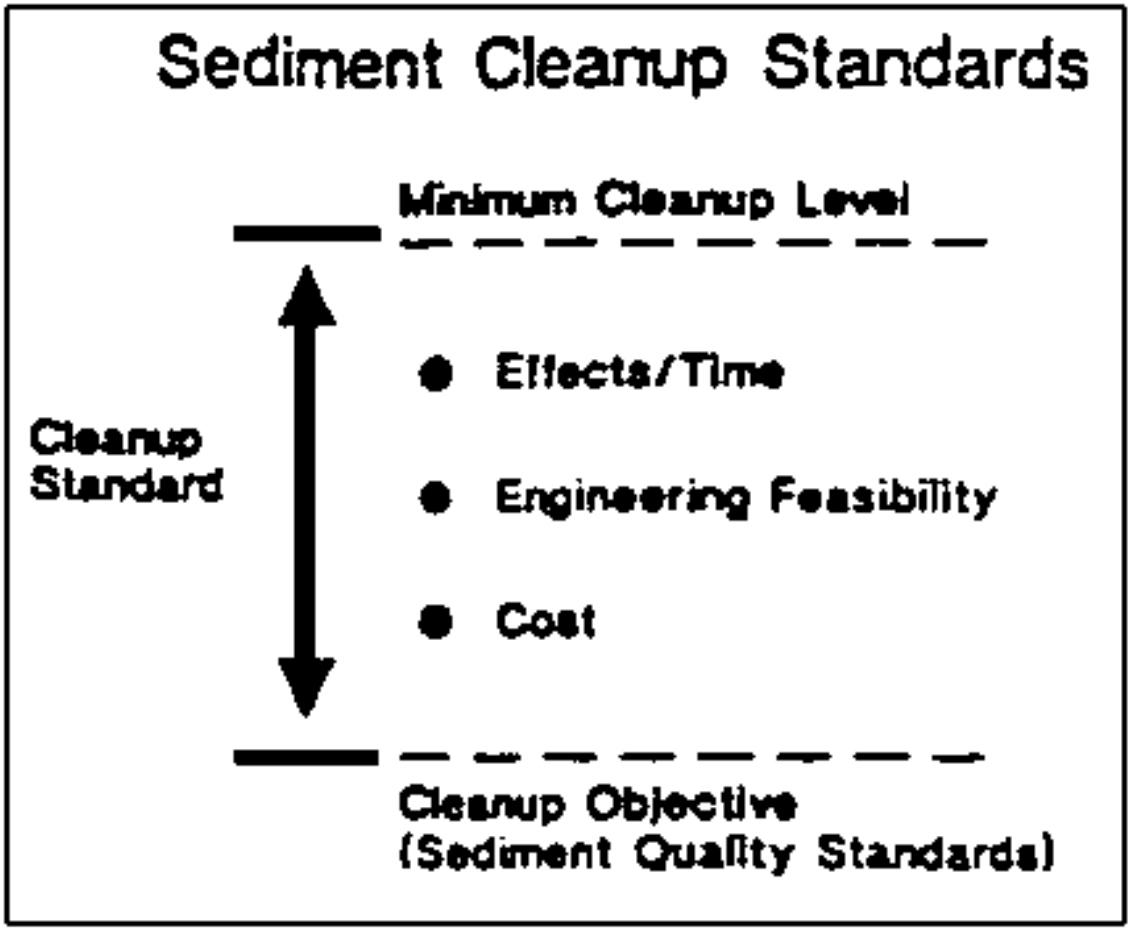
- Unresolved legal issue: whether a regulatory discharge permit that restricts, yet allows sediment contamination on someone else's land constitutes an action subject to proprietary laws

- Landowner approval over regulatory permits could result in the landowner holding the discharger hostage. And there are legal questions about Ecology delegating regulatory powers to the landowner

- Indemnifying the landowner for contamination that Ecology permits to be placed on their land would illegally rewrite legislated liability standards

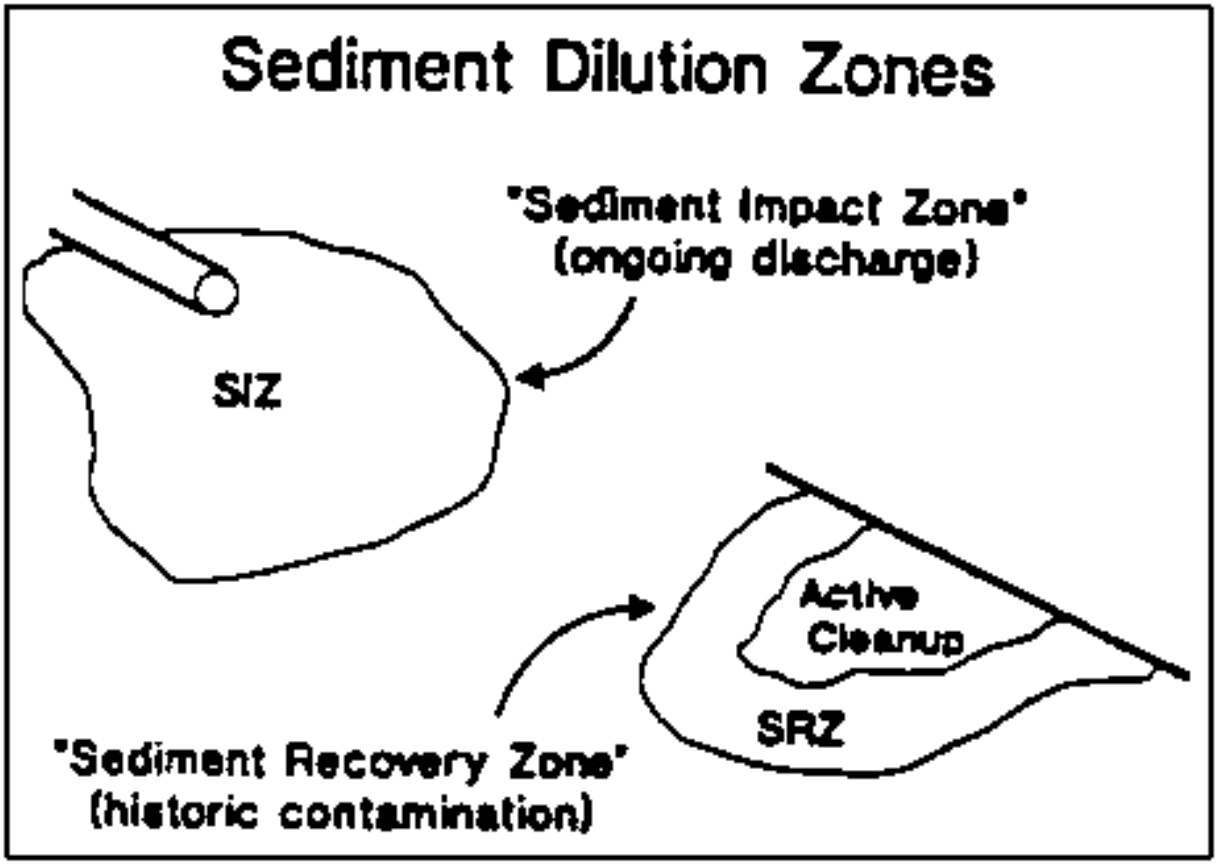
- Rule states that regulatory action does not address any proprietary requirements

- Rule aligns the sediment standards so discharges do not create new cleanup sites
- Rule establishes accountability to the discharger for sediment effects
- State agencies are integrating regulatory and proprietary interests



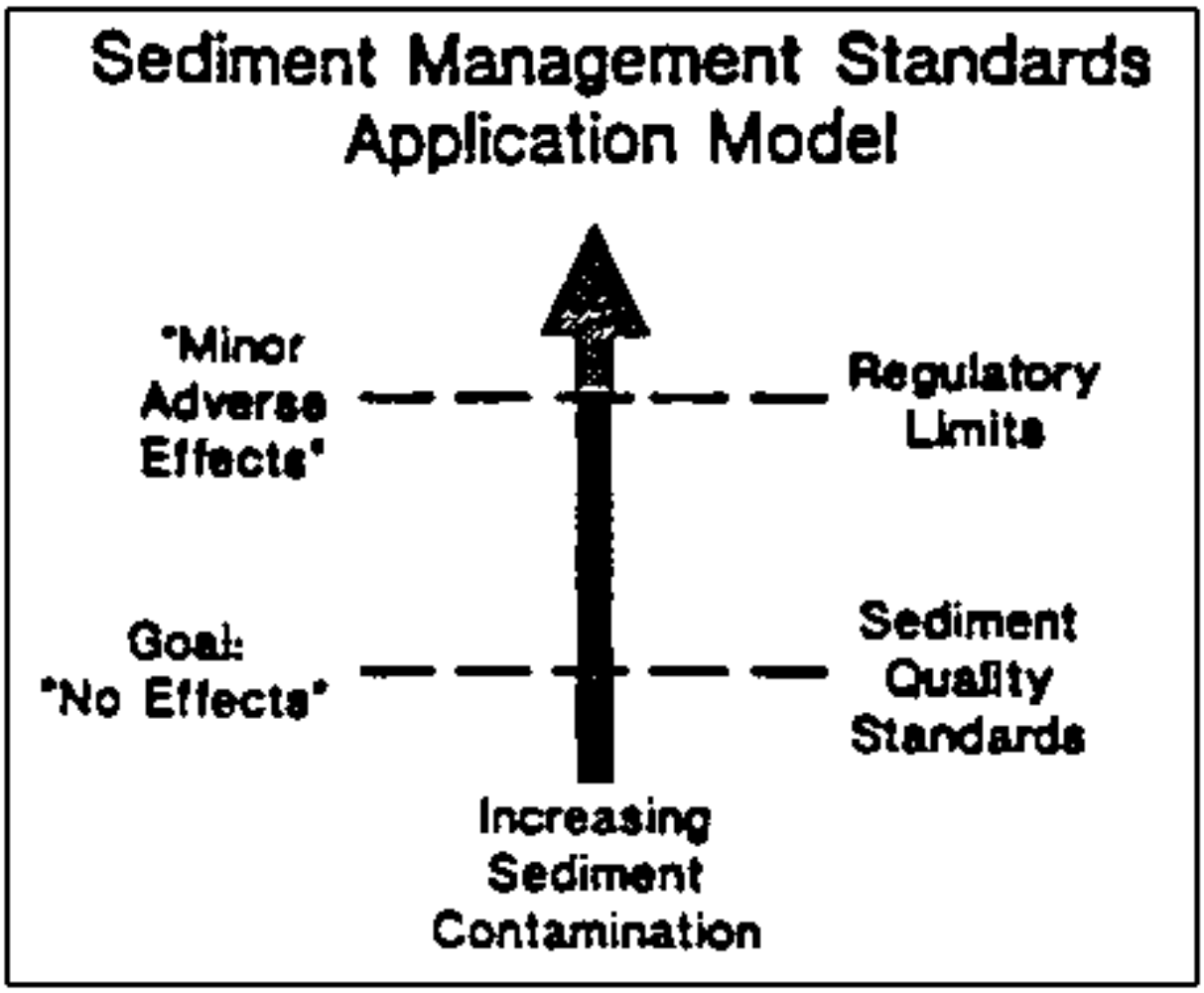
Sediment Cleanup Standards

- Example of the “application model” - the rule defines sediment cleanup standards using a “range of effects”
- Cleanup standard is defined on a site-specific basis, as close as practicable to the sediment quality standards (the “cleanup objective”), not to exceed the “minimum cleanup level”
- In defining practicability, net environmental effects, natural recovery rates, engineering feasibility and cost are all factors that are considered when determining the site cleanup standards



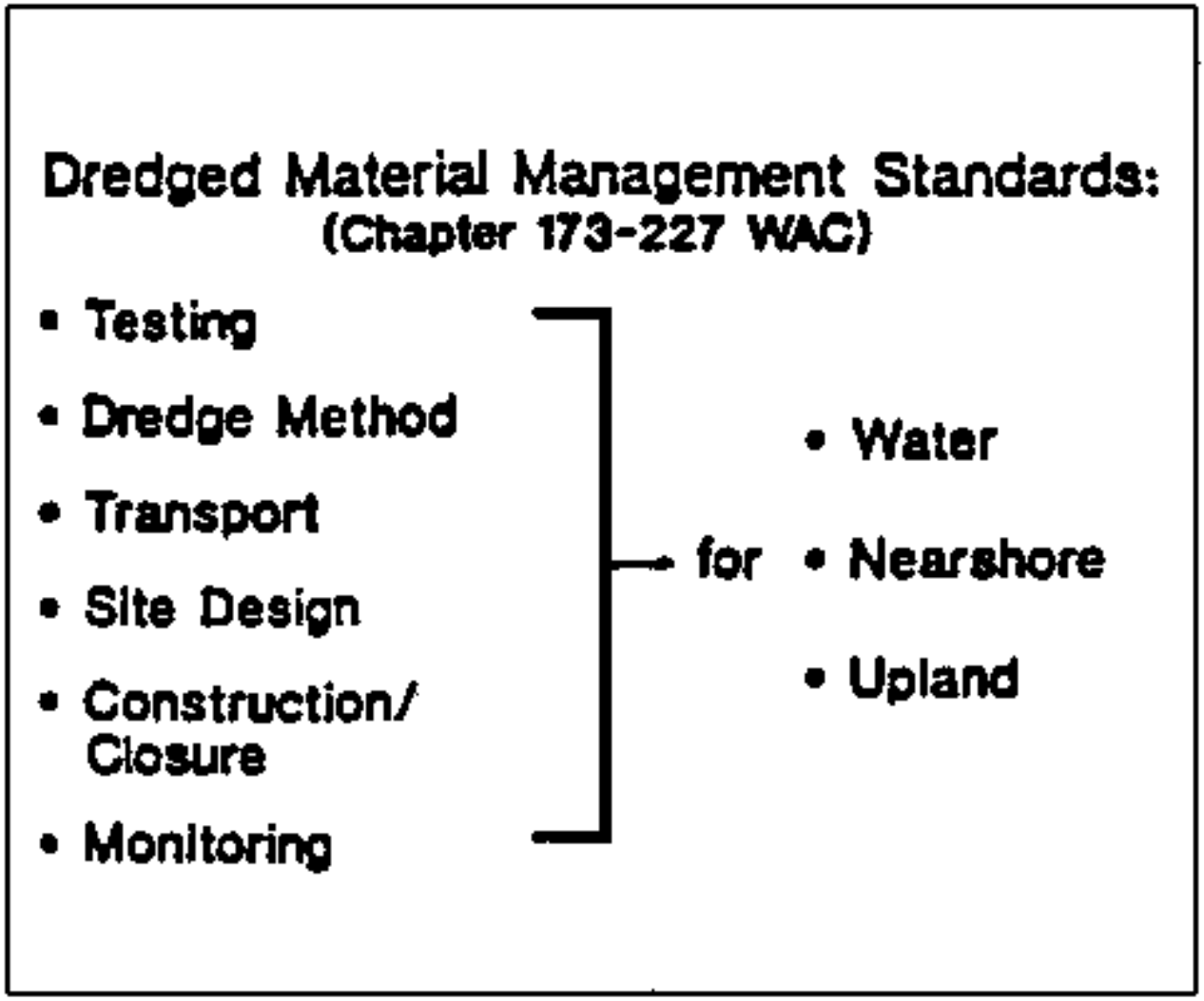
Sediment Dilution Zones

- The rule uses “sediment dilution zones” as the vehicle for authorizing adverse effects over the “no effects” sediment quality standards
- There are two types of dilution zones described in the rule: “sediment impact zones” and “sediment recovery zones”
- For ongoing discharges, the rule allows the State to authorize an area outside the discharge known as a “sediment impact zone” within which the discharge can exceed the lower standard, but not the higher, “minor effects” standard
- For historic contamination subject to cleanup, the State can determine that portion of the contamination above the “no effects” standard and below the “minor effects” standard does not need to be cleaned up - thus leaving a “sediment recovery zone”
- The same computer models are used to predict sediment impact zones from discharge effluent data and to predict the rate of natural recovery in sediment recovery zones



Regulatory Application Model

- Sediment quality standards represent a “no effects” goal
- Exceeding the sediment quality standard does not mean terminate discharge or start cleanup
- “No effects” standard was established solely using scientific information - not engineering feasibility or cost factors that are part of regulatory decisions
- A second sediment standard, the “minor adverse effects level”, acts as an upper bound or ceiling on regulatory decisions
- Between the two standards, source control and cleanup decisions are made in consideration of net environmental effects and cost/feasibility tradeoffs
- This “allowable range of effects” necessarily requires technical and policy judgement during implementation



Dredged Material Disposal Standards

- Per Element S-4 of the Puget Sound Plan, Ecology is developing a second sediment rule addressing dredging and disposal of sediments derived from navigation and cleanup projects

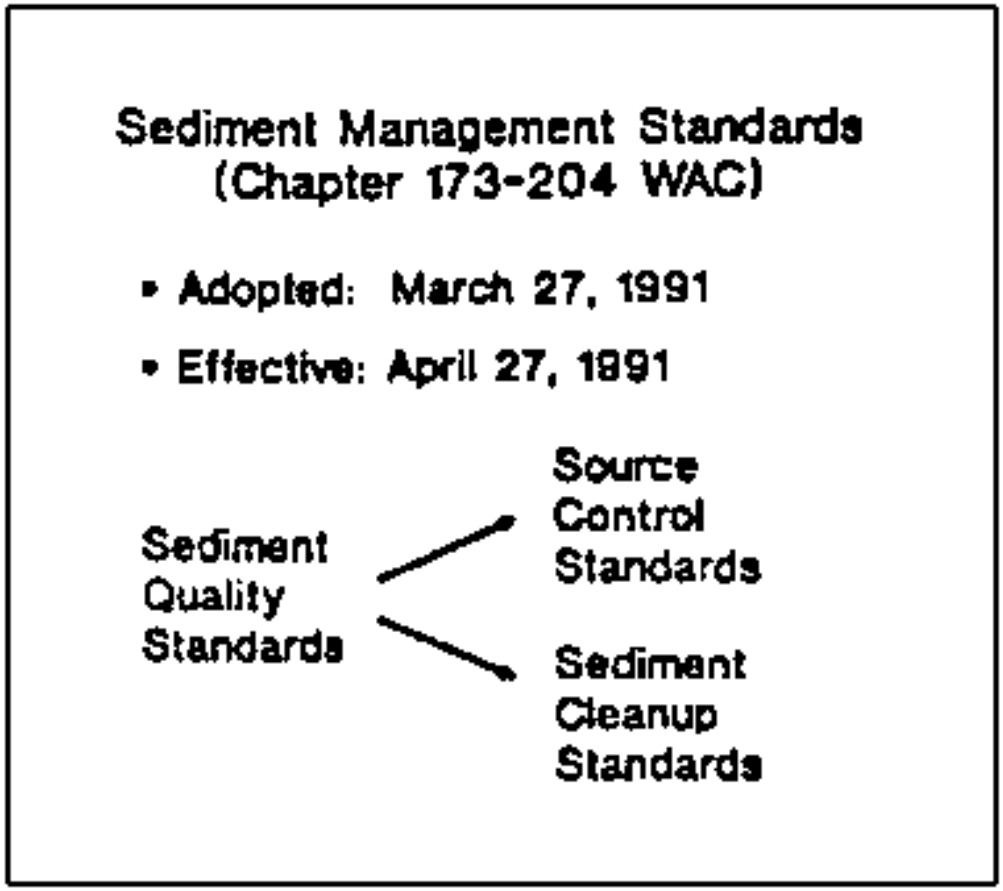
- Dredged Material Management Standards, Chapter 173-227 WAC, will specify technical and procedural requirements for all dredging and dredged material disposal actions

- Rule will codify key features of the current Puget Sound Dredged Disposal Analysis program

- Rule will provide “minimum functional standards” for disposal of sediments in upland disposal sites (pursuant to Chapter 173-304 WAC)

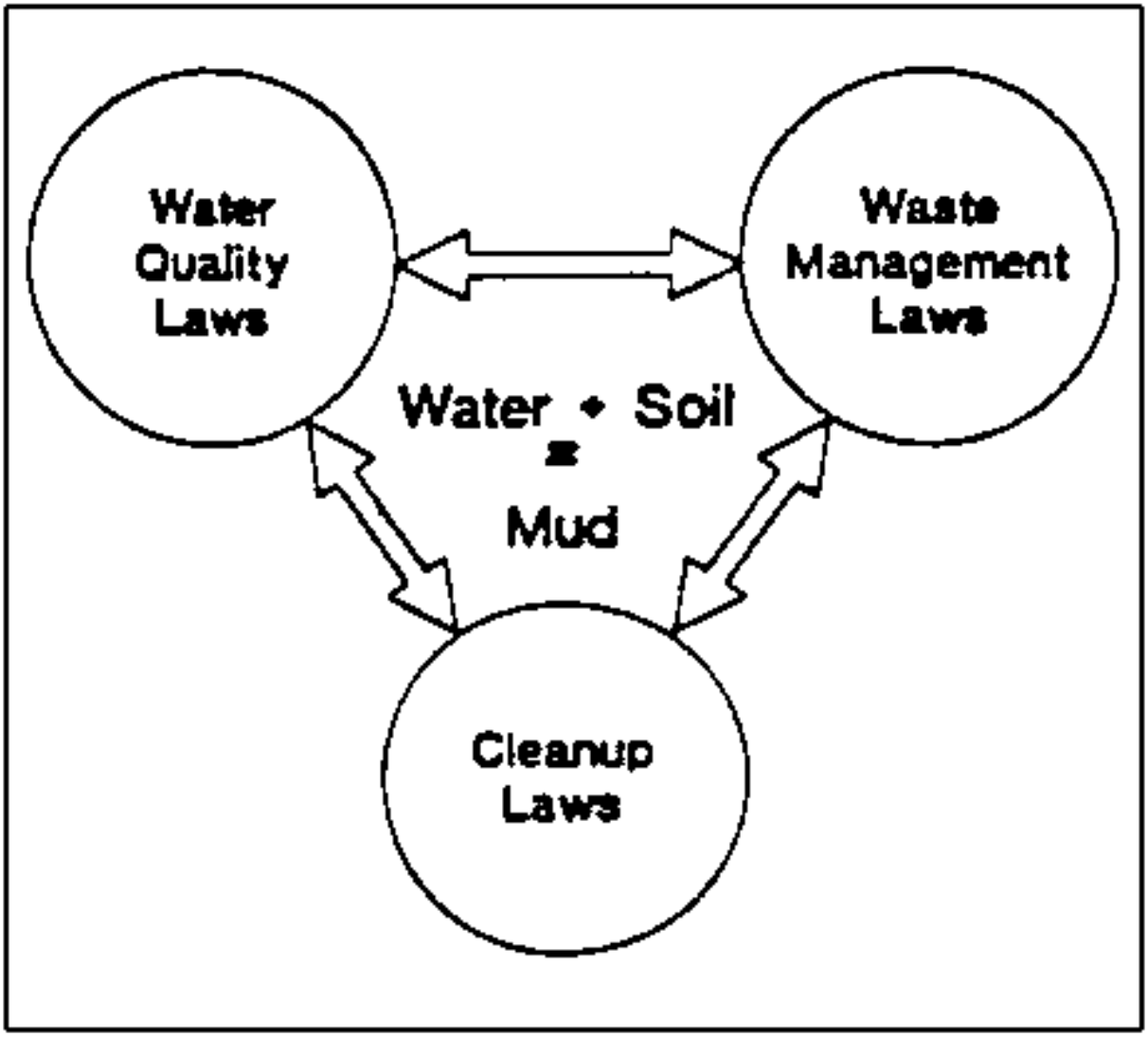
- Rule will be linked to the Dangerous Waste rule (Chapter 173-304 WAC) to address hazardous sediments

- Draft guidance manual due April 1992; draft rule scheduled for release by end of 1992



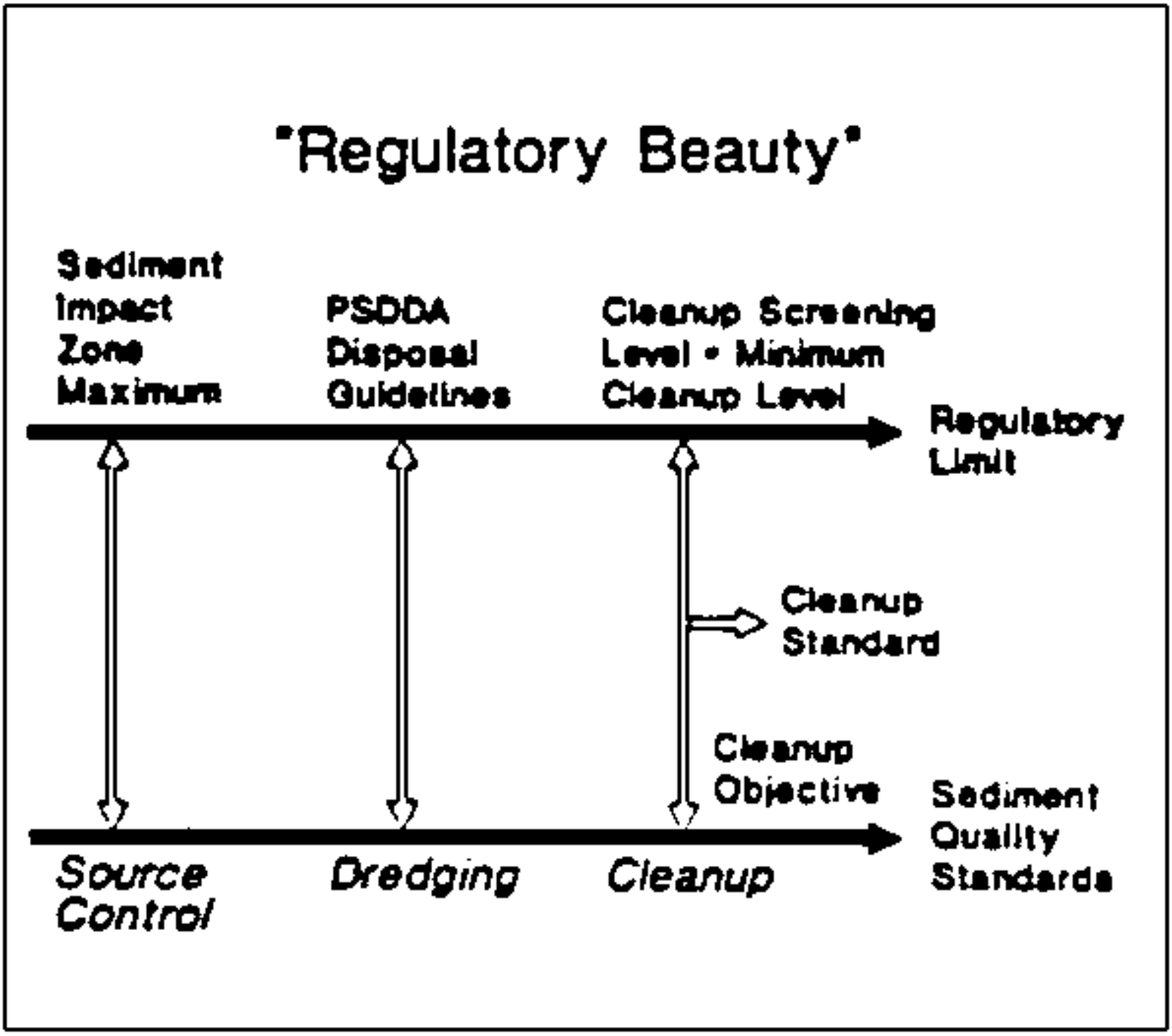
Sediment Management Standards

- Ecology recently adopted a new rule known as the Sediment Management Standards, Chapter 173-204 of the Washington Administrative Code
- Rule establishes a set of narrative, chemical and biological criteria as 'sediment quality standards'
- Rule describes use of standards in existing source control programs designed to control the discharge of contaminants (e.g., wastewater discharge permits)
- Rule applies the sediment quality standards in the sediment cleanup decision process
- Rule was recently approved by EPA as part of the State's “water quality standards” pursuant to Section 303 of the Clean Water Act



Institutional Challenges of Sediment Management

- Like water, sediments are an environmental medium and are subject to aquatic protection laws
- Unlike water, if sediments are picked up, they are similar to any other solid waste material
- Contaminated sediments result in cleanup liabilities to the discharger, the waterfront developer and the landowner
- Sediment management requires an innovative blend of legal mandates and procedures to effectively integrate water quality, dredging and cleanup programs



Cross-Program Implications

- A key objective of the sediment rule was to ensure that the various government programs that affect sediment quality worked in harmony with one another
- Same standards of quality are established for all regulatory programs
- We do not want permitted discharge zones that will then result in increased disposal costs and liabilities to navigation dredgers
- For cleanup programs, the upper standard is a cleanup trigger ("cleanup screening level") above which we will list a site for active cleanup, below which we will not list a site for active cleanup

- The status of point and nonpoint source controls is a key consideration in determining appropriate cleanup actions in sediments
- This arrangement ensures that we will not be permitting discharges or creating dredged material disposal sites that will later become future cleanup sites.

IMPLEMENTING THE SEDIMENT MANAGEMENT STANDARDS

Aquatic Weed Control in the Yarinacocha Pucallpa Lagoon

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Note of the Editor: At the time of the publication of these proceedings, only the abstract of the presentation was available. Further details or the complete paper may be available by contacting the author at the specified address.

ABSTRACT

The Yarinacocha lagoon is located in the Ucayali region of Peru. The average annual temperature in the region is around 80°F (26.29°C) with an average precipitation of 70 inches/year (1777 m.m. year).

Since 1982 an increase of ***water hyacinth, water lettuce, and umbrella flatsedge*** has been observed. Approximately 15% of the surface area of the lagoon (180 Ha.) is covered with aquatic plants. In other lagoons and lakes almost 100% of the surface area is covered, making these water bodies unnavigable. In addition some of the plant roots are fixed in the soils creating secondary forests when the area dried out.

This invasion of aquatic plants is due to the disappearance of the manatees, tapirs, and fishes that were caused by boat traffic, human consumption and deforestation.

The principal methods of weed control are mechanical removal, herbicides that do not cause contamination and biological methods through the use of crickets and herbivorous fish.

There are also preventative methods such as promoting the reproduction of manatees, fresh water turtles, placing control on fishing and finding additional use for aquatic weeds such as food products and fertilizer.

Sub-track: Protection and Restoration Strategies

The Role of Non-Governmental Organizations in Environmental Assessment in the Pantanal Region

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By now everyone is more or less acquainted with the context of the Pantanal, a vast wetland system located in South America. It is a very complex region, with a very high level of interconnectedness among the subregions that form it as well as the neighboring regions. We could mention, as an example, how it's hydrology influences the whole La Plata region, both by slowing down the flow of water coming from the upper basin into the Paraguay river, and by filtering solids in suspension and thus turning that water clearer. The cultural integration among the different regions of La Plata river basin is another factor that adds to that complexity.

We believe that, in that context, environmental assessment, like any other environmental issue, needs an “ecosystem-level approach” in order to be effective. This “ecosystem-level approach” should lead to an integration, from the beginning, of the multiple aspects involved, such as biologic, physiographic, socio-economic, and policy! providing broad and coherent analysis and solutions.

We have found that this kind of approach for environmental assessment stresses two points: building capacity for analysis, and communications. In the course of SODEPAN's programs, we've identified some actions to be taken, as well as constraints, regarding these two points, which I would like to talk about. First, however, it is necessary to introduce you to SODEPAN.

SODEPAN stands for Sociedade de Defesa do Pantanal. It is a private, non-profit organization founded by land owners of the Pantanal concerned with the maintenance of the ecological balance of the region. In its eight years of existence, SODEPAN has worked jointly with other agencies in the research of behavioral and biological needs of “flagship” species of the Pantanal, the ecology of flooded areas, and migration of fish, just to name a few examples. It has also conducted a diagnostic survey of the local political base and attitudes toward conservation in each microwatershed of the Upper Paraguay river basin, and has initiated a coalition of environmental groups in the La Plata region to address development issues such as MERCOSUR and the Hidrovia.

A recent reorganization and strategic planning session prepared SODEPAN to integrate the broad effort for the conservation of the Pantanal, which involves many different actors. The two issues of environmental assessment I intend to address, communications and capacity building, should be focused by the organization's programs from the perspective of our positioning within

this effort.

CAPACITY BUILDING

As for capacity building, we envision three major courses of action:

1. Develop capacity to assess major development schemes

Direct and indirect impact assessment is reasonably well developed already. We have participated in workshops to improve capability of analyzing environmental impact assessments (EIAs) with satisfactory results. However, sometimes this is not enough. Much of the assessment is based on incomplete studies, that reveal gaps in knowledge that must be fulfilled.

In addition, development projects are often related to other projects, which leads to the necessity for a broader understanding of the implications of each project in a wider development scheme, in order to make a comprehensive analysis. Using the example of the Hidrovia Project, it is predictable that it will influence other projects such as monocrop agriculture development in the west of Brazil, or the ZPE (zone for processing and exporting of industrialized goods) in Corumba.

2. Investigation of alternative scenarios

The need for the investigation of alternative scenarios can be explained in the context of the polarization between development and conservation that some development agencies suggest. We often run short of arguments to counter that position, because there are no studies that indicate the alternatives that can potentially integrate development and conservation. Elaborating models, assessing available technology that could be useful, and most important, valuing the natural resources and the potential economical losses due to bad use is essential.

3. Develop instruments for micro-scale planning

In a region where 95% of the land is privately owned, any conservation strategy needy support on that level. Environmental assessment must not only take this into account to be socially sound, but also be operational in orienting and promoting actions on that level. Rapid Environmental Assessment techniques can be a solution, in the sense that it is accessible. Also, in microwatershed actions and planning, like in Bonito or Rio Verde, it would be useful.

COMMUNICATIONS

The complexity of the Pantanal region, and the number of actors involved in the process of its development create a demand for coordination among these actors, and most important, a necessity for consensus around the guidelines for the development of the region. This situation presents an opportunity for a number of actions, some of which SODEPAN is currently undertaking.

1. Educate involved community groups

It is necessary to inform the involved community groups about development projects and policy making, in terms of their potential benefits and threats. In order to do that,

we've developed a program with the following activities: Circulate information through media, create a telephone information system (hot-line), and increasing the circulation of the organization's newsletter.

2. Build sound terms of reference for development programs and policy-making

Once the communities are well informed, it is necessary to create mechanisms that ensure their participation in the decision-making process. SODEPAN is currently carrying out a program of public hearings that will provide the baseline for the Mato Grosso do Sul state environmental policy act. This program will be enhanced and incorporate the use of focus groups.

3. Develop methodologies/coordinate efforts

The coordination of efforts of the various groups involved in the process of development of the Pantanal is essential. Not one single group can undertake this task alone. SODEPAN envisions creating a computer network and hold meetings with environmental and development agencies of the whole La Plata region, thus supporting open debate regarding issues of common interest and the development of appropriate and comprehensive methodologies to address these issues. This network could also serve as an early warning system of activities that could potentially create impacts on the environment.

PROBLEMS/OPPORTUNITIES

Even though many of the programs mentioned are already being carried out, SODEPAN still faces some major problems in getting them accomplished. It is a temptation to say that the major constraint to implement these actions is the lack of financial and technical resources. This is a reality in most of Latin American organizations, specially NGOs. However, I think that the challenge we face, the development of innovative methods to cope with complex scenarios such as the Pantanal, needs a bilateral, collaborative approach, in which local institutions would receive the resources, but would actively help adapting them to their specific reality. In return, methods developed from the integration of conceptual frameworks and real parameters, would certainly be useful once transposed to other complex scenarios. SODEPAN We certainly need help to overcome these constraints, but looking at them from the perspective of the opportunities they present, one sees that the whole matter is relevant not only on local level, but can also bring benefits to the whole world.

Conserving Aquatic Ecosystems for Sustainable Development

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Aquatic ecosystems, or wetlands, are an integral component of the water cycle and are thus inextricably linked with the management of water resources. Given the variety and importance of the services that wetlands provide to society, their conservation must be a central component of any rational strategy for the long-term utilization of water. In this paper, I review the connections between aquatic ecosystems (i.e. wetlands) and sustainable development, and stress the need

for society to incorporate wetland conservation within the formulation of water use policies.

WETLANDS: DEFINITIONS AND TYPES

Wetlands, or aquatic ecosystems, are defined by the Convention on Wetlands of International Importance (Ramsar Convention) as “Areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static, flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed six meters.” As a descriptive definition, it is broad and encompasses a variety of aquatic ecosystems, including reef and seagrass beds, mudflats, mangroves, estuaries, rivers, marshes, swamp forests, and lakes. Because this is a definition in an international convention, it is often adopted as the “official” definition of a wetland (Davies and Claridge 1993).

There are numerous ways to classify wetlands, and a variety of criteria can be applied to this end. Again, the Ramsar classification is widely recommended (Dugan 1992), and includes Salt Water Wetlands (Marine, Estuarine, Lagoonal, and Saline with internal drainage); Freshwater Wetlands (Riverine, Lacustrine, and Palustrine); and Man-Made Wetlands (Aquaculture/Mariculture, Agriculture, Salt Exploitation, Urban/Industrial, and Storage).

WETLAND LOSS AND DEGRADATION

Traditionally, wetlands have been considered useless ecosystems. Widespread ignorance about the important benefits that wetlands provide to human societies has contributed to this notion, promoting the destruction and degradation of wetlands throughout the world.

The conterminous U.S. has lost an estimated 53-55 percent of its original wetlands. By the 1980's, twenty-two states had lost 50 percent or more of the wetland areas that were contained within state borders (Dahl 1990). This loss is equivalent to an area larger than the state of California, and translates into a loss of one acre every single minute for the last two hundred years. Many human activities are responsible for the draining, filling, flooding, and degradation of wetlands and riparian habitats. Agriculture, dams and flood control projects, road building, urban development, pollution discharges, groundwater pumping, and deforestation are important agents of wetland destruction. Most wetland degradation occurs from changes to the land base, primarily due to agriculture (Dahl, pers. comm.).

Although reliable figures are not available for other countries in the hemisphere, evidence indicates that wetlands are rapidly being destroyed and degraded everywhere. Many countries that have been studied have shown losses in mangrove cover of more than 50%. Throughout Mexico and the Caribbean, many coastal wetlands have been lost because of tourism expansion. Agricultural runoff and other sources of contamination are also a serious threat in South America, especially in the La Plata Basin. Mining waste is dumped directly into many high Andean lakes, especially in Peru and Bolivia. Conversion to rice fields is also a serious problem, especially in Uruguay and Brazil. These losses erode many important wetland benefits and impinge upon their ability to act as the basis for future sustainable development.

SERVICES THAT WETLANDS PROVIDE TO SOCIETY

Wetlands provide a great variety of benefits to society. These benefits are often referred to as functions, uses, values and attributes, features, and goods or services, and are defined as any of

these terms which may have a value to people, wildlife, natural systems or natural processes (Claridge 1991). According to Adamus and Stockwell (1983), there are about 75 such characteristics of wetlands that can be considered beneficial. In this paper, I classify wetland benefits as functions, products, and attributes following Davies and Claridge (1993) and Dugan (1992).

Wetland Functions

Water Supply. - Includes direct extraction of water by people, water supply to an aquifer (groundwater recharge), groundwater discharge, and water supply to another wetland. The value of these functions is illustrated by an example from the state of Massachusetts (USA), where 60 communities, a total of 750,000 people, depend on groundwater supplied by wetlands to fulfill their water needs (Motts and Heeley 1973, in Dugan 1992). Conversely, intensive mariculture in Malaysia that relies on groundwater, coupled with a high rate of wetland destruction, has depleted groundwater supplies to local communities (Davies and Claridge 1993).

Flood regulation. - This function occurs both through flood water storage, and through flood slow downs by wetland vegetation. The disappearance of millions of acres of wetlands along the Mississippi River watershed played a critical role in amplifying the magnitude of the 1993 floods, with the ensuing loss of lives and property, estimated at more than 10 billion dollars. In a similar fashion, the Pantanal in Brazil and Bolivia slows the flow of water in the Paraguay river, thus avoiding catastrophic flooding downstream. It is well documented that the loss of this “sponge” function would produce extensive damage to rich agricultural areas in Argentina (Bucher et al. 1993). Another study showed that if 40% of the wetlands along the Charles River in Massachusetts (USA) were drained, flood damage would increase by a minimum of $3 million/year. If they were completely drained, however, the damage would have been $17 million/year (Dugan 1992 and references therein).

Prevention of Saline Water Intrusion. - This function is especially important in coastal areas where saline intrusion negatively impacts the availability of fresh groundwater. This function also occurs at the surface, where water flow usually limits seawater entry (Davies and Claridge 1993).

Protection from Natural Forces. - This includes shoreline protection from storms and stabilization, the provision of windbreaks, and erosion control. The destruction of coastal wetlands often results in tremendous loss of life and property. Where bankside vegetation has been destroyed along rivers in England, the cost of reinforcement is estimated at $425 per meter (Turner 1989). In Bangladesh, tens of thousands of people are killed periodically by storm surges that could be prevented through the conservation of coastal wetlands.

Sediment retention. - This function benefits communities downstream by maintaining water quality, and benefits agriculture by renewing nutrients and soil.

Nutrient retention and toxicant removal. - This function maintains water quality by absorbing excessive nutrients and removing toxicants from the water. In the Florida (USA) cypress swamp, 98% of all nitrogen and 97% of all phosphorus are removed from wastewater this way. In Massachusetts (USA), a study showed that the cost of replacing the tertiary waste treatment services provided by wetlands was $123,000 per hectare (Oldfield in Dugan 1992).

Biomass export. - The high productivity rate in wetlands yields biomass that is often exported

and utilized, especially by fisheries downstream.

Micro-climate stabilization. - As part of their role in the hydrological cycle, wetlands equalize climate, especially rainfall and temperature.

Global Carbon Sink. - Many wetlands hold large amounts of carbon in the form of peat, that if released, could significantly add to the global carbon problem and thus to global warming (Davies and Claridge 1993).

Water transport. - This is an important function, especially in rural areas where wetlands serve to transport people and products between adjacent communities.

Tourism. - Wetlands support a heavy recreational industry that includes opportunities for hunting, fishing, birdwatching, etc. In Canada, for example, the value of wetland recreation is estimated at U.S.$4 billion/year. The overall tourism industry provided $55 billion to developing countries in 1988 (Davies and Claridge 1993; Dugan 1992).

Wetland Products

The high rate of primary productivity in wetlands results in the availability of a variety of products, including forest resources, wildlife resources, fisheries, forage resources, agricultural resources, energy resources, etc. The value of these products is often measured in millions of dollars annually for any given locality, and represents an important source of income for rural communities.

Two-thirds of all fish caught commercially depend on wetlands at one point or another of their life cycles. This percentage increases in some fisheries, such as the Gulf of Mexico, where 90% of the fish harvested (worth $700 million annually) consist of species dependent upon coastal mangroves (Dugan 1992).

Peat is used as an energy source in many rural areas. In Perú, peat, called *champa,* is regularly used as a household fuel, especially for cooking (Pulgar-Vidal 1946).

Wetland Attributes

Although it is often difficult to assign a monetary value to wetland attributes, these benefits nonetheless represent an important resource that needs to be conserved for ethical, aesthetical, cultural, and biological reasons.

Biological Diversity. - Some of the most spectacular diversity and concentrations of wildlife, both resident and migratory, occur in wetlands. Wetlands often play critical roles in the life-cycle of many species. The disappearance of wetlands have been documented to impact heavily upon the population of migratory species of birds (Castro et al. 1990). A recent study has shown that although wetlands represent less than 5% of all the land area of the U.S., they harbor about 50% of all endangered and threatened species (Feierabend 1992).

Gene Bank. - The use of genes from wild species occurring in wetlands is an important way of improving cultivated varieties of plants. In addition, wetlands can host inordinate amounts of the genetic composition of some species. In some migratory shorebirds, for example, up to 60%-90% of all individuals are sometimes found within a single wetland (Morrison and Ross 1989).

Socio-cultural Significance. - Wetlands are significant components of the landscape providing aesthetic values; are associated with religious and spiritual beliefs and activities; help maintain important cultural elements; and are often sites of historic importance (Davies and Claridge 1993). According to tradition, the first flag of Peru was conceived by General San Martin while observing flamingoes in Paracas, Perú. This historic event helped in the creation of the Paracas National Reserve in Peru and adds to its importance as a site of national heritage value (Davies and Claridge 1993).

WETLANDS AS A BASIS FOR SUSTAINABLE DEVELOPMENT

Valuation

Public policy requires economic valuation of the public benefits of wetland conservation. Since most wetlands provide several of these benefits simultaneously, the total value of a wetland thus cannot be accurately estimated unless all functions, products, and attributes are incorporated into the calculations (James 1991).

Quantification at the local scale for the harvestable products such as food and fuel is straightforward. Recreational and aesthetic values of wetlands, and their diversity of plants, fish, and wildlife can also be approached with conventional economic methods based on the businesses supported by recreational experiences, or based on willingness to pay for the recreational experience (Castro et al. 1994).

Higher ecological values are external to the market system because the benefits are accrued by society as a whole. Attempts have been made to assign economic value to these functions based on what it would cost to replace the function, or by depreciating the natural capital that is eroded when a natural resource is depleted (Solórzano et al. 1991).

Regardless of the method utilized, it is clear that the very valuable benefits that wetlands provide to society must be somehow incorporated within national accounting schemes in order to change the perception that wetlands are useless ecosystems, and to promote the conservation of their valuable benefits.

The Huanchaco Extractive Reserve in Peru: An Example of Sustainable Use

The Huanchaco Extractive Reserve in northern Perú illustrates how the many benefits that wetlands provide to society can be incorporated within a community development scheme. This project is currently being implemented by the Wetlands of Perú Program, a consortium of governmental and non-governmental agencies in Peru, and is a priority of the National Wetlands Conservation Strategy of Peru (Pulido et al. 1992).

Archaeological evidence suggests that coastal wetlands have been managed in Peru for at least 2,000 years. Many ancient civilizations were organized along the coast to benefit from a variety of wetland products, that included birds, eggs, fish and mollusks, peat (as fuel), and cattail (Typha) fibers. Many of these products were utilized for the manufacturing of tools, containers, housing, and fishing vessels. The clearest evidence of active wetland management comes from Chan Chan, a large precolumbian city in northern Perú (population estimated to be between 20,000-100,000 by 1,500 A.D.). The city included several large artificial wetlands that were communally managed to obtain a variety of products, primarily cattail fibers used for housing and

building fishing vessels (Rostorowski 1981 and references therein).

After the Spanish conquest, these traditions were abandoned in most coastal areas. Even though today it is possible to find wetland products extracted from coastal wetlands, the wetlands themselves are not actively managed. The Chan Chan system, however, was the only location where ancient wetland management was still practiced until ca. 1940. At this time water sources that maintained these artificial wetlands vanished because of competition from expanding agriculture in the basin. Local fishermen, who relied on these products to build their fishing vessels ("totora horses or *caballitos de totora*") were forced to start managing natural wetlands in the Huanchaco area, a few miles away, and to build additional artificial wetlands. The Huanchaco wetlands have been continuously managed since ca. 1940. Because the management of Huanchaco was based on the Chan Chan system, it represents a traditional management system that can be traced back thousands of years (Rostorowski 1981).

Today, more than 500 people, mostly fishermen, directly depend upon the *totora* extracted from Huanchaco for survival. Huanchaco was declared an "Extractive Reserve," in 1992, covering an expanse of 4,672 hectares (Valqui and Zegarra 1993).

The main goal of the Huanchaco Project is to rescue the ancient techniques of wetland management in coastal Perú, by developing a demonstration project. Specific objectives include: to document the ancient techniques of coastal wetland management and to study their adaptation within a contemporary context; to refine these techniques to maximize their values for biodiversity conservation; to explore the development of alternative markets for the wetland products generated; and to promote the utilization of these techniques in additional wetlands along the coast of Perú.

Although in its initial stages, this project will provide important benefits at several levels. It will rescue techniques that can be used for the sustainable management of wetlands, while providing important habitats for biodiversity. In addition, it will help conserve this important site, its biological and cultural values, and the 500 people that depend upon it. It will serve as an international showcase demonstrating that wetlands can be sustainably managed to benefit both people and biodiversity.

The project will also help elevate the standard of living of local communities, and will develop economic incentives for wetland conservation. It will provide important scientific information, including a better understanding of the system, the factors limiting productivity and species richness, and a clear description of the management system. Finally, it will help conserve the last location where a cultural tradition has been continuously utilized for more than 2,000 years. The potential to reproduce this model along the coast of Peru (and potentially northern Chile) is very large. The project will help develop an approach that integrates conservation with the development of economic benefits to local populations.

CONCLUSIONS AND RECOMMENDATIONS

The conservation of aquatic ecosystems is inextricably linked with the long-term availability and management of water resources. Wetlands provide a variety of direct services to society, including water supply and purification, flood control, aquifer recharge, riverine flow regulation, prevention of saline water intrusion, sediment and nutrient retention, toxicant removal, energy production, and many others. In addition, wetlands are critical habitats to a rich biodiversity, and

include more than 2/3 of all fish caught commercially. Wetlands provide unmatched opportunities for recreation and are an integral part of the national heritage of many countries.

Because these services are not incorporated into national accounting schemes, they are assumed to be free, resulting in the widespread destruction of these ecosystems. Wetland loss has been very severe, with some countries, such as the U.S., having lost more than 50% of all their wetlands. The accelerated destruction of wetlands throughout the Americas eliminates these services and erodes the basis for future sustainable utilization of water resources. The 1993 severe floods in the mid-western United States were amplified many-fold by the loss of wetlands and their flood control services along the river. Examples illustrating the direct connection between wetlands and water resources management abound.

Any long-term, rational scheme for the management of water resources must recognize the complex but critical connections between the health of aquatic ecosystems and the long-term availability of clean water. The conservation of wetlands and their benefits is therefore sustainable development in its purest form.

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Management of Aquatic Ecosystems - The Pantanal Case

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The greatest challenge regarding the Pantanal, as any other little modified ecosystem, is how to orient its occupation and development aiming the maintenance of biodiversity and quality of life. Actions to be taken, in addition to political will, depend on the knowledge about the structure and functioning of these environments we may have.

The Center for Agriculture Research in the Pantanal (CPAP) is one of the 45 units of The Brazilian Company of Agriculture Research (EMBRAPA), located in the city of Corumbá, in the center of Pantanal. It has as institutional mission to generate, adapt, and transfer knowledge and technologies that may contribute to the sound and sustainable development of Pantanal.

The Center is currently composed by 40 researchers, among which there are 6 hold doctorate (Ph.d.), 30 magister (M.Sc.), and 4 undergraduate level degrees. They represent the following fields: Wildlife, Fishing Resources, Plant Resources, Cattle Ranching Production Systems, Animal Health, Soils, Climatology, Hydrology, Limnology, Socio-Economy and Technology Transfer. It also counts on 147 employees for research support and administration and two farms in the Pantanal.

1. Characteristics of the Pantanal

The Pantanal is an extensive alluvial plain located in the center of South America. Its floodplain area occupies about 140,000 square kilometers, with the Paraguay River running north to south as its principal stream. Geographically, the Pantanal is located in the Brazilian central-west, with smaller areas in northeastern Paraguay and southeastern Bolivia.

The basin is regulated by a hydrological pulse regime. Seasonal variations of flooding and drought determine a process of ecological succession, with the installation and development of species during the wet season, and another during the dry season. This fact, associated with the high temperatures and humidity, ensures the high productivity of the ecosystem. Pluri-annual periods of alternacy of drier and more wet cycles determine the length of floodings and therefore the availability of habitats and resources for the species. These variations influence the antropic occupation and regional economic activities.

The Pantanal is composed of various sub-regions, with different soil, vegetation and hydrological characteristics, creating a mosaic of habitats that enables the existence of a great number of plant and animal species. Also, its geographic position allows for the interchange of species with other important Latin American biomass such as Amazon “Cerrado”, the Atlantic Rain Forest or “Mata Atlántica”, and the Chaco.

2. Productive Systems

Cattle Ranching

Cattle Ranching, initiated more than 200 years ago, is the main economic activity in the region. It is carried out under traditional standards on big “fazendas” (farms). At present, the herd has some 3.8 million heads raised on an extensive basis, with a density of one animal per 3.6 hectares, and US$ 60 million. The herd feeds basically on native grasses. During the dry season, there is a loss of quantity and quality of the pastures, and during the wet season there is a reduction in the area available for pasture. To buffer this seasonably in food supply, many farmers have been introducing, in the last 20 years, exotic grasses in the field and non-flooding forest areas. Cost-benefit studies are necessary regarding this issue, for these areas represent feeding, reproduction and shelter habitat for many animal species.

Fishing

Fishing is an activity of strong regional socio-economic significance, both in its professional/subsistence and touristic forms. Basically 8 major species are captured. Professional/subsistence fishing gathers some 7,500 fishermen, generally associated with cooperatives and fishing communities. The majority has only the lower level of formal education, and live in the borders of riverside cities.

Fish capture an average 1.51/4.55 ton/year, and yearly total reaches an estimate 8,000 ton/year. Fish is marketed “in natura” as protein for human consumption. Meanwhile, it is desirable to improve the economic performance per captured fish. In order to do that, CPAP is researching the viability of using sub-products as the skin, and the bones for flocer and oil. Tourist fishing is responsible to a massive fish capture, due to the 60,000 fishers that come from all over Brazil to the Pantanal.

Over 250 fish species have been listed in the Pantanal. They perform a very important ecological

role in energy flux and nutrient cycling. Moreover, they represent the staple food for many reptiles, mammals and especially migratory birds that nest in the region. CPAP has conducted some studies about community structure, diversity and feeding of fish. CPAP is currently conducting a study on the feeding of around 100 species of the Miranda River floodplain that will lead to the elaboration of this communities food web.

Meanwhile, there are many important questions to be answered, as well as biological phenomena to be quantified. Because of the lack of scientific information, current fishing regulation is very restrictive. It only allows the use of hooks, prohibiting nets, and imposes a three month non-fishing season, during the breeding and reproduction period. This causes a strong economic impact upon the sectors that depend on fishing.

CPAP is proposing a research program to produce information to support the design of a management plan for fish resources in Pantanal. Projects include:

- assessment of Fish stock of main species explored by professional and tourism fishing; and
- study of the growth, reproduction and feeding of these species.

This plan will technically support fishing regulation in order to achieve a better and more sustainable use of fish resources. Among the regulations studied are minimal size for capture, protection areas, closing season, allowed fish equipment, and allowed amount of capture for professionals and amateurs.

In the 1980's, the Tucunaré, a *Cichidae* predator fish from the Amazon basin, was accidently introduced in the Pantanal. This phenomena is being studied in two phases:

- Study on the biology and speed of expansion of this species in the Pantanal;
- Assessment of its impact upon the rest of the fish community.

Tourism

The scenic beauty of the Pantanal, marked by richness of its fauna, diversity flora and variation of aquatic ecosystems, give the region an excellent potential for the development of eco-tourism and environmental education activities. In addition to sports fishermen, the region annually receives around 100,000 tourists, of which 70% come from abroad, particularly from Germany, Italy and Spain. The great tourism potential of the region demands studies and planning, in order to make eco-tourism an important column in the region's economy and support the sustainable use of the system.

As far as cattle ranching is concerned, tourism could be an important economic alternative for ranchers, once this activity has very specific characteristics in region, architecture, costumes, hand-work, traditional uses, food and cattle management, became very peculiarly adapted to the Pantanal region in the course of 200 years of its occupation.

3. Alternative Productive Ecosystems

The richness of animal and plant species, together with a raising demand for natural products, offer a possibility for increasing producer's income as well as job offers through the sustainable use of this resources.

Flora

The main plant resource of the Pantanal is its natural grasslands, which range from aquatic vegetation to trees, upon which the herd and grass eating fauna depend. On the ranches, plants are used for wood, leather, roofing, medicine, insect keeling, fibers and food. There are many medicinal plants with good potential for extraction, in addition to others yet unexplored. Some isolated cases of use for commercial purposes, such as for food, medicine, charcoal and artisan crafts are observed. Deforestation and uncontrolled fire are threats to the great unexplored potential of plant resources in Pantanal.

The CPAP's herbarium is the greatest collection of plants of the Pantanal. It houses more than 8,000 specimens of which 1,500 are identified species. A work with information, phenology, popular use and main characteristics of all arbor-shrubs, gramineas, and aquatic macrophytes already identified will be published soon.

Fauna

The extraction of faunistic resources of the Pantanal, except for ictiofauna, is forbidden by Brazilian laws, due to the lack of knowledge about biology of species and population dynamics. Fauna represents big enforcement costs for both the state and federal government, especially in the Pantanal, because of the extensive size of the region, the length of international borders and the difficult access. Past experiences have proven unsuccessful control of hunting and poaching just with the implementation of enforcement. It could be more promising to value fauna, so that the landowners would be interested in the sustainable use of these resources. At the same time, they would be stimulated to conserve this animal's habitats, and indirectly to preserve other species with no economic value, with no additional cost. This economic alternative to the existing productive system could reduce further the uncontrolled introduction of exotic grasses as well as other high impact activities.

Currently, the main target species for poaching are: caiman, lizards, anaconda, birds and felines. Together, they represent millions of dollars that could be contributed to the socio-economic development of the region.

4. CPAP Sustainable Wildlife Conservation Program

At present, CPAP is carrying out a program for the execution of the ecological studies applied to the conservation and technologies for the sustainable use of wildlife in the Pantanal. The sub-projects under this program are:

- aerial monitoring system of the distribution and abundance of large vertebrates in the Pantanal;
- experimental studies for the sustained use of natural populations of *jacaré* and *capibara* in the Pantanal;
- experimental studies for the sustained use of feral populations of pigs.

In order to carry out this ambitious program, CPAP has established partnerships with the several governmental agencies including: Federal University of Mato Grosso do Sul (UFMS), CECITEC, State Secretariat for the Environment of Mato Grosso do Sul (SEMA-MS), the Brazilian Institute of Environment (IBAMA), National Council of Research (CNPq), FINEP, the British Council, University of Florida at Gainesville, and the following non-governmental agencies: Fundação o

Boticário, Sociedade de Defesa do Pantanal (SODEPAN), Conservation International, and World Wildlife Fund (WWF).

However, execution of this and other programs under CPAP's mission are hindered by major constraints, such as:

- Lack of resources and training for the maintenance of facilities and equipment;
- Lack of financial resources for the acquisition of capital equipment and materials;
- Training of personnel and the necessity for consulting services.

CPAP is actively pursuing additional partnerships to foster the sustainable management and research of wetlands systems. The Pantanal, due to its vast extension and diversity, has found analogues in other latitudes Among these analogues are the Florida Everglades, the Orinoco Delta, and other smaller wetlands systems scattered throughout the hemisphere. Institutions in these areas are welcomed to visit the Pantanal and share the wealth of information that would enable the preservation and adequate management of these ecosystems for the enjoyment of future generations.

The Everglades Nutrient Removal Project: Hydrology, Hydrodynamics and Operation

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INTRODUCTION

The Florida Everglades is a unique ecosystem which sustains a variety of flora and fauna that are specific to the region. This ecosystem has been affected by many factors, both natural and anthropogenic. Changes to the natural hydroperiod and increased nutrient enrichment of inflow waters have transformed the floral and faunal communities of the Everglades (Davis, 1991; Koch and Reddy, 1992; Swift and Nicholas, 1987). The increased nutrient loading, primarily phosphorus (P), is largely due to agricultural runoff from the Everglades Agricultural Area (EAA). The 1991 Marjory Stoneman Douglas Everglades Protection Act (Section 373.4592 Florida Statute) requires the South Florida Water Management District (District) to regulate water quality in the Everglades system. The District proposes the development of Storm Water Treatment Areas (STAs) for reducing the P loading to the Everglades. These wetland treatment systems will function as nutrient filters.

The Everglades Nutrient Removal (ENR) project is the first wetland to be constructed and will initially function as a demonstration scale project. This 1500 ha (3700 ac) system, currently one of the largest constructed wetlands in the world, is designed to use different types of vegetated marshes to reduce the total P concentrations and loads in the EAA drainage water. The primary objectives of the ENR project are; 1) to reduce the amount of P in the water flowing into the Loxahatchee National Wildlife Refuge (Water Conservation Area 1, a regulated wetland system which was part of the original Everglades), and 2) to develop wetland treatment design criteria, operation schedules, and maintenance requirements for large scale application of wetland treatment systems (Everglades Systems Research Division, 1993). The experience gained from

the ENR project will be used to optimize wetland design and operation of large scale STAs for treating agricultural runoff from over 200,000 ha (500,000 acres) of agricultural drainage basin. The ENR project differs from many other constructed wetlands due to its size, pulsed loading of water, quantity of water to be treated, total P concentration range in which it will operate, and low 0.05 mg l^{-1} (50 ppb) total P discharge requirement (Newman, et al, 1993). The purpose of this paper is to describe the hydrology, hydraulics, and operation of the Everglades Nutrient Removal constructed wetland.

SITE DESCRIPTION

The ENR project site has highly organic soils and flat topography and is located in South Florida, about 32 km (20 miles) west of the city of West Palm Beach (Figure 1). Originally, the area was part of the natural Everglades system that consisted of custard apple and willow-elderberry swamps and sawgrass marshes interspersed with tree islands, wet prairies and sloughs (Davis, 1943). Since drainage and agriculture started in the area over six decades ago, about 1.52 m (5 ft) of the top muck soil has been lost due to soil subsidence, oxidation and shrinkage. At present, the surface 1-2 m (3.28 ft to 6.56 ft) is peat that overlays several meters of carbonate rock (Jammal and Associates, 1991).

The average ground elevation is 3.05 m (10 ft NGVD). A 12 km (7.5 miles) long perimeter levee, excluding the L-7 levee, surrounds the constructed wetland and the enclosed area is divided by internal levees into four treatment cells (Figure 2). The northern two parallel treatment cells (Cell 1 and Cell 2), referred to as Flow-way Cells, are being vegetated mainly through natural regrowth of cattails. The southern two cells (Cell 3 and Cell 4) are referred to as Polishing Cells. Polishing Cell 3 is planted with mixed marsh vegetation composed of Pickerelweed *(Pontederia Cordata)*, Arrowhead *(Sagittaria latifolia)*, Duck Potato *(Sagittaria lancifolia)*, Maidencane *(Panicum hemitomon)*, Sawgrass *(Cladium jamaicense)* and Spikerush *(Eleocharis spp.)*. Emergent macrophyte growth will be controlled in Polishing Cell 4 and it will be operated as a submerged/algal based vegetation system. A strip of natural regrowth will occur at the outlet of Cell 4. This vegetated area will function as a filter strip to minimize algal outflow.

HYDROLOGY

Hydrologic characteristics are probably the primary factors that influence and determine the establishment and maintenance of specific types of wetlands and wetland processes. Hydrology creates unique biological, chemical and physical conditions that make wetland ecosystems different from well-drained surface water systems and subsurface aquatic systems (Mitsch and Gosselink, 1986).

To evaluate the nutrient removal performance of the ENR project, nutrient mass and hydrologic budgets are required. A comprehensive water quality and quantity monitoring program was developed to provide parameter data necessary to accurately determine nutrient and hydrologic budgets. Water budgets will be calculated by monitoring rainfall, evapotranspiration, surface inflows, surface outflows, and seepage in and out. The balance of all the above components yields a change in storage, which represents the seasonal pattern of water stages within the wetland.

Rainfall

South Florida has a humid subtropical weather pattern with warm rainy summers and mild winters. Most of the rain occurs in the summer and fall. The wet season extends from the beginning of June to the end of October. In the Everglades Agricultural Area where the ENR project is found, 66 percent of the annual rainfall occurs during the wet season on the average (Abtew and Khanal, 1993). Wet season rainfall is from convective rainfalls, localized thunderstorms, tropical depressions and hurricanes. The dry season (November through May) rainfall is mainly frontal rainfall. The historical (1929-1991) average annual rainfall for the area is 133.2 cm (52.4 inches) (Abtew and Khanal, 1993).

An accurate water budget of the ENR constructed wetland is required to evaluate and improve the performance of the treatment system. Rainfall, one of the largest components of the water budget, needs to be measured as accurately as possible. Summer rainfall patterns indicate the occurrence of highly localized convective rainfall. Accurate areal rainfall measurement therefore requires a network with a high gage density. The decision was made to install ten continuous recording, ripping-bucket raingages to establish the extent of spatial and temporal variability of rainfall within the ENR. Data from this ten gage network will be used to compute hourly and daily areal rainfall for each cell and the whole site based on the Thiessen method. After one year of data collection, the network will be reevaluated and the number of stations may change according to results of this network analysis. The raingage network is shown in Figure 3.

Evapotranspiration

Another major component of the ENR hydrologic system is evapotranspiration (ET). Initially, evapotranspiration will be measured with lysimeters (Abtew et. al., 1993). Lysimeters will be installed in each of three vegetation communities; cattails, mixed marsh, and algae covered open water without macrophytes (Figure 3). Actual evapotranspiration measured from the lysimeters, will be used for water budget computation. An illustration of the lysimeter is shown in Figure 4. High resolution weather data will be collected at the site for calibration of the Penman-Monteith equation using concurrent measurements of evapotranspiration with the lysimeters.

Surface Inflows and Outflows

Water is supplied to the ENR Project via a pump station (G-250). Records for the pump operations will be used to determine discharges into the entrance (Buffer) cell. Water is moved from one cell to another by means of 16.76 m (55 ft) long and 1.83 m (6 ft) diameter circular culverts with risers. A riser consists of an upright half-culvert which contains stop logs acting as a variable height weir. The culverts operate under full flow with downstream control. Water, initially pumped into the Buffer Cell, can be routed into Cell 1 through a series of ten culverts with risers (G-252A-J) or Cell 2 through a series of five culverts with risers (G-255A-E). These 15 risers are 2.1 m (7.0 ft) in diameter. Outflows from Cell 1 are routed to Cell 3 through a series of ten culverts with risers (G-253A-J) and from Cell 2 to Cell 4 through a series of five culverts with risers (G-254A-E). These 15 risers are 3.7 m (12.0 ft) in diameter. Water exits Cell 3 and Cell 4 into collection canals and is discharged from the project through the outflow pump station (G-251). Records for the pump operations will be used to determine discharges into the Water Conservation Area 1 (WCA-1), supported also by ultrasonic velocity meter (UVM) measurements in the discharge canal. The locations of surface water control structures are shown in Figure 2.

To meet objectives of the ENR project, accurate determinations of hydrologic and nutrient

budgets for each treatment cell are required. Preliminary modeling of the ENR Project indicated that 30 percent of the time low flow conditions with culvert velocities less than 6.1 cm s^{-1} (0.2 ft s^{-1}) will exist. Under low flow conditions, the resulting head differential, which is on the order of a hundredth of a foot, does not permit use of stage-discharge equations to accurately calculate flow through the culverts. Therefore, alternative methods for monitoring inflows to and outflows from each treatment cell were evaluated. Previous experience has shown that electromagnetic velocity meters are not reliable under very low flow conditions and are very sensitive to fouling. Any debris or growth contacting the sensor will generate erroneous data. Hence, these meters would require extensive maintenance. Use of mechanical velocity meters to monitor flow requires that they be mounted near the center of the culvert cross section. This design is susceptible to fouling from water column debris and breakage by alligators.

Through peer reviews of the hydrologic monitoring system it was suggested that UVMs could be utilized to determine inflows and outflows to each treatment cell. UVMs operate using a bidirectional transmission of sonic energy between two transducers aligned at some angle to the flow. This technique is based on the principle that a pulse of sound traveling diagonally across a stream will be accelerated by the velocity in the downstream direction and will be decelerated when traveling in the upstream direction. Velocity is computed from the difference between the forward and backward travel time and the angle in degrees between the acoustic path and the flow.

SEEPAGE

To estimate horizontal seepage into and out of the ENR project, 12 pairs of staff gages and 12 piezometers, located along the perimeter and interior levees, will be used to determine water level gradients. Readings from staff gages and water levels in the piezometers will be collected at the same time in order to accurately determine head gradients. Water levels will be monitored with continuous recording stage gages and periodically read staff gages located throughout the site. Seepage rate coefficients will be determined from tests, and be used to estimate seepage based on head gradient data.

HYDRODYNAMIC MODELING

Some of the most important parameters affecting nutrient removal in wetland treatment systems are intimately related to water processes. Parameters such as water depths, hydraulic loading rates (HLR), and hydraulic retention times (HRT) can be obtained from hydrodynamic modeling simulations, and play an important role in designing wetland systems for nutrient removal. Hydrodynamic modeling is, in these circumstances, of extreme importance when interacting with water quality modeling. The capability of a model to simulate and predict water quality is dependent on its ability to simulate all the relevant hydrodynamic processes.

Hydrodynamic modeling for shallow water flow in wetlands is, in general, based on the solution of the Saint Venant differential equations, which describe continuity and momentum. In this particular case, the equations are in two horizontal dimensions (e.g. x and y directions) and vertically averaged for incompressible flow (Roig and King, 1992). Their results represent gradually varied, unsteady state flow, which is able to accurately provide flow depths, average flow velocities, hydrographs, flow patterns and HRTs.

Wetland vegetation plays an important role in hydrodynamic modeling. Vegetation influences

hydrologic conditions by consolidating the soil against erosion, trapping sediments, building peat deposits, interrupting water flows, and changing flow paths. The influence of vegetation on infiltration and soil water storage is due to plant roots and to the effect of organic matter on and in the soil, and to plant roots. Experiments have shown a positive correlation between the quantity of organic matter present in the soil and its water-holding capacity.

Knowledge of hydraulic resistance in marsh type wetlands is important in any application of the above mentioned equations. It has been hypothesized that longer HRT will result in increased phosphorous uptake. The HRT for the treatment cells increases as flow resistance increases. Currently, little information is available for resistance values in heavily vegetated wetlands. In most of the previous work, Manning's equation has been used to estimate overland flow resistance as a function of velocity, depth and slope. However, resistance values in marsh type systems are also a function of the distribution of vegetation both laterally and vertically, species composition and seasonal variations. Hydraulic resistance values can be predicted as a function of flow depth and vegetation characteristics.

The SHEET-2D model solves the non-conservative form of the differential equations by means of an implicit finite difference method and a double sweep scheme. This model was used to obtained steady state flow simulations for a range of constant inflows from 2.12 $m^3 s^{-1}$ (75 cfs) to 16.98 $m^3 s^{-1}$ (600 cfs). This simulations extended for 30 days with a time step of 30 seconds to assure reasonable accuracy, reaching steady state conditions after 21 days (Guardo and Tomasello, 1993). Flow vectors from these simulation results are depicted in Figure 5.

OPERATION

A portion of the agricultural drainage pumped out of the EAA is diverted to the ENR project via a 3.4 km (2.1 miles) supply canal that connects to the West Palm Beach canal upstream of the S-5A pump station. The West Palm Beach canal is one of the major channels for agricultural drainage from the EAA and water supply from Lake Okeechobee to the coast and Water Conservation Area 1. The inflow pump station (G-250) moves water from the supply canal into a 55 ha (135 ac) Buffer Cell via six pumps with a total capacity of 16.98 $m^3 s^{-1}$ (600 cfs). Water is then distributed to Flow-way Cell 1 and/or Flow-way Cell 2 through a series of culverts. Flow rates and water depths are regulated via risers and stop logs. Water is routed from Flow-way Cell 1 to Polishing Cell 3 and from Flow-way Cell 2 to Polishing Cell 4 via culverts with risers and stop logs. Water flows from Cells 3 and 4 into collection canals at the outlet where six pump units discharge the treated water into Water Conservation Area 1. Seepage out of the wetland through the western and northern sections of the perimeter levee is collected in a seepage canal and can be pumped back into the Buffer Cell using three seepage pumps (located at the inflow pump station) with a total capacity of 5.66 $m^3 s^{-1}$ (200 cfs). At the end of the treatment process, the outflow pump station (G-251) discharges the treated water to Water Conservation Area 1. The outflow pump station has six units with a total capacity of 12.74 $m^3 s^{-1}$ (450 cfs). If sufficient treatment is not attained with a single pass, water from the end of the system can be recirculated via the seepage canal.

There will be two ENR operation stages, each having distinct water level criteria: the startup phase (Stage I) and the long term phase (Stage II). Stage I will last from one to two years and is divided into two periods: the early startup period and the later startup period. During Stage I, it is necessary to insure good development and growth of the vegetation within the treatment cells.

Therefore, mimicking the drainage pumping pattern of the S-5A pump station will be restricted since long periods of flooding with high water depths would damage the developing plants due to the lack of oxygen and light. Following the start-up phase, the long term phase (Stage II) operation will begin. During Stage II, higher water depths will be allowed in the treatment cells. Within the limits of the criteria presented below, as much water as possible should be conveyed to the ENR before the S-5A pumps are turned on during a storm event. According to the preliminary operation scheme of the ENR, the recommended average water depths for maximize plant growth during Stage II should be 61 cm (2.0 ft), 70 cm (2.3 ft), 46 cm (1.5 ft), and 61 cm (.2.0 ft) in Flow-way Cell 1, 2, and Polishing Cells 2, 4 respectively (Guardo and Kosier, 1993).

The performance objective of the ENR project is to ensure that its discharge contains a lower phosphorus load than its inflow load from EAA stormwater runoff. Average annual total phosphorus concentration at the outlet should not exceed the corresponding concentration at the inlet during normal pumping from the ENR to the Refuge. To achieve this objective, total phosphorus levels at the inlet of the ENR and at its outlet pump station will be monitored on a weekly basis. The four-week moving average total inflow P concentration will be compared with the four-week moving average total outflow P concentration to account for an average hydraulic retention time (HRT) of approximately 28 days (Guardo and Kosier, 1993).

Controlled experiments to test the effects of water depth, hydraulic loading rates, hydraulic retention times and vegetation type on phosphorus removal will be conducted in two banks of Test Cells. Each bank has 15 cells and each cell has a unit area of 0.20 ha (0.5 ac). One bank of Test Cells is in Flow-way Cell 1 and the other is in Polishing Cell 3 (Figure 3). Results of the experimental work will be used to optimize the detailed design and operation of the ENR and additional STAs that will be constructed along the southern edge of the EAA. The average water depth was considered 60 cm (1.97 ft) and the average HLR 2.1 cm d^{-1} (0.83 in d^{-1}). These values yield the average HRT of 28 days. Two values above and below the average values were considered. They were 90 cm (2.95 ft) and 30 cm (0.98 ft) for the water depths, and 6.3 cm d^{-1} (2.48 in d^{-1}) and 0.7 cm d^{-1} (0.28 in d^{-1}) for the HLRs. Different combinations of water depths and HLRs will be used in the test cells to study several scenarios with different plant species.

CONCLUSION

The ENR project is a large constructed wetland for the treatment of agricultural drainage. As cattail revegetates naturally and other planted marsh plants fully develop, the former farmland will slowly convert over to a marsh ecosystem after being flooded. This transformation and its implications for nutrient removal will be documented and quantified as a part of a research plan. The ENR project is expected to require at least a year until vegetation is fully established. While the ENR project will become operational after construction is completed, it will not reach full operating performance until the following year. The nutrient removal capability of this ecosystem will be evaluated through water and nutrient budgets. Subsequent fine-tuning of the operational parameters should allow the project to reach peak performance in two to three years thereafter.

Since the ENR project is both a treatment and demonstration project, there is the need for good accounting of hydrologic, biological, and chemical parameters to monitor and improve performance of the system. A ten gage rainfall network is designed as an initial dense network to sample spatially variable hourly and daily rainfall. Evapotranspiration of the treatment macrophytes and algal covered open water has not been measured in the region. A lysimeter

system is designed to solve this problem. Also, with flat topography and low hydraulic heads, flow velocity measurements are not easy. UVMs will be used to measure low velocity flows and its performance will be intensively tested for use in other projects in south Florida. Data gathered in the first year of monitoring will be analyzed and the hydrologic network will be reevaluated and changes made accordingly.

Sufficient data will be collected during the first three years of the project to calibrate and validate a two-dimensional mathematical water quantity/quality model. The model will evaluate the effect of various combinations of HLRs, water depths, vegetation types and densities on nutrient removal. The operating schedule of the project will be based on optimization of the long term nutrient removal via peat accretion under the operating conditions developed for the South Florida environment (Koch and Reddy, 1992). The experience, research results, monitoring data, and validated model obtained from this prototype, demonstration-scale project will be used to optimize wetland design and hydrologic management of the full size STAs.

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Figure 1. Location of the Everglades Nutrient Removal Project

Figure 2. The Everglades Nutrient Removal Project

Figure 3. Raingages, Lysimeters and Weather Station Location

Figure 4. Illustration of Lysimeter at the Everglades Nutrient Removal Site

Figure 5. Flow Vectors Obtained from SHEET-2D Simulations at Day 27 for a 12.74 $m^3 s^{-1}$ (450 cfs) Inflow

Lessons Learned from Five Decades of Wetland Restoration and Creation in North America

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Substantial portions of this report are taken directly from J. A. Kusler and M. E. Kentula, eds., 1990. Wetland Creation and Restoration: The Status of the Science. Island Press, Washington, D.C., USA

Presented originally at The Ecological Basis of Restoration of Wetlands in the Mediterranean Basin, a training Course at the Hispanoamerica University of La Rábida (Huelva), Spain, 7-11 June 1993.

INTRODUCTION

In 1987, the U.S. Environmental Protection Agency (EPA) initiated a project to prepare a single source document summarizing the status of the scientific basis for wetland restoration and creation in the United Stales.

Thirty-two recognized wetland scientists assembled the known information and prepared draft papers for peer review. Jon A. Kusler and Mary E. Kentula edited the 29 resulting papers, which were published in October of 1989 as an EPA publication (EPA 600/3-89/038 a and b). The two volumes were reprinted as a single volume by Island Press (Washington, D.C.) in 1990 (ISBN 1-55963-044-2). This presentation summarizes the major findings of that report, in the hopes that our mistakes will not be repeated, and our successes will encourage others to continue our work.

This report is divided into four principal sections: (1) terminology and definitions; (2) conclusions regarding the adequacy of our scientific understanding concerning wetland restoration and creation; (3) recommendations for filling the gaps in scientific knowledge; and (4) recommendations for wetland managers with regard to restoration and creation based upon the status of our scientific understanding. The report concludes with an example of integrated watershed management.

TERMINOLOGY: SUGGESTIONS FOR STANDARDIZATION

It has been our collective experience that much confusion exists about specific terms, and they are used in different ways by different authors in different parts of the world. Unfortunately, much of the existing confusion is becoming formalized as states, counties, and municipalities develop their own regulations related to wetland creation and restoration. This discussion of terminology is meant to highlight the major problem areas.

Historical Context

In looking for a starting point, we were able to find only three existing glossaries applicable to the topic. These were contained in the U.S. Army Corps of Engineers Wetlands Delineation Manual prepared by the Environmental Laboratory Waterways Experiment Station, Vicksburg (Environmental Laboratory 1987), the U.S. Fish and Wildlife Service's classification of wetlands and deepwater habitats of the United States (Cowardin et al. 1979), and the proceedings of a conference titled Wetland Functions, Rehabilitation and Creation in the Pacific Northwest: The State of Our Understanding, prepared by the Washington State Department of Ecology (Strickland 1986). Three additional glossaries (Helm 1985, Rawlins 1986, and Soil Survey Staff 1975) were recommended by reviewers and have been used to improve this section. To these combined glossaries were added definitions from individual authors of published papers or proceedings, for example Zedler (1984) and Schaller and Sutton (1978), and regulatory or review agency rule promulgation, such as U.S. Fish and Wildlife Service (1981). Where the existing definitions were checked against dictionary definitions, Webster's Unabridged Dictionary, Second Editions (McKechnie 1983) was used as the reference dictionary. Some geological terms were taken from Bates and Jackson (1984) and Gary et al. (1927) as recommended by reviewers.

Discussion

The five key definitions are: mitigation, restoration, creation, enhancement, and success. Briefly, Webster's (1983) defines these terms as follows:

Mitigation	alleviation; abatement or diminution, as of anything painful, harsh, severe, afflictive, or calamitous (p. 1152);
Restoration	a putting or bringing back into a former, normal, or unimpaired state or condition (p. 1544);
Creation	the act of bringing into existence (p. 427);
Enhancement	the state or quality of being enhanced; rise, increase, augmentation (p. 603);
Success	favorable or satisfactory outcome or result (p. 1819).

For the purposes of this document, we are defining these terms so that there is as little ambiguity

and overlap as possible. The glossary definition and an explanation of each of the key terms is provided below.

Mitigation - For the purposes of this document, the actual restoration, creation, or enhancement of wetlands to compensate for permitted wetland losses. The use of the work mitigation here is limited to the above cases and is not used in the general manner as outlined in the President's Council on Environmental Quality National Environmental Policy Act regulations (40 CFR 1508.20).

Mitigation banking - Wetland restoration, creation, or enhancement undertaken expressly for the purpose of providing compensation for wetland losses from future development activities. It includes only actual wetland restoration, creation, or enhancement occurring prior to elimination of another wetland as part of a credit program. Credits may then be withdrawn from the bank to compensate for an individual wetland destruction. Each bank will probably have its own unique credit system based upon the functional values of the wetlands unique to the area. As defined here, mitigation banking does not involve any exchange of money for permits. However, some mitigation programs, such as those in California, do accept money in lieu of actual wetland restoration, creation or enhancement.

Restoration - Returned from a disturbed or totally altered condition to a previously existing natural or altered condition by some action of man. Restoration refers to the return to a pre-existing condition. It is not necessary to have complete knowledge of what those pre-existing conditions were; it is enough to know a wetland of whatever type was there and have as a goal the return to that same wetland type. Restoration also occurs if an altered wetland is further damaged and is then returned to is previous, though altered, condition. That is, for restoration to occur it is not necessary that a system be returned to a pristine condition. It is, therefore, important to define the goals of a restoration project in order to properly measure the success.

In contrast with *restoration, creation* (defined below) involves the conversion of a non-wetland habitat type into wetlands where wetlands never existed (at least within the recent past, 100-200 years). The term re-creation is not recommended here due to confusion over its meanings. Schaller and Sutton (1978) define restoration as a return to the exact pre-existing conditions, as does Zedler (1984). Both believe restoration is therefore seldom, if ever, possible. Schaller and Sutton (1978) use the term rehabilitation equivalent to our restoration. For our purposes, “rehabilitation” refers to the conversion of uplands to wetlands where wetlands previously existed. It differs from restoration in that the goal is not a return to previously existing conditions but conversion to a new or altered wetland that has been determined to be “better” for the system as a whole. Reclamation is also used to mean the same thing by some, but “wetland reclamation” often means filling and conversion to uplands, therefore its use is not recommended.

Creation - The conversion of a persistent non-wetland area into a wetland through some activity of man. This definition presumes the site has not been a wetland within recent times (100-200 years) and thus restoration is not occurring. Created wetlands are subdivided into two types, artificial and man-induced. An artificial created wetland exists only as long as some continuous or persistent activity of man (i.e., irrigation, weeding) continues. Without attention from man, artificial wetlands revert to their original habitat type. Man-induced created wetlands generally result from a one-time action of man and persist on their own. The one-time action might be

intentional (i.e., earthmoving to lower elevations) or unintentional (i.e., dam building). Wetlands created as a result of dredged material deposition may have subsequent periods during which additional deposits occur. Man-initiated is an acceptable synonym.

Enhancement - The increase in one or more values of all or a portion of an existing wetland by man's activities, often with the accompanying decline in other wetland values. Enhancement and restoration are often confused. For our purposes, the intentional alteration of an existing wetland to provide conditions which previously did not exist and which by consensus increase one or more values is enhancement. The diking of emergent wetlands to create persistent open-water duck habitat is an example; the creation of a littoral shelf from open water is another example. Some of the value of the emergent marsh may be lost as a result (i.e., brown shrimp nursery habitat).

Success - Achieving established goals. Unlike the dictionary definition, success in wetlands restoration, creation, and enhancement ideally requires that criteria, preferably measurable as quantitative values, be established prior to commencement of these activities. However, it is important to note that a project may not succeed in achieving its goals yet provide some other values deemed acceptable when evaluated. In other words, the project failed but the wetland was a “success”. This may result in changing the success criteria for future projects. It is important, however, to acknowledge the non-attainment of previously established goals (the unsuccessful project) in order to improve goal setting. In situations where poor or nonexistent goal setting occurred, functional equivalency may be determined by comparison with a reference wetland, and success defined by this comparison. In reality, this is easier said than done.

ADEQUACY OF THE SCIENCE BASE

1. Practical experience and the available science base on restoration and creation are limited for most wetland types and vary regionally.

Experience in wetland restoration and creation varies with region and wetland type, as does the evaluation and reporting of such experience in the scientific literature. Hundreds and perhaps thousands of coastal and estuarine mitigation projects have been constructed along the Eastern seaboard. These projects have been subject to a fair amount of follow-up monitoring and have been quite widely reported in the literature. Fewer projects have been implemented on the Gulf and Pacific coasts and, correspondingly, there is a smaller literature base.

In general, much less is known about restoring or creating inland wetlands. However, two types of inland wetland projects have been quite common: impoundments to create waterfowl and wildlife marshes, and creation of marshes on dredged spoil areas along major rivers. Despite the number of these impoundment projects and a relatively large literature base dealing with waterfowl production and other related topics, only a modest portion of the literature critically examines these efforts. A modest literature base is available on wetlands created on dredged spoil. The best known research is that of the U.S. Army Corps of Engineers Dredge Materials Program.

2. Most wetland restoration and creation projects do not have specific, measurable goals, complicating efforts to evaluate “success”.

Project goals have rarely been specified, even in cases where wetlands have been intentionally

restored or created. This has complicated efforts to evaluate “success”. Lacking such goals, success has commonly been interpreted as the establishment of vegetation that covers a percentage of the site and exists for a defined period of time (e.g., 2-3 years). Such measures of success, however, do not indicate that a project is functioning properly nor that it will persist over time. Often these criteria have some relationship to the characteristics of the natural wetlands of the same type in the region, but this relationship is limited. In the rare cases where project goals have been formulated and follow-up studies conducted, there have been situations where failure to meet specific goals has occurred although there was partial or total revegetation of the site.

Ideally, success should be measured as the degree to which the functional replacement of natural systems has been achieved. This is much more difficult to assess and cannot be routinely quantitatively determined. The ability to estimate success of future projects will be fostered through establishing specific goals that can be targeted in an evaluation.

3. Monitoring of wetland restoration and creation projects has been lacking and needs more emphasis.

Despite thousands of instances in which wetlands have been intentionally or unintentionally restored or created in the United States, in the last 50 years there has been very little short term monitoring and even less long term monitoring of sites. Monitoring of sites and comparisons with naturally occurring wetlands over time would provide a variety of information including rates of revegetation, repopulation by animal species, and redevelopment of soil profiles, patterns of succession, and evidence of persistence.

DOCUMENTED SUCCESS OF RESTORATION AND CREATION

1. Restoration or creation of a wetland that “totally duplicates” a naturally occurring wetland is difficult; however, some systems may be approximated and individual wetland functions are documented to have been restored or created.

Total duplication of natural wetlands is difficult due to the complexity and variation in natural as well as created or restored systems and the subtle relationships of hydrology, soils, vegetation, animal life, and nutrients which may have developed over thousands of years in natural systems. Nevertheless, experience to date suggests that some types of wetlands can be approximated and certain wetland functions can be restored, created, or enhanced in particular contexts. It is often possible to restore or create a wetland with vegetation resembling that of a naturally occurring wetland. This does not mean, however, that it will have habitat or other values equaling those of a natural wetland nor that such a wetland will be a persistent, i.e., long term, feature in the landscape, as are many natural wetlands.

2. Partial project failures are common.

For certain types of wetlands, total failures have been common (e.g., seagrasses, certain forested wetlands). Although the reasons for partial or total failures differ, common problems include:

- lack of basic scientific knowledge, due to emphasis on civil engineering;
- lack of staff expertise in design, and lack of project supervision during implementation phases;

- improper site conditions, e.g.: water supply, hydroperiod, water depth, water velocity, salinity, wave action, substrate, nutrient concentration, light availability, sediment rate, improper grades (slopes);
- invasion by exotic species;
- grazing by geese, muskrats, other animals;
- destruction of vegetation or the substrate by floods, erosion, fires, other catastrophic events;
- failure of projects to be carried out as planned;
- failure to protect projects from on-site and off-site impacts such as sediments, toxics, off-road vehicles, groundwater pumping, etc.; and
- failure to adequately maintain water levels.

3. Success varies with the type of wetland and target functions including the requirements of target species.

A relatively high degree of success has been achieved with revegetation of coastal, estuarine, and freshwater marshes because elevations are less critical than for forested or shrub wetlands, native seed stocks are often present, and natural revegetation often occurs. Marsh vegetation also quickly reaches maturity in comparison with shrub or forest vegetation. However, some types of marshes, such as those dominated by *Spartina patens,* have been difficult to restore or recreate due to sensitive elevation requirements.

Much less success has been achieved to date with seagrasses and forested wetlands. The reasons for lack of success for seagrasses are not altogether clear, although use of a site where seagrasses have previously grown seems to improve the chances of establishing the plants. Lack of success for forested wetlands is due, at least in part, to their sensitive long term hydrologic requirements. Such systems also reach maturity slowly.

Although certain types of wetland vegetation may be restored or created, there have been few studies concerning the use of restored or created wetlands by particular animal species. Restoration or creation of habitat for ecologically sensitive animal or plant species is particularly difficult.

4. The ability to restore or create particular wetland functions varies by function.

The ability to restore or create particular wetland functions is influenced by (1) the amount of basic scientific knowledge available concerning the wetland function; (2) the ease and cost of restoring or creating Certain characteristics (e.g., topography may be created with relative ease, while creation of infiltration capacity is difficult); and (3) varying probabilities that structural characteristics will give rise to specific functions. For example (note this is meant to be illustrative only), the most successful are typically:

- Flood storage and flood conveyance functions can be quantitatively assessed and restored or created with some certainty by applying the results of hydrologic studies. Topography is the critical parameter and this is probably the easiest parameter to

restore or create.

- Waterfowl production functions may be assessed or created with fair confidence in some contexts due to the large amount of experience, scientific knowledge, and information on marsh design, and marshes are, relatively speaking, easily restored or recreated.

- Wetland aesthetics may or may not be difficult to restore or create, depending on the wetland type and the site conditions. Visual characteristics are, in general, much easier to restore than subtle ecological functions.

- Fisheries habitat may be assessed and restored or created. However, the ability to restore or create fisheries habitat will depend on the species and the site conditions.

- Some food chain functions may be assessed, restored, or created. Other more subtle functions are difficult due to the lack of basic scientific knowledge and experience.

More difficult are:

- Certain pollution control functions (e.g., sediment trapping) may be relatively easy to assess and create. However, others (e.g., immobilization of toxic metals) may be difficult to create, particularly in the long term, because of uncertainties concerning the long term fate of pollutants in wetlands and their impact on the wetland system.

- Groundwater recharge and discharge functions are difficult to assess and create. One compounding factor is that soil permeability may change in a creation or restoration context (e.g., a sandy substrate may quickly become impermeable due to deposition of organics).

- Heritage or archaeological functions (e.g., a shell midden located in a marsh) are impossible to restore or create since they depend upon history for their value.

5. Long term success may be quite different from short term success.

Revegetation of a restored or created wetland over a short period of time (e.g., one year) is no guarantee that the area will continue to function over time. Unanticipated fluctuations in hydrology are a particularly serious problem for efforts to restore or create wetland types (e.g., forested wetlands) with very sensitive elevation or hydroperiod requirements. Droughts or floods may destroy or change the targeted species composition of projects.

Hydrologic fluctuations also occur in natural wetlands. But hydrologic minima and maxima as well as “normal” conditions exist within tolerable ranges at particular locations, otherwise the natural wetland types would not exist. Natural wetlands have been tried and tested by natural processes and are, in many instances, “survivors”.

Long term damage to or destruction of restored or created systems may be due to many other factors in addition to unanticipated hydrologic changes. Common threats include pollution, erosion and wave damage, off-road vehicle traffic, and grazing. Excessive sediment is a serious problem for many restored or created wetlands located in urban areas with high rates of erosion and sedimentation. Unlike many natural wetlands, restored or created wetlands also often lack

erosional equilibrium (in a geomorphic sense) with their watersheds.

6. Long term success depends upon the ability to assess, recreate, and manipulate hydrology.

The success of a project depends to a considerable extent, upon the ease with which the hydrology can be determined and established, the availability of appropriate seeds and plant stocks, the rate of growth of key species, the water level manipulation potential built into the project, and other factors. To date, the least success has been achieved for wetlands for which it is very difficult to restore or create the proper hydrology. In general, the ease with which a project can be constructed and the probability of its success are:

- Greatest overall for estuarine marshes due to (1) the relative ease of determining proper hydrology; (2) the experience and literature base available on restoration and creation; (3) the relatively small number of wetland plant species that must be dealt with; (4) the general availability of seeds and plant stocks; and (5) the ease of establishing many of the plant species. However, it is difficult or impossible to restore or create certain estuarine wetland types due to narrow tidal range or salinity tolerances, e.g., high marshes dominated by *Spartina patens* on the East Coast. The same is true of estuarine wetlands in regions or areas with unique local conditions, e.g., the hypersaline soils common in southern California salt marshes.

- Second greatest for coastal marshes for the same reasons as those given for estuarine wetlands. However, high wave energies and tidal ranges of the open coast reduce the probability of success.

- Third greatest for freshwater marshes along lakes, rivers, and streams. The surface water elevations can often be determined from stream or lake gauging records. There is a fair amount of literature and experience in restoring and managing these systems. However, vegetation types are often more complex than those of coastal and estuarine systems. Problems with exotic species are common. Determination and restoration or creation of hydrology (including flood levels) and hydrology/sediment relationships are more difficult. This is frequently compounded by altered hydrology and sedimentation patterns due to dams and water extractions.

- Fourth greatest for mangrove forests, due to sensitivity to small changes in elevation, wave energy, and temperature extremes. Propagules and seedlings are also relatively slow-growing.

- Fifth greatest for isolated marshes supplied predominantly by surface water. There is limited experience and literature on restoring or creating such wetlands except for waterfowl production where water levels are manipulated on a continuing basis. Determination and restoration of hydrology is very difficult unless mechanisms are available for actively managing the water supply. Depending on the wetland type, plant assemblages can also be complex.

- Sixth greatest for forested wetlands along lakes, rivers, and streams. Determination and restoration or creation of hydrology is very difficult due to narrow ranges of tolerance. Water regimes may be evaluated with the use of records for adjacent

waters, but such records are often not sensitive enough. There is also limited literature or experience in restoring such systems. Vegetation is diverse; both the understory and the canopy communities may need to be established. Moreover, it may take many years for a mature forest to develop.

• Seventh greatest for isolated freshwater wetlands (ranging from marshes to forested wetlands) supplied predominantly with ground water. Determining and creating the hydrology is very difficult. There is limited experience and literature except on some prairie pothole wetlands.

• Eighth and least for seagrass meadows, due to water quality requirements. Seagrasses require overlying water that is low in dissolved nutrients and suspended sediments and high in light transparency. Substrate, depth, and currents are also critical factors in establishing seagrass meadows.

7. Ecological success often depends upon the long term ability to manage, protect, and manipulate wetlands and adjacent buffer areas.

Restored or created wetlands are often in need of “mid-course corrections” and management over time. Original design specifications may be insufficient to achieve project goals. Created or restored wetlands are also particularly susceptible to invasion by exotic species, sedimentation, pollution, and other impacts due to their location in urban settings and the inherent instability of many of their systems. Careful monitoring of systems after their original establishment and the ability to make mid-course corrections and, in some instances, to actively manage the systems, are often critical to long term success.

Efforts to create or enhance waterfowl habitat by wildlife agencies and private organizations through the use of dikes, small dams, and other water control structures have been quite successful due, in large measure, to the ability to control and alter the hydrologic regime over time. Water levels may be changed if original water elevations prove incorrect for planned revegetation. Drawdown and flooding may be used to control exotics and vegetation successional sequences.

However, most wetland restoration or creation efforts proposed by private and public developers do not involve water control measures. In addition, few developers are willing to accept long term responsibility for managing systems. Water level manipulation capability and long term management capability are also insufficient, in themselves, without long term assurances that the system will be managed to achieve particular wetland functional goals. For example, water level manipulation and long term management capability exist for most flood control, stormwater, and water supply reservoirs. But wetlands along the margins of these reservoirs are often destroyed by fluctuations in water levels dictated by the primary management goals.

Restored or created wetlands should be designed as self-sustaining or self-managing systems unless a project sponsor (such as a wildlife agency or duck club) clearly has the incentive and capability for long term management to optimize wetland values.

The management needs of restored or created wetlands are not limited to water level manipulation. Common management needs for both wetlands subject to water level manipulation and those not subject to such manipulation include:

- Replanting, regrading, and other mid-course corrections.
- Establishment of buffers to protect wetlands from sediment, excessive nutrients, pesticides, foot traffic, or other impacts from adjacent lands.
- Establishment (in some instances) of fences and barriers to restrict foot traffic, off-road vehicles, and grazing animals in wetlands.
- Adoption of point and nonpoint source pollution controls for streams, drainage ditches, and runoff flowing into wetlands.
- Control of exotics by burning, mechanical removal, herbicides, or other measures.
- Periodic dredging of certain portions of wetlands subject to high rates of sedimentation (e.g., stormwater facilities).

8. Success depends upon expertise in project design and upon careful project supervision.

Hydrologic and biological as well as botanical and engineering expertise are needed in the design of many projects. In addition, the involvement of experts with prior experience in wetland restoration or creation is highly desirable. Too much emphasis on civil engineering expertise only has hampered successful wetland restoration efforts in North America. Less expertise may be needed where restoration is to occur, the original hydrology is intact, and nearby natural seed stocks exist.

Careful project supervision is also needed to ensure implementation of project design. It is not enough to design a project and turn it over to traditional construction personnel. For example, bulldozer operators often need guidance with regard to critical elevation requirements, drainage, and the spreading of stockpiled soil. Plantings must be shaded from the sun and kept moist until they are placed in the ground.

9. “Cook book” approaches for wetland restoration or creation will likely be failures.

Too little is known from a scientific perspective about wetland restoration to provide rigid, “cook book” guidance. The interdependence of a large number of site-specific factors also warrants against too rigid an approach. For example, in a salt marsh, maxima and minima in hydrologic conditions for particular plant species may depend not only on elevation but on salinity, wave action, light, nutrients, and other factors. Often the best model is a nearby wetland of similar type.

Although “cook book” approaches prescribing rigid design criteria are not desirable, guidance documents suggesting ranges of conditions conducive to success are possible. Requirements for wetland creation that incorporate such general criteria, combined with incentives and flexibility to allow for experimentation offer an increased probability of success as well as a contribution to the information base.

FILLING THE GAPS IN SCIENTIFIC KNOWLEDGE

A variety of measures are needed to fill the gaps in our scientific knowledge. The full range of topics needing further research is impressive and perhaps intimidating, given the limited funds

available for wetlands research. Cost-effective measures will be needed to fill the gaps, relying, to the extent possible, upon cooperative sources of funding and innovative strategies. For example, the private and public development sector may be able to provide a portion of the needed research through the monitoring of various restoration and creation projects. Research in wetland restoration and creation may also take place cost-effectively as part of broader lake restoration, strip mine restoration, river restoration, reforestation, Superfund cleanup, or post-natural-disaster (flood, fire, landslide) recovery efforts. Some of the measures needed to fill the gaps include:

1. Systematic monitoring of restoration or creation projects.

Given the high cost of demonstration projects, the greatest potential for filling gaps in scientific knowledge may lie with careful monitoring of selected types of new restoration or creation projects. Standardized methods for project evaluation and project monitoring are needed to facilitate determination of “success” and comparisons between systems and approaches. A regional, national and international database on projects should be created.

Monitoring should involve:

- Careful baseline studies on the original, native wetland systems before they are degraded or destroyed.

- Monitoring of selected features of the new or restored systems at periodic intervals (e.g., time zero, six months, a year, three years, five years, ten years, twenty-five years, etc.) to determine characteristics of the restored or created wetlands (vegetation types, vegetation growth rates, fauna, etc.), functions of the wetlands and persistence of the wetlands. The precise features needing monitoring and the level of monitoring detail will differ, depending upon the type of wetland and specific research needed.

Monitoring of new projects can be made a condition of project approval, although, equitably and practically, there must be limits to the prior or post-construction studies and to the duration of the post-construction monitoring period. Project sponsors may be required to carry out monitoring to ensure project success over a specified period of time, but they may balk at more basic research responsibilities. Cooperative projects between project sponsors and academic institutions and nonprofit or government research organizations may reduce the burden on project sponsors while improving the quality of long term monitoring. Such cooperative projects may also involve comparisons between restored or created wetlands and natural wetlands in the region.

After-the-fact monitoring of restoration and creation projects already in existence may also provide valuable information, although many such projects lack detailed baseline information concerning the original wetland or the specifics of the restoration or creation effort (e.g., size, substrate, planting, etc.).

2. Demonstration projects.

Wetland demonstration projects established by universities, research laboratories, or agencies to test various restoration or creation approaches offer the greatest “control” and have the greatest potential for answering some research questions. The National Wetland Technical Council recommends the establishment of a series of such demonstration projects on a regional basis.

However, such projects will likely be expensive to establish and monitor. Funds may be generated by making such projects multi-objective like the riverine wetland demonstration projects on the Des Plaines River north of Chicago established by Wetland Research. This demonstration project also provides a regional park and wetland educational area.

3. Traditional scientific research.

More scientific research is needed on a wide variety of specific topics. Many of the topics relate to basic issues in wetland science, not simple wetland restoration or creation. Some of this research needs to be conducted on natural as well as altered or created systems. The research could involve laboratory experiments, traditional field research, the monitoring of restoration or creation projects, and the establishment of demonstration projects.

Particularly critical topics include:

- The hydrologic needs and requirements of various plants and animals, minimum water depths, hydroperiod, velocity, dissolved nutrients, and the role of large scale but infrequent hydrologic events such as floods and long term fluctuations in water levels.

- The importance of substrate to flora, fauna, and various wetland functions such as removal of toxics.

- Characteristics of rates of natural revegetation in contrast with various types of plantings.

- A comparison of the functions of natural versus restored or created wetlands with special emphasis upon habitat value for a broad range of species, food chain support, and water quality protection and enhancement functions.

- An evaluation of the stability and persistence of restored or created systems in various contexts and in comparison with natural systems.

- An evaluation of the impact of sediment, nutrients, toxic runoff, pedestrian use, use by off-road vehicles, grazing, and other impacts upon restored or created wetlands and their functions in various contexts. Further investigation of management alternatives to reduce or compensate for such impacts is also needed.

- Landscape-level comparisons of natural and restored or constructed systems, including wetland and upland systems, from a broad range of ecological perspectives.

Further research into wetland restoration and creation will help provide the scientific know-how for restoring systems which are already degraded as well as for reducing future impacts. It will, more broadly, test the limits of knowledge of wetland ecosystems and how they function. The result will be the production of valuable, broadly applicable, scientific information. Without such knowledge, the restoration and creation of wetlands in many contexts will continue to be largely a matter of trial and error.

4. Continued synthesis of existing scientific knowledge.

Additional specific guidance documents based upon existing information could be prepared for the restoration and creation of specific types of wetlands and specific functions. Although production of syntheses is typically limited by time, funding, and geographical scope, pertinent information is constantly being generated.

Such synthesis efforts might productively draw upon the “grey” wetland literature, such as permit files and the records of wildlife refuge managers and nonprofit land management organizations. They might also productively draw (where applicable) upon the larger body of scientific literature with information of potential interest to specific aspects of restoration or creation. These include scientific reports and studies pertaining to restoration of lakes, restoration of streams, restoration of strip-mined areas, Superfund cleanup efforts, and restoration of other ecological systems such as prairies. Studies of natural response and recovery processes for systems impacted by floods, volcanoes, fires, and other natural processes should also be consulted.

Synthesis efforts should focus not only upon the creation or restoration of systems but also on their subsequent maintenance and management. Particularly good candidates for such syntheses (because of the large number of restoration or creation efforts now being attempted) include:

- Wetlands created to serve as stormwater detention areas,
- Wetlands along the margins of flood control and water supply reservoirs and other impoundments designed to provide habitat, control erosion, protect water quality, etc.,
- Wetlands designed to served as primary, secondary, or tertiary treatment facilities.

RECOMMENDATIONS FOR WETLAND MANAGERS

There are many policy questions and mixed policy-science questions which the wetland regulator must address in evaluating permits proposing wetland restoration and creation such as prior site analysis requirements (e.g., alternative site analysis); acceptable levels of degradation for the original wetlands; desired levels of compensation (e.g., acreage ratios); types of compensation (e.g., in-kind, out-of-kind); and location of compensation (on-site, off-site). Based upon review of the adequacy of the scientific base for wetland restoration and creation, recommendations may be made with have broad scale applicability to restoration or creation efforts wherever they may occur.

1. Wetland restoration and creation proposals must be viewed with great care, particularly where promises are made to “restore” or “recreate” a natural system in exchange for a permit to destroy or degrade an existing more or less natural system.

Experience to date indicates that too little is known about restoration and creation and there are too many variables to predict “success” for restoration or creation in many contexts. There have been too few projects with too little monitoring, and there is too limited a literature base. This does not mean, however, that wetlands with characteristics approximating certain natural wetlands or with specific functions resembling those of the natural wetlands cannot, in some instances, be restored or created. Enough is known to suggest key factors or considerations in restoration and creation. And there is a considerable body of experience pertaining to certain types of wetlands (e.g., marshes for waterfowl production) in certain contexts.

2. Multidisciplinary expertise in planning and careful project supervision at all project phases is needed.

Experience to date suggests that project success will depend, to a considerable extent, upon the care with which plans are prepared and implemented and the expertise of the project staff. Restoration and creation projects require slightly different types of inputs at each phase:

- Project design: Wetland restoration or creation without hydrologic design will fail. This does not mean that a hydrologist must be involved with every project but that hydrology must be carefully considered. Careful documentation of elevations and other hydrologic characteristics of naturally occurring systems, including either the original unaltered system or nearby systems, can be a helpful guide. Individuals with hydrologic as well as botanical and biological expertise are essential for successful project design. A soils expert may also be needed, depending upon the project.

- Project implementation: Careful supervision of bulldozer operators and other implementation personnel by someone with a complete understanding of the critical parameters for the project such as grade, drainage, soil, and planting needs is critical.

- Post-project monitoring and mid-course corrections: Botanical and biological expertise is essential for project monitoring and to design mid-course corrections.

A project applicant should provide information concerning the qualifications of project staff at each phase of project design and implementation, such as degree qualifications, work experience, etc.

3. Clear, site-specific, measurable goals should be established.

Because no wetland can be restored or duplicated exactly, it is important that the applicant establish site-specific goals for a restoration and creation project related to existing and proposed wetland characteristics and functions. These goals should be used to assist design, monitoring, and follow-up as well as to act as a benchmark for success. These goals can, depending upon the circumstances, relate to the size of the area being restored, the type of vegetation, the density of vegetation, vegetation growth rates, target fauna species, intended management activities, and other parameters.

4. A relatively detailed plan concerning all phases of a project should be prepared in advance to help the regulatory and review agencies evaluate the probability of success for that type of wetland, at that site, meeting specific goals.

Generalized project information indicating that a project applicant will “create a wetland” at a particular site provides no real basis for determining the probable success of a project. Although needed information will differ, depending upon the type of wetland and area, at a minimum, a plan needs to specify:

- Clear project goals and measures for determining project success;
- The boundaries of the proposed restoration or creation area;
- The proposed elevations;
- Sources of water supply and connection to existing waters and uplands;

- Proposed soils and probable sedimentation characteristics;
- Proposed plant materials;
- Whether exotics are, or may be, present and, if so, what is to be done to control them;
- Methods and timing for plantings (if replanting is to take place);
- A monitoring program, and
- Proposed mid-course correction and project management capability.

The amount of formality and detail needed for a restoration plan may depend upon the size of the project, its location, the type of wetland, and other factors.

5. Site-specific studies should be carried out for the original system prior to wetland alteration.

Due to complexities in natural systems, the lack of an extensive scientific base, and difficulties in formulating standards for restoration or creation at a site, a careful inventory of wetland characteristics (size, hydroperiod, soil type, vegetation types and densities, fauna) should take place prior to wetland destruction to determine wetland values and functions, act as a guide for restoration at the site or creation at an analogous site, and form the comparative basis for determining the success of the restoration or creation project.

6. Careful attention to wetland hydrology is needed in design.

Although the basic design needs for “successful” (i.e., meeting specified goals) wetland restoration or creation will differ by type of wetland and area, wetland hydrology is the key (although not necessarily sufficient in itself) to long term functioning systems. Relevant hydrologic factors include: water depths (maxima, minima, norms), velocity, hydroperiod, salinity, nutrient levels, sedimentation rates, levels of toxics and other chemicals, etc.

7. Wetlands should, in general, be designed to be self-sustaining systems and “persistent” features in the landscape.

To the extent possible, restoration and creation projects should be self-sustaining without the need for continued water level manipulation or other management over the life of the project unless such management is an intentional feature of the project (e.g., a wildlife refuge for waterfowl production) and a government agency or other responsible body with long term maintenance powers will have responsibility for the project.

Reforestation or creation projects attempting to replace natural wetlands or designed to serve long term objectives should also include design features ensuring the long term existence of such projects. To be persistent, wetlands must not be located in areas where natural or manmade processes such as wave action, excessive sedimentation, toxics, or changes in water supply will destroy them. However, many must also undergo periodic major stresses such as fires, floods, and icing over which interrupt the vegetational sequences that occur in most natural wetlands. Such stress must be of a magnitude sufficient to interrupt successional sequences but not great enough to destroy the wetland.

8. Wetland design should consider relationships of the wetland to the watershed water sources, other wetlands in the watershed, and adjacent upland and deep water habitat.

Although cost may prevent broad scale analyses for every restoration and creation project, an analysis of a proposed restoration or creation in a broader hydrologic and ecological context is needed, particularly where “in-kind” goals are not to be applied, where the existing wetland is already degraded, where specific habitat or other values dependent upon the broader context are to be created, or where expected urbanization or other alterations in the watershed or on adjacent lands may threaten the wetland to be created or restored.

9. Buffers, barriers, and other protective measures are often needed.

Protective measures are needed for many restored or created wetlands which may be threatened by excessive sedimentation, water pollution, diversion of water supply, foot traffic, off-road vehicles, and exotic species. Such measures are particularly needed in urban or urbanizing areas with intensive development pressures. Measures may include buffers, fences or other barriers, and sediment basins.

10. Restoration should be favored over creation.

In general, wetland restoration at the site of an existing but damaged or destroyed wetland will have a greater chance of success in terms of recreating the full range of prior wetland functions and long term persistence that wetland creation at a non-wetland site. This is due to the fact that pre-existing hydrologic conditions are often more or less intact, seedstock for wetland plants are often available, and fauna may re-establish themselves from adjacent areas.

11. The capability for monitoring and mid-course corrections is needed.

Due to the lack of basic scientific knowledge, lack of experience in restoring and creating many types of wetlands, and the possibility that any effort will fail to meet one or more goals, restoration and creation projects should be approached as “experiments”. The possibility of mid-course corrections should be reflected in project design in the event that the project fails to meet one or more specified goals. Such corrections may involve replanting, regrading, alterations in hydrology, control of exotics, or other measures.

12. The capability for long term management is needed for some types of systems.

In some instances, long term management capability is critical to the continued functioning of a system. Such management may include water level manipulation, control of exotics, controlled bums, predator control, and periodic sediment removal.

13. Risks inherent in restoration and creation and the probability of success for restoring or creating particular wetland types and functions should be reflected in standards and criteria for projects and project design.

Risks and probability of success should be reflected in the stringency of design requirements, area ratios (e.g., 1:1.5, 1:2) and standards for possible mid-course corrections for projects. Where restoration or creation is very risky or the possibility of project failure may have serious consequences (e.g., destruction of endangered species), successful completion of the restoration or creation project prior to damage to or destruction of the original wetland is needed.

14. Restoration for artificial or already altered systems requires special treatment.

Restoration and creation efforts for wetlands already in an altered condition raise special issues

and special problems. In restoring an altered wetland, an historical analysis suggesting natural conditions and functions may provide better guidance for restoration than simple documentation and replication of the status quo. A regional analysis of wetland functions and values and "needs" is also desirable.

15. Emphasis on ecological restoration of watersheds and landscape ecosystem management requires advanced planning.

The failure of small scale projects in North America has led to a new emphasis on ecological restoration of watersheds and landscape ecosystem management. This requires advanced planning to determine the ecological restoration needs of a region prior to initiating restoration programs.

AN EXAMPLE OF INTEGRATED WATERSHED MANAGEMENT

The Kissimmee River, Lake Okeechobee, and Everglades (KLOE) Watershed (Figure 1) is perhaps one of the largest, if not the largest, ecosystem restoration efforts in the world. The three primary projects are: (1) restoration of the Kissimmee River flowing into Lake Okeechobee; (2) the treatment of stormwater runoff coming from the Everglades Agricultural Area (EAA); and (3) the restoration of historical water flows to Florida Bay through Taylor Slough. The total cost of these projects is estimated at $1 billion (U.S.) but may rise.

A summary of just the primary EAA- and non-EAA-related projects comprising one-third of the total project is presented in Table 1, taken from the Everglades SWIM (Surface Water Improvement and Management) plan prepared by the South Florida Water Management District. The total KLOE Watershed ecosystem occupies 5,778 square miles (14,965 km^2) and the projects are planned to be accomplished over the next decade.

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The Role of Wetland Filters in Ecosystem Restoration

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For almost as long as there has been civilization, humans have exploited wetlands. They have been drained for agriculture, or to eliminate pests. They have served as dumping grounds. They have been fished, hunted, and logged. As a result of human activities the amount and nature of wetlands on most continents have been dramatically changed. This trend has only accelerated in the last 100 years with the increase in our ability to alter our environment. We have developed alternatives to provide those wetland functions we view as desirable. We built dams and water treatment systems for water control and purification. We have developed stocking and rearing programs to replace natural nurseries. But to a greater extent than we have substituted for them, we have eliminated wetlands.

“Restoration” of ecosystems is currently of great interest, and wetlands are increasingly becoming a focus of restoration or re-creation efforts. It is worth noting that it is very rare that the restoration of an entire landscape ecosystem is even contemplated. Rather we restore or reclaim portions of the systems within a landscape, to the extent that the human activities will allow. We are in fact reclaiming essential functions of the system (as we see it) within a fraction of original space. A significant part of those essential functions is associated with wetlands.

In the last two decades, the concept of wetlands as filters has been developed in a variety of ways. Wetlands are being restored or created to repair past human impacts, and to reduce the impacts of human activity on the rest of a particular system. Such work occurs at two different scales, often for different purposes. Large scale restorations often focus on re-establishing hydrologic patterns for flood control or habitat restoration purposes. They are generally restorations of former marshes and rely on natural re-vegetation. The St. Johns River Upper Basin Project, a 61,000 hectare marsh restoration project in Florida is designed primarily for flood control, restoring a large amount of marsh habitat to store floodwater rather than channeling it downstream (Sterling and Padera, in press). The marsh vegetation acts as a dam, slowing the downstream movement of water. The system is designed to temporarily store as

much a 680 million cubic meters of storm runoff. The Kissimmee River Project is restoring wetland hydrology along a 96 km stretch of the channelized river above Lake Okeechobee, FL (Lou Toth, personal communication). A portion of the former river oxbows that the canal cut through and cut off have once again been flooded by diverting water from the canal. Wetland restoration for flood control is now being considered for sites along the upper Mississippi River as a result of the disastrous flooding that occurred along that river this summer.

Smaller wetland treatment systems are being used to reduce nutrient loading to receiving water bodies. They have been developed primarily for small communities with limited resources and failing secondary treatment facilities, or none at all. These systems are replacing old, failing secondary treatment systems, or are being installed where none existed before as a less expensive alternative to standard mechanical treatment systems. They are usually much less than 40 hectares in extent, are planted, and are relatively intensively managed and monitored. They are most often designed to treat influent water in specific ways associated with discharge quality regulations. Such systems have been in use for over a decade to treat municipal, farm, and industrial waste streams, with considerable success. The EPA has documented the presence of more than 150 systems in use for secondary treatment of primarily residential waste from small communities in all regions of the United States (Reed and Brown 1992). Most of the systems have been built since 1980, and many of those since 1988. Most of the systems inventoried treat less than 3785 m^3/day. The systems been shown to be effective in treating solids, nitrogen, and biological oxygen demand, fecal coliforms to required standards. Phosphorus removal has been less extensively evaluated, primarily because runoff quality rules have generally not focussed on phosphorus. Farms are increasingly turning to wetland filters to reduce the nutrient content of runoff from feedlots and holding pens for small farms. The U.S. Environmental Protection Agency has developed a design manual for small municipal and individual marsh treatment systems (Hyde et al. 1984, Crites et al. 1988) and various federal agencies are developing standard designs for treatment of farm runoff.

In Florida, wetland filtration systems on the order of thousands of acres, designed to meet chemical treatment goals, are being developed and operated (Kadlec and Newman, 1992). The City of Orlando FL operates a 486 hectare system to polish the effluent from an advanced secondary sewage treatment plant. The system is currently operating at approximately 50,000 m^3/day, with a full operation target of about 76,000 m^3/day. At Lake Apopka Florida, The St. Johns River Water Management District is operating a two cell, 240 hectare demonstration project is being used to prove the efficacy of solids and nutrient removal with wetlands, as part of the Lake Apopka Restoration Project (Lowe et al, 1989, 1992). The wetland filter, built former marsh drained for farming, filters solids and associated nutrients from a hypertrophic lake, and returns the filtered water to the lake. When the system is fully operational (approximately 1416 hectares) it will be able to treat two lake volumes annually and strip the lake of its internal nutrient load. This will also eventually result in the restoration of the lakeside marshes.

The South Florida Water Management District has just begun the operational phase of the 1416 hectare Everglades Nutrient Removal Project Marsh, an experimental system to filter dissolved nutrients from agricultural discharge waters that are currently polluting the Florida Everglades. The full expression of this system, the Everglades Agricultural Area Stormwater Treatment Areas, are expected to comprise approximately 14,000 hectares in a set of filtration marshes set within the 404,685 hectare Everglades Agricultural Area (Kadlec and Newman 1992).

There are numerous examples of current proposals for the use of wetland filters to treat waste or runoff streams. A wetland filtration system have been proposed to treat the municipal wastes in Cancun, Mexico, where the untreated or primary treatment effluent is now entering the groundwater system there. Wetland treatment systems for treatment of treated wastewater are being planned for use in Thailand (Don Hammer, personal communication). A system is being proposed in Egypt to treat stormwater runoff prior to entering the Nile. Experimental bench scale systems outside Cairo have been shown to be effective in treating primary treatment effluent from residential sources (Butler et al. 1993).

Wide application of wetland filtration in the repair or restoration of systems outside Europe and North America has yet to occur. However, there is no reason why the concept, appropriately modified, cannot be applied in tropical as well as temperate climates. I have had the opportunity, as a consultant for the government of Nicaragua, to consider application of the wetland filter concept to the restoration of aquatic systems in Nicaragua, particularly Lake Managua, one of the most polluted lakes in Central America, and the management of Lake Nicaragua, the second largest lake in the Americas outside the Great Lakes of North America (Stites, 1992).

Lake Managua receives the effluents of Managua, Nicaragua, with a population of over one million. It is estimated (Wheelock 1992) that 227,124 - 378,540 m^3 of untreated sewage and stormwater runoff enter the lake daily. The sub-basin containing the city is undergoing rapid deforestation (and subsequent erosion) as the population expands. A number of industries discharge directly to the lake. In the larger basin, the runoff of intense agricultural activities within the basin. The lake, which historically drained to Lake Nicaragua during wet years, has not done so for the last forty years as a result of low rainfall; evaporation exceeds inflows. This has resulted in steadily increasing conductivity, and likely a parallel concentration in other materials. The lake is hypertrophic in character, is naturally high in arsenic and boron as a result of the volcanism in the basin, and is further contaminated by mercury from an industrial process. The lake has high levels of human coliforms, and the cholera vibrio was identified in the lake in 1991. Lake Nicaragua, by contrast, is one of the cleanest large lakes in the hemisphere, and almost an order of magnitude large than Lake Managua. It has a relatively small contributing human population, and agricultural activity is less intense within its basin.

The condition of Lake Managua and the Cuenca Sur, the sub-basin containing the city and the rapidly growing population, the restoration activities underway, and necessary steps that need to be taken are summarized in Wheelock et al. 1992. Wetland filters can play a significant role in the restoration of the system. A decentralized wastewater treatment system using wetland filters, might be used to significantly improve the quality of water entering the lake from the urban area. At present, a number of combined storm/sewage drains flow down-slope to the lake. A network of in-line treatment systems, primarily gravity driven, consisting of solids removal, primary treatment, and wetland filtration, would return to the main drain a treated effluent, which could result in a significant improvement of the water quality as it flows toward the lake. If, as proposed, the sewers were intercepted at lake edge and the water treated, the necessary treatment would be significantly less.

Secondly, industries along the lake edge such as petroleum refineries and food processing plants could use wetland filters to improve the quality of their effluent. Wetland filters could again be placed in line, between the plant and the lake, to achieve significant improvement in effluent water quality. Similar treatment of industrial effluents is already occurring in the United States.

Those systems could serve as a design models.

Finally, the non-point runoff from agricultural activities in the west and south edges of the lake might be treated by the re-development of wetlands in those areas. Larger, less intensively managed systems, placed between the agricultural activity and the lake would serve to restore wetland habitat in the area, slow storm flushes off these areas, simultaneously trapping solids and nutrients in the runoff.

While there are a bench scale models, a fully operational wetland filter system to treat municipal wastes in a tropical environment has yet to be designed and operated. Some aspects of the system, such as vegetation, might be easier to manage, as such problems as temperature related die-off would not be a factor. Other issues, particularly insect pest management, would be much different in the tropics, and would require particular attention. However, it does not seem that there are any insurmountable problems. The construction and operation of a small system that could be used to define basic operation and management rules and to resolve problems particular to tropical environments is now necessary.

The water quality of Lake Nicaragua very high. It is a largely undeveloped water shed, with primarily agricultural activity, and little high intensity farming. Water quality is most at risk in the north end of the lake, nearest Managua. The agricultural activities in the area between the two lakes, and the city of Granada appear to be the main contributors to nutrient enrichment of the lake in that area. The city of Granada has a sewage system for part of the city, that drains into a settling/oxidation pond outside the city. The effluent from the oxidation ponds drain into Lake Nicaragua. The system is similar to those in several other towns outside Managua, but the Granada oxidation ponds were renovated in 1991. This system would be an ideal site for development of a marsh treatment system. The town is not heavily industrialized, so the threat of toxic contaminants in the waste stream that could kill the biological system is relatively low. The oxidation ponds are surrounded by open land and are somewhat distant from the town and the local population, so that concerns over mosquito borne diseases might be lessened. The oxidation ponds are operating much below capacity, so that if necessary the operation of the pond could be changed to produce a different quality effluent. Finally, the system drains into Lake Nicaragua, near enough to a large swimming beach to likely have an influence on the water quality there. Improvement of the discharge should have a positive effect on the local lake water quality.

It is likely that there are many other sites also appropriate for a wetland filter project. The development of wetland filtration systems in tropical climates is in its infancy. A demonstration project is necessary to prove the method, develop an understanding of operation and management of these systems in the tropics, and to develop the experience and expertise of Central and South American professionals, who can then expand the use of wetland filters throughout the tropics, in the western hemisphere and beyond. As it happened in the northern hemisphere, once this process has begun, the use of wetland filters will expand rapidly, as the recognition of the value of these systems grows.

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Development of the Kissimmee River Restoration Plan: Lessons Learned and Recommendations for Comprehensive Restoration Projects

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Editor's Note: The presentation made by Dr. Toth was based on the following paper, which is being published in Implementing Integrated Environmental Management, John Cairns (ed.), May 1994. Printed with permission of the authors.

Integration of Multiple Issues in Environmental Restoration and Resource Enhancement Projects in South Central Florida

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INTRODUCTION

In the last half century the vast wetland landscape of Florida's Kissimmee River, Lake Okeechobee and Everglades ecosystems has been impacted by urbanization, intensive agricultural land use and construction of the central and southern Florida flood control project[1,2]. Urban sprawl and a variety of agricultural activities, including the citrus industry, vegetable and sugar cane farming, and dairies altered hydrology and water quality characteristics, while the flood control project compartmentalized the system with an interconnected network of canals, levees and water control structures (Figure 1).

In recognition of impacts that these anthropogenic factors had on fish and wildlife resources of the region, restoration, rehabilitation and/or resource enhancement measures are underway or being planned for the Kissimmee River and its headwater lakes, Lake Okeechobee, and the Everglades ecosystem, including Everglades National Park and Florida Bay. The planning process for addressing environmental degradation in each of these systems has been conducted independently, but has integrated a multitude of political, institutional, socio-economic, cultural, and ecological issues and factors. In this chapter we discuss how multiple issues were integrated in planning for restoration of the Kissimmee River and protection and enhancement of environmental resources in Lake Okeechobee. Based upon these experiences we provide recommendations for developing and implementing integrated environmental restoration and enhancement programs.

KISSIMMEE RIVER RESTORATION

In the Kissimmee River basin the flood control project[3] lowered and regulated water stages in the river's headwater chain of lakes, greatly modified discharge characteristics[4], and transformed

approximately 180 km^2 of interacting river and floodplain wetland ecosystem into a series of deep stagnant reservoirs, with a central drainage canal[5]. Resultant drainage led to increased cattle grazing and associated range “improvements” (e.g., secondary drainage systems, fertilization and planting) on the floodplain and dairy operations were established in the river's lower watersheds.

The magnitude of the river channelization project and its highly visible aesthetic effects immediately sparked public outcry[6] that was the genesis of the river restoration initiative. Building upon this emotional basis, the focus of the nascent restoration movement quickly shifted to resource based concerns. The initial impetus involved perceived effects of channelization on water quality in the downstream lake (Okeechobee). Early proponents of restoration suggested that channelization of the river was resulting in accelerated eutrophication of Lake Okeechobee by providing a conduit for the transport of sewage effluent that was being discharged into the river's headwater lakes[7,8]. Although intensive agricultural land use and associated secondary drainage practices were soon identified as the primary causes of elevated nutrient loads in the channelized system[9,10], downstream water quality remained a river restoration issue.

Figure 1. Location map of Florida's Kissimmee River, Lake Okeechobee and Everglades ecosystems overlaid by the major structural components of the central and southern Florida flood control project. The shaded area shows the approximate boundary of the historical Everglades.

As evidence of the impacts of channelization on fish and wildlife mounted[11], the primary impetus for river restoration shifted to concern for losses of wetlands and river resource values. In addition to the alteration of physical and chemical characteristics, at least 12,000 ha of floodplain wetlands were lost, and fish, wading bird and waterfowl resources were greatly impacted[5,12,13].

This broad array of environmental impacts provided a solid foundation for the restoration initiative but presented a challenge for formulation of a restoration plan. Through most of the years of study that preceded development of the adopted river restoration plan, proposed restoration measures used select resource values (e.g., wetlands, game fish, waterfowl, wading birds, and water quality) as independent objectives[14]. The initial emphasis on water quality led to plans for reestablishing the nutrient filtration function once provided by the river's floodplain wetlands[15,16]. As the plan evaluation process proceeded, reestablishment of floodplain wetlands gained popularity as a generic restoration objective. However, this objective did not incorporate criteria that would reestablish the range of wetland functional values that were impacted by channelization. Rather, select groups of associated wildlife such as wading birds, waterfowl or endangered species were targeted. Meanwhile, the principal objective relating to losses of river channel resources focussed on game fish, particularly the largemouth bass fishery.

Evaluations of alternative restoration measures[14] also were conducted as if targeted river resource values and functions were independent. Typical expressions of expected benefits were acres of floodplain which would be reflooded, reductions in nutrient loads, or habitat for “high profile” taxonomic groups such as wading birds. During this period the most comprehensive measure of projected restoration benefits was derived from a “Habitat Evaluation Procedure” (HEP)[17] analysis of 25 taxonomic categories.

The adoption of a holistic ecosystem restoration goal - *reestablishment of ecological integrity*[18,19] - was a pivotal event in the restoration planning process, and emanated from a 1988 symposium on the technical, policy and institutional issues relating to the river restoration initiative[20]. The development of this goal required an understanding of the complex manner in which channelization impacted the system's resources, and recognition that the broad array of lost values and functions could only be achieved through reestablishment of the physical, chemical, and biological characteristics, processes and interactions that governed the ecology and evolution of the historic ecosystem. The basis for this understanding was provided by 20 years of preceding studies on the system's resources, impacts of channelization, and potential restoration measures[13]. This scientific foundation led to a unified perspective on the restoration goal even though the various project biologists represented state and federal agencies which traditionally have more narrow resource interests or concerns. The ecological integrity goal shifted the focus of restoration planning from independent objectives involving discreet taxonomic components or ecological functions to the organizational determinants and self-sustaining properties of river/floodplain ecosystems.

The development of a comprehensive set of restoration guidelines and criteria[21] (Table 1) was the next significant step in the evolution of the restoration plan. These criteria were founded upon the physical form and hydrologic determinants of ecosystem integrity that were altered by river channelization and other aspects of the flood control project[13,19,22] and provided a rigorous and objective basis for analyses of alternative restoration plans[23].

Kissimmee River restoration criteria have several innovative features. Many of the criteria have stochastic components that implicitly recognize the importance of the continuously shifting range of hydrologic variability in restoring and maintaining the biodiversity of wetland ecosystems[24]. This feature broke with the more traditional approach of using static and/or deterministic criteria based upon optimal requirements of individual species[17]. While the latter approach may be appropriate in more narrow applications such as restoration of endangered species habitat, stochastic-based criteria recognize that natural ecosystems are not biological Utopias in which the optimal requirements of all component species are constantly present.

Though many of the Kissimmee River restoration criteria are interdependent and mutually reinforcing, the ecosystem restoration goal requires that all criteria be met simultaneously[21]. This key integration requirement provides for the development of the interrelationships and interactions that form the basis of emergent properties[25] of ecosystems which facilitate persistence of a high diversity of species[26], and maintained the focus of the plan evaluation and selection process on the ecosystem restoration goal. Thus, plans that failed to meet even one of the criteria were eliminated even though they could have some ecological benefits. Piecemeal restoration scenarios such as floodplain impoundments that could be managed for select ecological groups (e.g., wading birds, waterfowl, endangered species) or functions (nutrient assimilation) also were precluded. By basing the plan evaluation process on complete and simultaneous reestablishment of the organizational determinants of ecological integrity, only plans that have potential for restoring the full range of structural and functional values could be selected.

Table 1. Guidelines and Criteria for Restoring the Ecological Integrity of the Kissimmee River Ecosystem

Physical Form Guidelines

Reestablishment of Lateral Connectivity Between the River and Floodplain

Reestablishment of Longitudinal Continuity of River and Floodplain

Reestablishment of the Mosaic of Prechannelization Habitats Including Replicates of Rare Wetland Plant Community Types

Hydrologic Criteria

Continuous River Flow with Duration and Variability Characteristics Comparable to Prechannelization Records

Average Flow Velocities Between 0.3 - 0.6 m s^{-1} When Flows are Contained Within River Channel Banks

Stage-Discharge Relationship that Results in Overbank Flow Along Most of the Floodplain When Discharges Exceed 40-57 m^3 s^{-1}

Stage Hydrographs that Result in Floodplain Inundation Characteristics Comparable to Prechannelization Hydroperiods, Including Seasonal and Long-Term Variability Characteristics

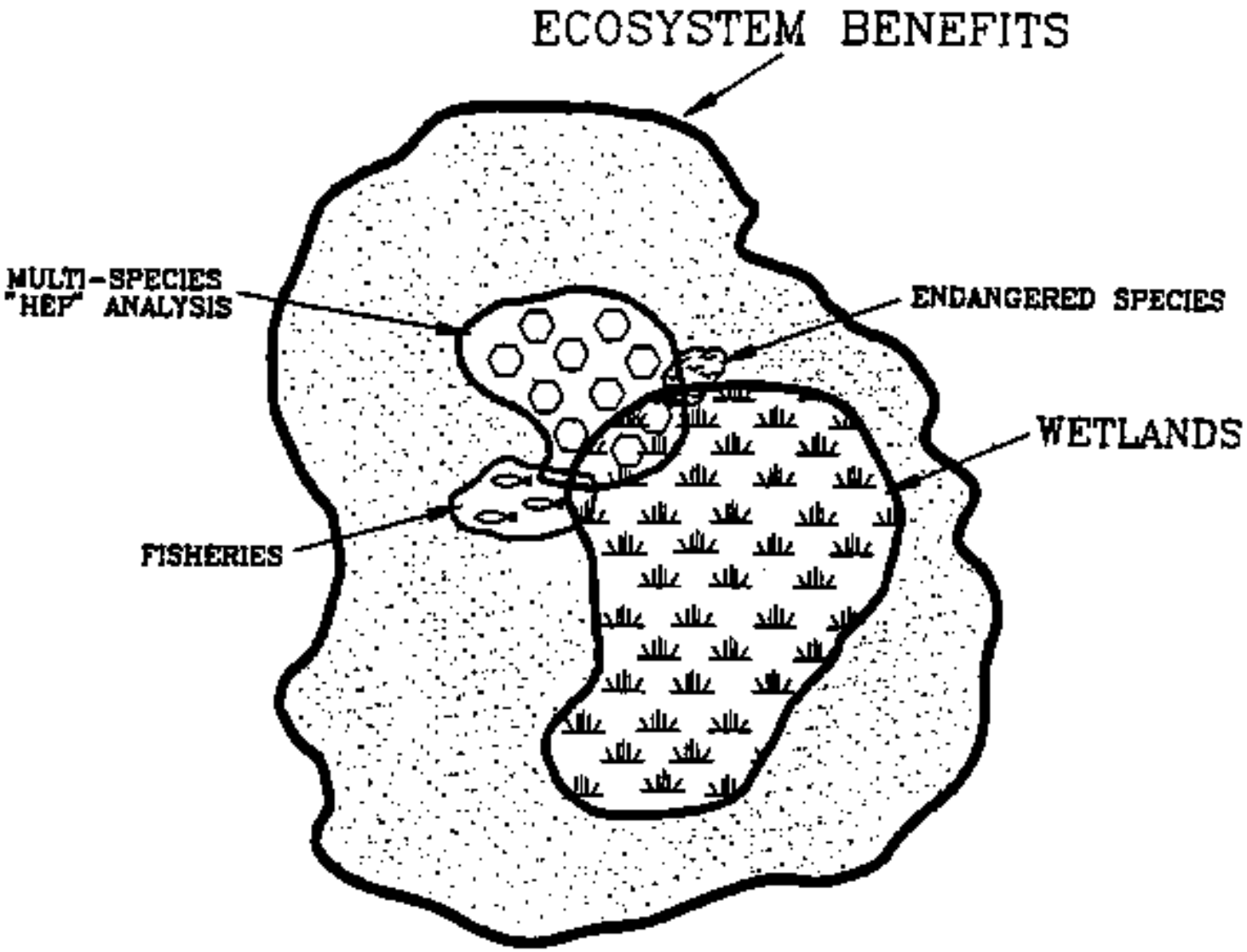
Stage Recession Rates on the Floodplain that do not Exceed 0.3 m mo^{-1}

An important corollary of this plan evaluation process is that the only appropriate measure of projected benefits of the restoration plan is the amount of ecosystem that will have restored ecological integrity. Measures of projected benefits that were used previously yield only a subset of the broad range of benefits provided by an ecosystem restoration plan (Figure 2). Similarly, the success of the adopted restoration plan should be tracked by documenting the area over which the criteria are fully and simultaneously reestablished, as well as by measuring responses by various species, ecological communities and functions[27].

The long history of political support for the restoration project provided essential sustenance for the technical and scientific studies that led to the development of the restoration plan. This support began in September 1971, while channelization was still underway, when Florida's Governor Askew's conference on water management evoked major attention to the degradation of water quality and fish and wildlife resources in the Kissimmee River valley[7]. Two years later the Florida legislature established and funded the “Special Project to Prevent the Eutrophication of Lake Okeechobee”[28], which resulted in several recommended river restoration measures. In recognition of these and other studies, and the growing advocacy among environmental organizations, in 1976 the Florida legislature provided a legal mandate[29] for development of river restoration measures. The first federal support for river restoration occurred in 1978 when U.S. House and Senate committees passed identical resolutions[30] directing the Corps of Engineers to “determine whether any modifications of the system of flood control works was advisable with respect to questions of water quality, flood control, navigation, recreation, loss of fish and wildlife resources, other current and foreseeable environmental problems, or loss of environmental amenities.” The state's political support was solidified in 1983 when Governor Graham issued an

executive order[31] calling for the restoration of the Kissimmee River-Lake Okeechobee-Everglades ecosystems, and again in 1990 when Governor Martinez officially established and endorsed a recommended restoration plan. Federal interest in the river restoration initiative was reiterated in 1990 with authorization for a feasibility study of the state's recommended plan[32] and in 1992 with authorization for cost-sharing of a $372 million restoration project[33]. Under separate authority[34] the federal government has provided $25.3 million for Kissimmee River restoration with six consecutive years of annual appropriations since 1986.

Figure 2. Conceptual comparison of the benefits of ecosystem restoration with other, more traditional measures of restoration benefits.



This consistent political support for Kissimmee River restoration was due largely to the success of the project in addressing and incorporating numerous opposing social and cultural factors in the development and selection of the restoration plan. Two of these, the need to maintain navigation and flood control were established as planning constraints[35]. However, the socio-economic impacts and conflict associated with agricultural and to a lesser extent human encroachment onto the drained floodplain, and the local public's mistrust of government also

were significant issues.

In the late 1800s through the 1920s the Kissimmee River was used for commercial navigation and in 1902 Congress authorized a navigation project to provide and maintain a 9.1 m (30 ft) wide and 0.9 m (3 ft) deep channel at the “ordinary” stage of the river[36]. While this authorization provided the only legal basis for the restoration project's planning constraint, a small but organized contingent argued that construction of the 9 m deep, 60-100 m wide flood control canal enhanced navigation potential and usage by larger boats and that consequently, any loss of depth afforded by the canal would greatly reduce navigation; Boating surveys put this special interest group's opposition to the river restoration initiative in perspective, and restoration planning and evaluation for navigation concerns was appropriately geared to the small fishing boats that remain the primary users of the system.

Maintenance of flood control was a more restrictive planning constraint, particularly in conjunction with the rigorous ecosystem restoration goal. The basic planning approach was to either maintain levels of flood damage prevention provided by the channelized river, or to compensate landowners for increased flooding risk through acquisition of fee title or flowage easements (flooding rights). However, because acquisition was not economically feasible in the highly urbanized areas, reduction in flood control in developed regions around the headwater lakes was a prohibitive constraint. As a result, the potential for restoration of the river/floodplain ecosystem was limited to the central 130 km^2 of the channelized system[23]. In addition to land acquisition, structural measures such as levees or berms along the perimeter of the floodplain may be needed to meet the flood control constraint.

The need to reflood drained land on the floodplain and around the headwater lakes was perhaps the most controversial issue of the restoration initiative. The earliest and most consistent source of opposition to restoration of the river was voiced by landowners, particularly ranchers, in both the upper and lower basins who benefitted from the drainage that resulted from the flood control project. This source of opposition was at least partly calmed in the early 1980s when the land acquisition program was established to compensate landowners for reflooded land This acquisition effort has been accomplished using the state's legislatively created “Save Our Rivers” program[37], which is funded by a tax on real estate transactions. The land acquisition program also was bolstered by the state's “Preservation 2000” initiative[38], although this program does not yet have a permanent source of funding.

The land buying effort stalled several times due to a gridlock regarding state sovereign lands. Because the state of Florida, by virtue of its sovereignty[39], has vested title to all land below navigable waters (delineated by the ordinary high water line), state officials periodically have blocked land acquisition along the Kissimmee by contending that much of the land that will be reflooded by the restoration project is already state-owned. Knowing that the ordinary high water mark along the historic Kissimmee River and its headwater lakes had not been legally established, landowners in the valley disputed the state's sovereignty claims and contended legal titles to, and years of tax levies on, land up to the river's banks. Faced with the possibility of lengthy legal deliberations to resolve this dispute, which would have delayed if not thwarted the restoration project, in 1993 the Florida cabinet adopted a resolution[40] permitting the acquisition of disputed lands for the purpose of accomodating the river restoration project.

The most vehement public opposition to the project was generated in 1991 when the U.S. Army Corps of Engineers draft feasibility study on the restoration plan suggested that 356 private residences could be displaced by project-induced flooding. Although most of these residences would have been affected by only extreme flooding events and alternatives to relocation exist, the threat of displacement provided the foundation for a well-organized opposition movement. This conflict resulted in a scaled-back restoration plan (Table 2)[41] that reduced the number of potentially affected residences to 47. The modified plan also addressed economic concerns by reducing the total project cost $104 million. From an environmental restoration perspective the scaled-back plan compromised approximately 26 km^2 of restorable river/floodplain ecosystem.

Starting with the initial outcry that produced the call for restoration, public involvement has continuously influenced the course of the restoration initiative. Since 1971 numerous public meetings have been held to solicit input and provide up to date information on restoration-related studies and planning efforts. Despite these frequent attempts at public education and the solid scientific foundation for the restoration plan, much of the public sentiment that underlies opposition to the restoration project continues to emanate from a basic mistrust of the governmental entities that have been at the forefront of the restoration project. Although this source of opposition has little or no substantive basis and resistance to change will always be present, public education regarding the value of restoration is perhaps the most significant remaining challenge of the restoration movement.

PROTECTION AND ENHANCEMENT OF LAKE OKEECHOBEE

Lake Okeechobee is a vital link in the Kissimmee, Okeechobee, Everglades landscape. This large (1730 km^2) and relatively shallow (2.7 m) sub-tropical lake is the second largest lake in the conterminous United States. This unique lake is an extremely important ecological, economic, and recreational resource to South Florida, providing water for urban and agricultural interests, flood control, and a multiple-use resource which supports valuable commercial and sport fisheries[42].

As a result of the central and southern Florida flood control project, Lake Okeechobee presently is almost completely surrounded by a levee (Herbert Hoover Dike) and rim canal, and surface water inflow and outflow occurs primarily through water control structures. Portions of the levee were initially constructed in the early 1900s by local interests, but most construction occurred following major hurricanes in 1928 and 1947. The levee was completed in 1965.

Table 2. Key Features and Expected Ecological Benefits of the Kissimmee River Restoration Plan.

Construction and Operational Components

Backfilling of 35 km of Canal

Recarving of 14 km of Obliterated River Channel

Removal of Two Water Control Structures

Modifications of the Flood Control Regulation Schedule and Operation Rules of the Kissimmee's Headwater Lakes

Expected Ecological Benefits

Restoration of 104 km^2 of River/Floodplain Ecosystem

Restoration of 70 km of Contiguous River Channel

Restoration of 11,000 ha of Wetlands

Restoration of Habitat for Approximately 320 Fish and Wildlife Species Including the Endangered Wood Stork, Bald Eagle and Snail Kite

The flood control levee impounded the lake and constricted the historically large littoral zone on the west and northwest side of the lake to its present size of approximately 400 km^2. Completion of the levee and associated water control structures also provided the capability to regulate water level for flood control during the wet season (July-October), and water supply during the dry season (November-June). The lake's water level presently is regulated from a low of 4.7 m to a high of 5.3 m NGVD, with drawdown occurring before the onset of the wet season. Earlier lake regulation shedules resulted in somewhat higher water levels[43] and may have impacted littoral zone vegetation structure[44].

The greatest concern relative to the health of Lake Okeechobee is increased inputs of nutrients from agricultural activities in the lake's northern basin. Lake Okeechobee is a eutrophic lake[45] and probably has been for several thousand years[46-48]. The lake's large size, shallowness, and sub-tropical location are important contributors to its present trophic state. However, data collected over the past 30 years suggest that impacts from human activities in the lake's catchment have accelerated and intensified the eutrophication process.

Historical water quality data from the lake show increasing total phosphorus concentrations[49-52]. Concern about Lake Okeechobee's water quality intensified after total phosphorus concentrations in the water column doubled from an average of 0.049 mg L^{-1} in 1973 to 0.098 mg L^{-1} in 1984[53]. Preliminary information suggested that excessive nutrient loading had reduced the lake's capacity to assimilate phosphorus[54].

Dairies have been implicated as the major source of nutrients, especially phosphorus, to the lake. Dairies and other grazing operations dominate land use north of the lake. Dairies relocated from south of the lake to north of the lake in the mid 1900s. Agricultural activities and water management practices in the Everglades Agricultural Area (EAA) south of the lake (Figure 1) also contribute nutrients to the lake through backpumping of nutrient-rich water. The EAA is

utilized predominately for production of sugar cane and winter vegetables.

In 1975, steps were taken to reduce nutrient loading from the dairies and from the EAA. These included “on-the-farm” measures to achieve nutrient reductions from dairy land uses, and plans to reduce backpumping and maximize water reuse. In 1981 a Water Quality Management Strategy[55] for the lake was adopted, and called for the reduction of nutrient inputs and continuation of the Interim Action Plan (IAP)[56] that modified the backpumping schedule for the EAA.

Increased public concern over deterioration of the lake's water quality and potential effects of backpumping prompted then-Governor Graham to form the Lake Okeechobee Technical Advisory Committee (LOTAC) in 1985. This Committee recommended 1) diversion of surface water inflows from watersheds contributing high nutrient loads (Taylor Creek/Nubbin Slough) to eastern counties for agricultural reuse, 2) rapid implementation of Best Management Practices (BMPs) on the dairies, and 3) continued implementation of the IAP[57]. LOTAC also emphasized the need for monitoring, research, and long-term management directed toward reversing the eutrophication trend.

Concern about water quality degradation heightened with a series of massive algal blooms that occurred on the lake beginning in 1986. These algal blooms, and a perceived shift in the lake's phytoplankton community to a species composition dominated by cyanobacteria such as *Anabaena*[58], resulted in further public and governmental agency actions. A “Lake Watch Program” was initiated to provide a formal means of tracking and reporting occurrences of bloom conditions.

Passage of the Surface Water Improvement and Management Act (SWIM) by the Florida legislature in 1987[59] led to development of the Lake Okeechobee SWIM Plan[60]. Utilizing a modified Vollenweider model[52,61], the plan established phosphorus performance standards for all tributary inflows to the lake, based upon a goal of reducing phosphorus loads by 40 percent by July 1992. All tributary inflows were required to meet a 0.18 mg L^{-1} performance standard for total phosphorus, or maintain their 1989 discharge concentration, whichever was less. Average annual off-site discharges were limited to 0.35 mg P L^{-1} for parcels converted to improved pasture, and to 1.2 mg P L^{-1} for all other non-dairy land uses. These non-dairy land uses also were required to obtain permits from the South Florida Water Management District through the Works of the District program[62]. In 1989, the Florida legislature appropriated $5.5 million dollars for funding SWIM enforcement and compliance monitoring, BMP monitoring, a Dairy Buy-Out program to financially compensate farmers who could not afford or did not want to implement BMPs, and other lake improvement activities.

Further occurrences of algal blooms and increased concern over the relatively high water level regulation schedule and its potential impacts on the lake's littoral zone resulted in formation of the Lake Okeechobee Littoral Zone Technical Group (LOLTZG) in 1988. LOLTZG[63] recommended implementation of a lower regulation schedule to correct deleterious effects of higher lake stages on the littoral zone.

In 1988, two multi-year research studies were initiated to gain more knowledge on various components of the lake ecosystem and to increase understanding of phosphorus dynamics.

These studies represented the first major research efforts designed to take a broader view of the lake ecosystem in developing and implementing improved lake management strategies.

The four-year “Lake Okeechobee Phosphorus Dynamics Study” was designed to develop simulation models of phosphorus dynamics, and to evaluate phosphorus loading, accumulation in sediments, and the role of the littoral zone. Initial results document the importance, both temporally and spatially, of sediment-water column phosphorus exchanges. A thorough understanding of sediment-water column phosphorus dynamics is necessary to predict the effects of phosphorus control practices in the watershed.

The five-year “Lake Okeechobee Ecosystem Study” was designed to inventory biological communities, study ecological relationships between littoral and open-water areas, and study impacts of changing nutrient levels and lake stage. The study focuses on 1) patterns of vegetation in the littoral zone and their controlling factors, using a combination of remote sensing and field surveys, 2) water chemistry, 3) plankton community dynamics, 4) larval and juvenile fish ecology, 5) and the distribution and ecology of wading birds. The lake's macroinvertebrate and adult fish communities were studied by the Florida Game and Fresh Water Fish Commission through an interagency memorandum of understanding.

Preliminary results from the first four years of study indicate that lake stage, and thus hydroperiod, is one of the most important factors controlling the patterns of littoral zone vegetation and wading bird foraging and nesting activity. A comparison of 1989 and 1990 computer-generated satellite maps of littoral zone vegetation with a map developed in the mid-1970s reveals substantial changes in the distribution of important plant species. Analyses of water chemistry patterns and phytoplankton response to nutrients indicate that nutrients, such as phosphorus, affect algae differently in different locations within the lake. Based on these response patterns, the lake has been divided into five distinct ecological zones (Figure 3).

As a result of research and recommendations from various advisory groups and from legislatively mandated goals, several lake management tools are currently being utilized. One of the first to be developed was the Lake Okeechobee Agricultural Decision Support System (LOADSS)[64]. This GIS-based software package is designed to provide resource managers a user-friendly decision support tool to estimate environmental and economic effects of various combinations of land use activities in the Lake Okeechobee basin. The GIS basin coverage incorporates information about land uses, soil associations, weather regions, management practices, hydrologic features, and political boundaries for approximately 600,000 ha of land. The user can create maps and reports detailing existing features, and can change land uses and management practices. The software package then uses outputs from various phosphorus simulation models and creates output defining phosphorus dynamics, economic indices, and environmental effects of these land use practices. Thus, the net effects of different regional land use practices can be investigated. A further enhancement of LOADSS is being planned to incorporate an optimization routine to suggest the best combination of land use practices.

The “Lake Okeechobee Ecosystem Study” has provided another potential management tool. Recent analyses showing correlations between nutrient concentrations and chlorophyll concentrations in some of the newly established ecological zones (Figure 3) can be used to better predict the influence of phosphorus control practices that are implemented in the lake's basin. Additional management tools under development include in-lake water quality models,

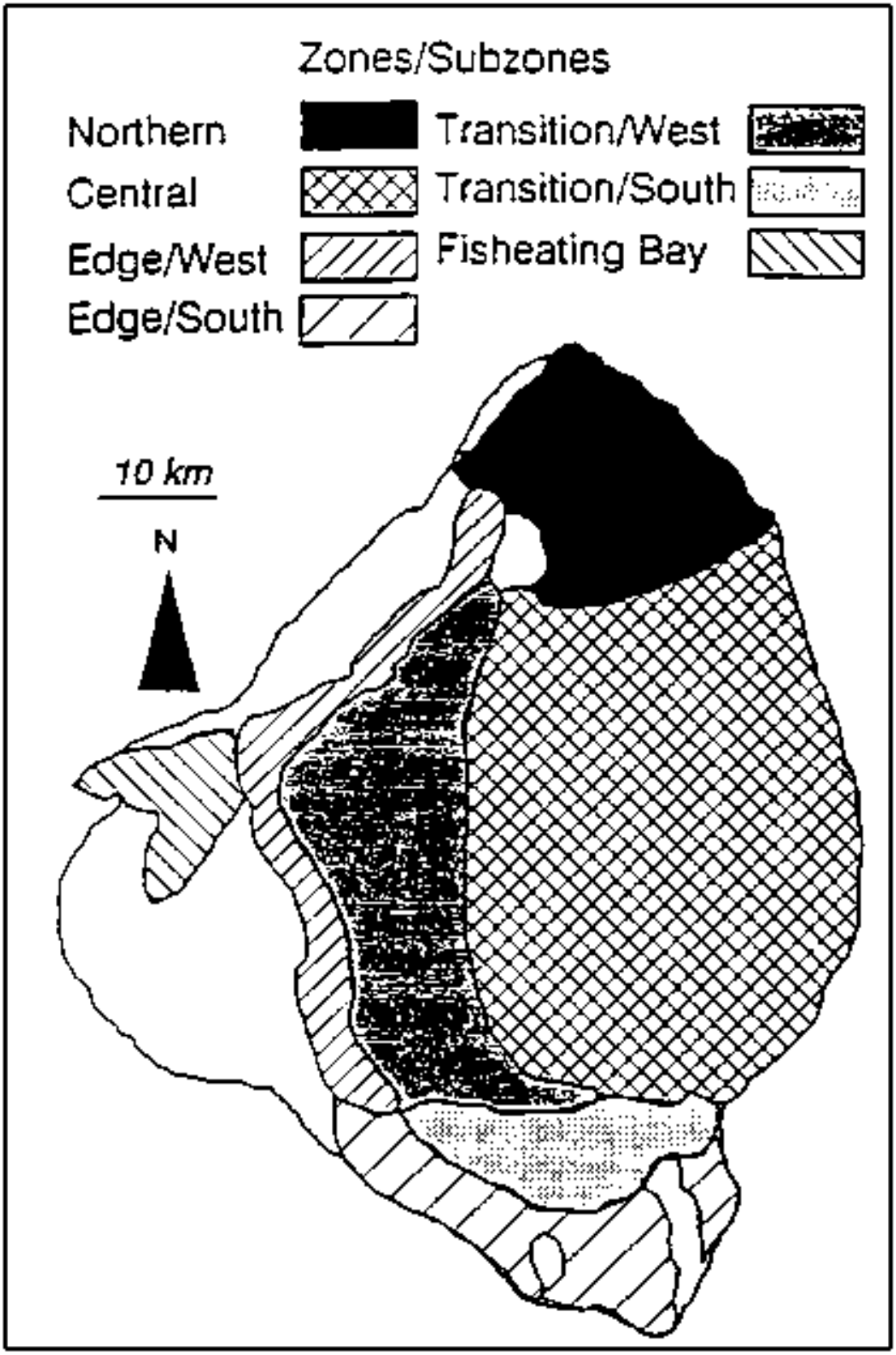
phosphorus transport models for the basin, and GIS-based systems for ecosystem-level data analysis.

Planning for integrated lake management has been hindered by occurrences of algal blooms and other indications of lake eutrophication. Governmental agency responses to these events have been driven largely by public and political pressure, rather than careful, well-conceived planning. In an attempt to improve the research and management planning process and to incorporate rational and educated strategies designed to protect and enhance Lake Okeechobee's ecological resources, decision analysis is being employed in the research planning process.

Decision analysis provides an organized, logical framework for decision under uncertainty. The first step in this process involves identification of the over-arching management objective - in this case, protection and improvement of water quality and ecosystem health of Lake Okeechobee. This step is followed by development of a series of management and research sub-objectives that address the overall objective. Perhaps most importantly, a series of attributes are identified that can serve as indicators of the degree to which each objective is being met. These attributes ideally should be independent, non-overlapping, and measurable. Finally, information needs related to the objectives are identified.

The decision analysis plan for Lake Okeechobee identifies seven research objectives related to the overall objective; 1) to determine ecosystem status and trends, 2) to determine causes of algal blooms, 3) to determine water quality trends, 4) to determine effectiveness of measures to improve water quality, 5) to determine sources and fates of critical elements, 6) to determine effects of lake water levels, and 7) to meet water quality standards. The influence of various management options on each attribute are then estimated. For example, the spatial and temporal extent of algal blooms might be an attribute of the research objective to determine the causes of algal blooms. A management objective related to this attribute might be removal of agricultural non-point sources of phosphorus inputs to the lake. Some estimate must then be made of potential effects of this management option on the specific attribute. This estimate is the most difficult part of the entire process because it entails a considerable degree of uncertainty. The goal of the research program should be to reduce uncertainty to an acceptable level so that appropriate management decisions can be made.

Figure 3. Ecological zonation in Lake Okeechobee resulting from preliminary findings of the Lake Okeechobee Ecosystem Study[44]. Ecological zones are derived from predominant phytoplankton chlorophyll response to nutrients and light deduced from a three-year, 47 - station water quality data set. Northern zone - controlled by nitrogen; Central zone - controlled by light; Edge zone - controlled by phosphorus; Transition zone - controlled by a combination of factors.



RECOMMENDATIONS FOR IMPLEMENTING INTEGRATED ENVIRONMENTAL RESTORATION AND RESOURCE ENHANCEMENT PROGRAMS

1. *Establish a clearly defined and realistic goal early in the planning process.*

Timely adoption of a goal is essential for plan development and evaluation. The Kissimmee River

restoration plan took 20 years to develop partly because a definitive goal was not established until 18 years after the restoration initiative began. The Kissimmee River restoration goal of restoring ecosystem integrity is unique in many ways but perhaps mostly because the implicit scope of this goal is attainable. Unlike most other altered ecosystems such as Lake Okeechobee, the Everglades, and the Mississippi River system, where the infrastructure that has destroyed ecosystem integrity is too well established and/or costly to remove, the principle determinants of ecological integrity that were affected by the central and southern Florida flood control project (i.e., physical form and hydrology) can be reestablished in at least the central portion of the channelized Kissimmee. Although less remunerative goals may be more realistic for other rehabilitation or resource enhancement projects, their importance and value can be just as, if not, more significant for select resources.

2. *Develop a solid scientific/technical basis.*

Detailed knowledge and understanding of the ecology of the natural and altered system is required for all aspects and phases of planning. Well-designed ecosystem-level research is necessary and typically involves years of study. However, the required time frame is minimized when early development of the goal provides a focus for the studies. Periodic peer review of technical and scientific studies is highly recommended to expand project expertise and establish credibility. A solid scientific/technical basis is needed to effectively deal with unsubstantiated sources of opposition that inevitably arise in environmental restoration movements.

3. *Employ a decision analysis framework to ensure that limited resources are best directed toward established goals.*

Decision analysis can be an ideal structure by which to plan and implement research efforts for restoration, enhancement and/or management of environmental resources. This framework focuses all efforts around an overall goal. Agreement among various interest groups regarding a long-term goal can be difficult to achieve. The decision analysis framework provides a mechanism for bringing researchers and resource managers to the table to work together using a common language. Decision analysis also creates a process for systematically addressing the uncertainty that is often associated with various restoration or management options.

4. *Develop rigorous criteria for achieving the established goal.*

Criteria are needed for objective evaluations of alternative restoration or enhancement measures. Criteria must be congruent with the goal and should emanate from the project's scientific/technical study basis. Quantitative criteria are desirable. Once a plan is adopted the criteria become objectives that should be used in evaluating the success of the project.

5. *Thoroughly evaluate and integrate social, cultural, and economic issues and concerns in the planning process.*

Evaluation and integration typically require a cooperative, interdisciplinary planning team with technical expertise and input on all relevant issues. Appropriate consideration of all issues and concerns will help foster and maintain the political support that is needed to facilitate most restoration efforts.

6. *Place less emphasis on “crisis management” and more emphasis on informed planning and*

research efforts.

Environmental restoration and management in large and complex systems such as the Kissimmee River, Lake Okeechobee and Everglades is challenging and sometimes elusive. Intense public and political pressures, combined with occasional litigation brought forward by various interest groups, hamper the integrated planning required to achieve long-term protection and restoration goals. However, careful, well-informed planning is the hallmark of successful environmental research and restoration and management programs. Research and planning efforts should not be driven solely by events that may play a prominent role in public perception but are not central to the overall goals or objectives. Well-intended but misinformed allocation of resources to these “brush fires” can detract from the goal.

7. *Establish continuous lines of communication for educating the public, environmental organizations and support groups during all phases of the project.*

Restoration movements typically are initiated and nurtured by environmental organizations with grassroots public and political support. It is critical that these support groups are aware of, and utilize, up-to-date scientific and technical information. Without this information the course of the initiative may be naively steered in potentially disastrous directions. Thus, project scientists must insure that their findings are effectively communicated to support groups.

In addition to providing accurate information on scientific/technical studies and environmental benefits of the project, public education efforts should strive to make the link between restoration/enhancement of environmental resources and “quality of life”, including associated economic benefits. The public also needs to be continuously reminded of the value of these projects in preserving our natural heritage for future generations.

8. *Implement a well-designed ecological evaluation program to document the success of the project.*

The design of the ecological evaluation studies must reflect the goal. The evaluation program will measure the pulse of the restoration/enhancement efforts and should document changes that are of both social and scientific importance. The evaluation studies will provide for continual fine-tuning of the project while it is in progress, and for adaptive management of the restored/enhanced system. The ecological evaluation program also will demonstrate the potential applicability of the project's planning principles and guidelines for other proposed restoration or rehabilitation programs.

9. *Establish effective leadership.*

Complex restoration projects need effective leaders who have a good understanding of all issues and concerns and are capable of guiding the project through the inevitable maze of bureaucratic roadblocks. To this end, long-term continuity among leadership is invaluable. Project scientists need to be an integral part of the leadership.

10. *Implement integrated environmental management and restoration programs according to natural boundaries rather than political or jurisdictional boundaries.*

Natural systems are defined by natural boundaries, rather than by artificial boundaries such as agency jurisdictional lines or political districts. As such, restoration and resource management

directed along natural boundaries will experience a greater degree of success than will efforts constrained by artificial boundaries. Though planning efforts for restoration, rehabilitation and enhancement of the Kissimmee River, Lake Okeechobee and Everglades ecosystems have been conducted independently, integrated management and protection of the environmental resources of the South/Central Florida landscape is recognized as the overall goal of these programs.

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Roundtable II - Water Supply and Sanitation Infrastructure in a Sustainable Development Context

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Background Paper

Sustainable Water Resources Management: The Challenge of the 21st Century, by Absalón Vásquez, Arsenio Milian, and Vinio Floris

Papers and Authors

Sub-track: **Technological Aspects of Multipurpose Water Resources Projects**

1. *Water Resources in an Era of Sustainable Development - An Integrated Economic, Engineering, Environmental and Institutional Approach,* by **Harold J. Day,** University of Wisconsin-Green Bay, Wisconsin, USA.

2. *A Hemispheric Network Development as a Vehicle to Ensure Education, Training and Technology Transfer in Water Resources Projects,* by **Hector R. Fuentes, V. A. Tsihrintzis** and **R. Jaffe,** Florida International University, Miami, Florida, USA.

3. *Priority Decisions in Latin America for Water Management,* by **Phillip Z. Kirpich,** Consulting Engineer, Miami, Florida, USA.

4. *Hydrometeorological Networks and Data Management for Prevention of Natural Disasters in Central America,* by **Medardo Molina,** FINNIDA Project, San José, Costa Rica; **Eladio Zárate,** Comité Regional de Recursos Hidráulicos, San José, Costa Rica; and **Nabil Kawas,** Servicio Meteorológico Nacional, Tegucigalpa, Honduras.

5. *Water Management for the 21st Century,* by **Albert Muniz, J. I. García-Bengochea, R. David G. Pyne** and **William B. Ziegler,** CH2M-HILL, Florida, USA.

6. *Planning - A Must in the Conservation of Natural Resources: The Puerto Rico Experience,* by **Haraldo Otero-Torres** and **Maria C. Flores de Otero,** Consulting Engineers, Rio Piedras, Puerto Rico.

7. *Appropriate Technologies of Wastewater Treatment for Sustainable Development,* by **Ernesto Perez,** Environmental Protection Agency, Region IV, Atlanta, Georgia, USA

Sub-track: **Economics and Financing**

8. *Water Markets and other Mechanisms to Decentralize Water Management,* by **Bill Easter,** University of Minnesota, St. Paul, Minnesota, USA.

9. *Financing Investments in Water Supply and Sanitation,* by **Terence R. Lee,** Economic Commission for Latin America and the Caribbean, Santiago, Chile.

10. *Strategy for Developing a Competitive Infrastructure in the Small Islands Economies of the Caribbean,* **José Martinez,** U.S. Army Corps of Engineers, San Juan, Puerto Rico.

11. *Designing Appropriate Financial Arrangements to Ensure the Proper Maintenance and Operation of Water Supply Facilities,* by **Enrique Moncada,** Universidad Nacional Agraria, La Molina, Lima, Perú.

12. *Environmental Issues and Environmentally Related Restrictions from the Perspective of the Borrowing Country,* by **José Ochoa-Iturbe,** Universidad Católica Andrés Bello, Caracas, Venezuela.

13. *Regional Plan for Investment in the Environment and Health,* by **Horst Otterstetter,** Director of Environmental Health, Pan-American Health Organization, Washington, D.C., USA.

14. *An Investigation of the Barriers to Private Sector Participation in Water Resources and Sewerage Services in Latin America,* by **Barbara Richard** and **Kenneth Rubin,** Apogee Research, Inc., Bethesda, Maryland, USA.

Background Paper: Sustainable Water Resources Management: The Challenge of the 21st Century

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A Background Paper prepared for discussion in the Roundtable Track II: Water Supply and Sanitation Infrastructure in a Sustainable Development Context

Water, air, food, heat and light constitute the five essentials for human existence. However, all body processes are so closely related to the presence of water, that it can be truthfully said that all life depends on it. Water plays an important role in all aspects of human existence; in the protection of the embryo in the mother's womb, the maintenance of body temperature, in assisting with adequate digestion and lubricating moving joints to name a few.

Though many will argue that the oxygen humans breathe and the carbon dioxide used by plants are equally if not more important than water, neither of these gases would be of use without water. Without this valuable fluid there can be no life - animal or vegetable.

In addition to bodily demands, there are other important needs for adequate supplies of water. Foods harvested from the lands are totally dependent upon water for their growth, since the soil's minerals must be in solution before they can be utilized by plants. Furthermore, a substantial part of the proteins and carbohydrates our body requires comes from animal, fish and plant life found only in or near oceans, lakes and streams. That is why water resources have played a critical role in the establishment of early settlements, since they were used not only for transportation, recreation, and fisheries, but most importantly were used as a source for drinking, washing, agriculture and waste disposal.

There are only two sources of water supply available to humans-surface sources such as lakes, streams and drainage basins that ultimately runnel water to holding reservoirs, and ground sources which include wells, springs and horizontal galleries. Both of these sources are not always separate. Hydraulic interconnections exist in such ways that ground waters at one particular location may appear at the surface of the earth at another distant site. It is worth noting that less than 3% of the fluid freshwater available in our planet occurs in streams and lakes. The other remaining 97% is underground.

As populations throughout the world continue to increase at an alarming rate, we are faced with

the problem of more and more competition for water resources primarily for domestic consumption, irrigation, power generation, flood control, recreation, transportation, and the maintenance of natural systems for the conservation of fish and wildlife. It has become evident that some form of compromise between competing uses is essential, since the different uses are not necessarily compatible.

It has been determined that where the resources are properly managed and the demands for safe drinking water is met, national development and improvement of living standards have occurred. Where it has not been met, development has lagged and living standards have remained low. Unfortunately a recent United Nations report concluded that two thirds of the world's underprivileged people have no access to drinking water, and while millions become homeless from floods, hundreds of millions are coping with drought.

Since many of these quantity related problems are due to poor management. It is of utmost importance that priorities be established for the more efficient use and management of water resources that are not equally distributed on our planet. Inefficient irrigation practices, excessive demands by industries and municipalities and lack of conservation practices, are some of the obstacles that must be conquered before true Sustainable development is achieved. As a result, competition for water resources, especially in areas frequently affected by drought, or where scarcity generally exists, create instability between regions, cities, and even nations. Our challenge today is to establish our priorities more adequately and implement available technologies that should improve our efforts to use the resources more efficiently to avert critical consequences due to waste, mismanagement and overuse.

Water, a Renewable Resource

In theory, water is a renewable resource, since its origin is the water that falls as rain and snow on the land surfaces. However, supply replenishment depends on such factors as location, climate, time of the year, evaporation, etc., in addition to the impact caused by demands that may utilize water faster than natural recharge may occur.

As previously discussed, there are many different demands in the use of water (commercial, industrial, and public among them); but in general, the use of water for irrigation and agricultural pursuits has exerted high demands, while smaller quantities were consumed by people.

Past experiences have shown that in many parts of the world, water is considered an unlimited resource that can be obtained very inexpensively. This type of mind set has led to negative impacts to the quantity and quality of the resources. Both the quality and quantity are interconnected in the development of water when is required to meet the demands for a particular use. They should never be considered independently from each other, since the usefulness of the maximum water withdrawn will be limited by its quality. From the users' point of view, water quality is evaluated by the physical and chemical characteristics necessary to satisfy a specific use.

If one or more of these characteristics exceeds the amount that can be tolerated for a given use, some type of treatment may be applied to change or remove the undesirable elements, so that water will serve the intended purpose. Through the years technology has advanced to the point where a given water quality can be achieved. However these are times when alternative sources have to be located far away from the intended use, since it may be more economically feasible.

On the other hand, larger demands exerted by larger populations, and industries also create large quantities of wastes that may contaminate our major sources with organic and inorganic pollution. Of all environmental problems we face, contaminated water is probably the one of highest repercussion. Each year millions of people throughout the world die of illnesses attributable to waterborne intestinal diseases. As our population grows, the need to conserve, properly treat and reuse water will increase.

In the past few years we have seen technological advances that may help our efforts to use water resources more efficiently. More economical and efficient membranes are being used for desalination purposes and new methods of supply augmentation such as Aquifer Storage and Recovery (ASR) are being implemented successfully. Other methods such as well field optimization, wastewater reuse for irrigation or as salt water intrusion barriers are also tools that, through technology, can improve the efficiency of use of our water resources.

Irrigation and Drainage: Present and Future

Many believe that Latin America and the Caribbean Region is humid by definition. The truth is that 25% of the total land corresponds to arid or semi-arid zones due to irregular distribution of rainfall. This problem started being addressed around the middle of the century with a massive building of infrastructure for storage of water. In the last 25 years cultivated land has increased 70%, from 8'245,000 Ha. to 15'231,000 in 1987, as shown in Figures 1 and 2, and in Table 1. This expansion rate is higher than in any region in the world.

However, there is a trend in the Region to provide more even distribution of water in time and space, and also to optimize its use (e.g. improve irrigation efficiency) by following a better water management and other related resources at the watershed level.

The economic and financial crisis of the 80's generated questions about the role of governments in water supply and management policies. From all the countries in the Region, Brazil, Mexico and Chile, are the ones who have made the most important changes in those policies. All these countries have selected different mechanisms but all have as a common denominator: the attempt to integrate and coordinate water management in a sustainable development context. Peru, for instance, is currently in the process of defining a new water policy in which the private sector, government and all users are involved. The peruvian government understands that a water market is needed keeping in mind that water is, above all, a very important public asset to which all humans should have access to, not only to satisfy basic needs, but for enjoyment and recreation as well.

Countries in Latin America use different means to promote irrigation and drainage. If we take Brazil and Peru as an example, they use the following motivations and means:

- encourage the implementation of large irrigation and drainage projects based on regional development plans, such as the irrigation project of the Vale do Sao Francisco in Brazil and the large irrigation projects in the coast of Peru;

- promote small and medium size projects based on specific goals for regions or zones.

With regards to improvement of irrigation efficiency, all countries of the Region share the same concerns. However, there are some differences in how to achieve that goal. Venezuela, for

instance, has a very aggressive agricultural policy for achieving irrigation efficiency by improving drainage capabilities in irrigated lands.

Other problems that the Region faces are related to salt water intrusion in coastal areas due to excessive freshwater pumping from wells. Consequently, there are severe salt water intrusion cases in the Caribbean islands, Argentina (cities close to Mar del Plata), Mexico and El Salvador, where the drinking water standards have been exceeded. This is also a problem in areas in North America, principally in the State of Florida of the United States of America.

Water and Soil Conservation

A severe problem of soil loss affects almost all Latin America and Caribbean states. Soil erosion not only causes the loss of soil *per se,* but also creates severe degradation in downstream rivers and canals (e.g. hydroelectric power plants, navigation, flood control problems) and subsequent destruction of the ecosystem and environment.

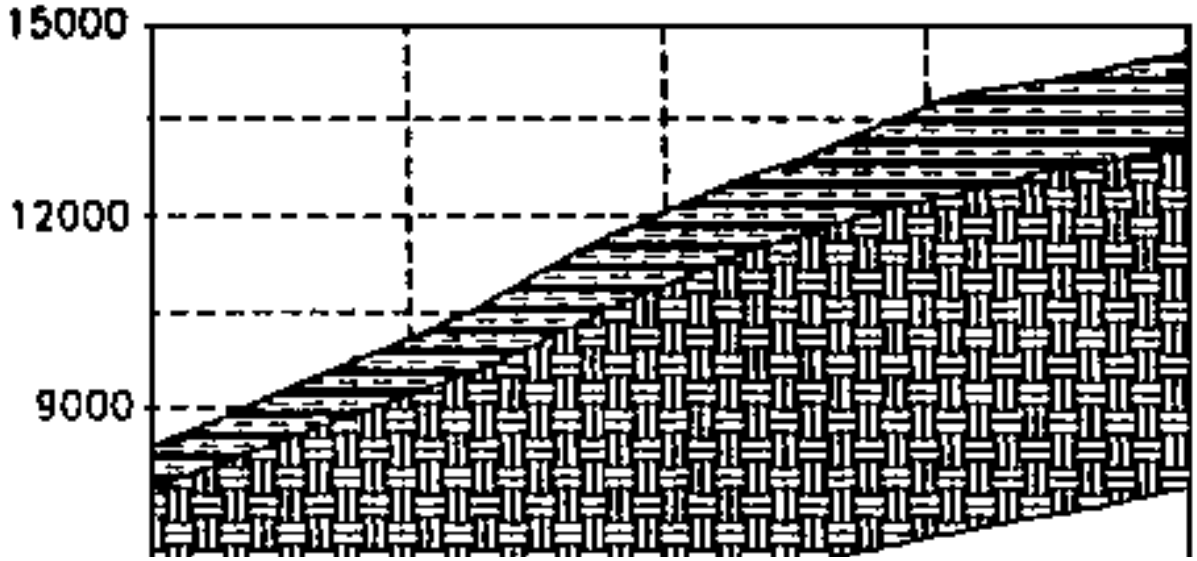
Most of the lands with severe problems are located in the mountainous or sierra regions. It might sound difficult to believe but many pre-columbian indian cultures used techniques that were extremely efficient in the prevention of soil erosion, however, those techniques have not been continued and now the problems faced are severe. An important effort for conserving water and soil is being carried out by the governments of the Region at the basin level. Table 2 shows the characteristics of watershed management implemented by different Latin American countries.

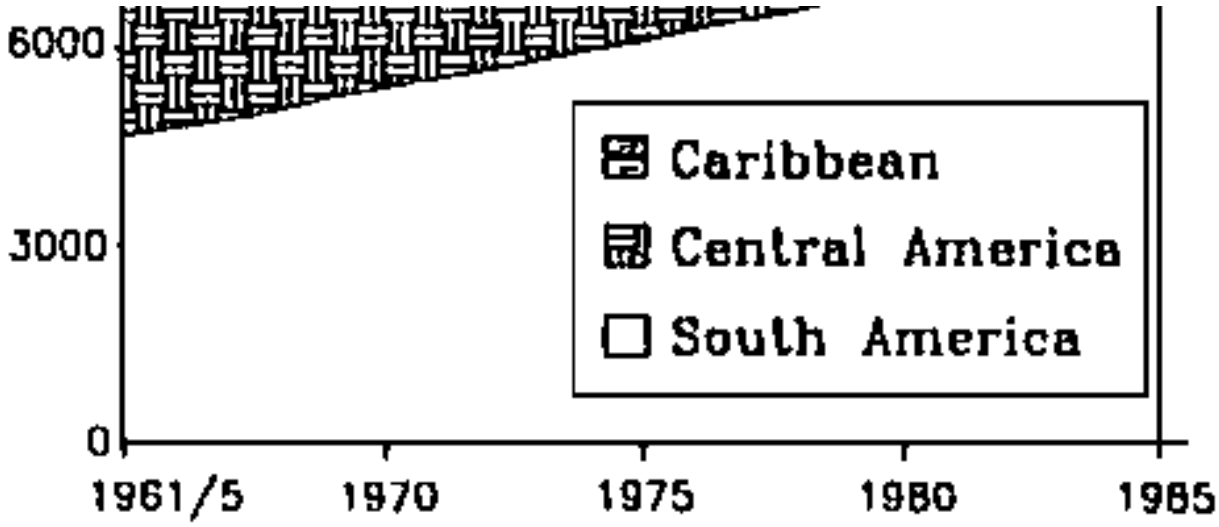
It is essential to understand the need to manage the resources in such a way that current generations can benefit, yet maintain a high level of quality for future generations. This is the concept of sustainable development that is quickly gaining international acceptance. It is basically a process in which the allocation of resources and investments are made consistent with present as well as future needs. This implies harvesting only the sustainable production or enjoying only the sustainable level of services their ecosystem can deliver.

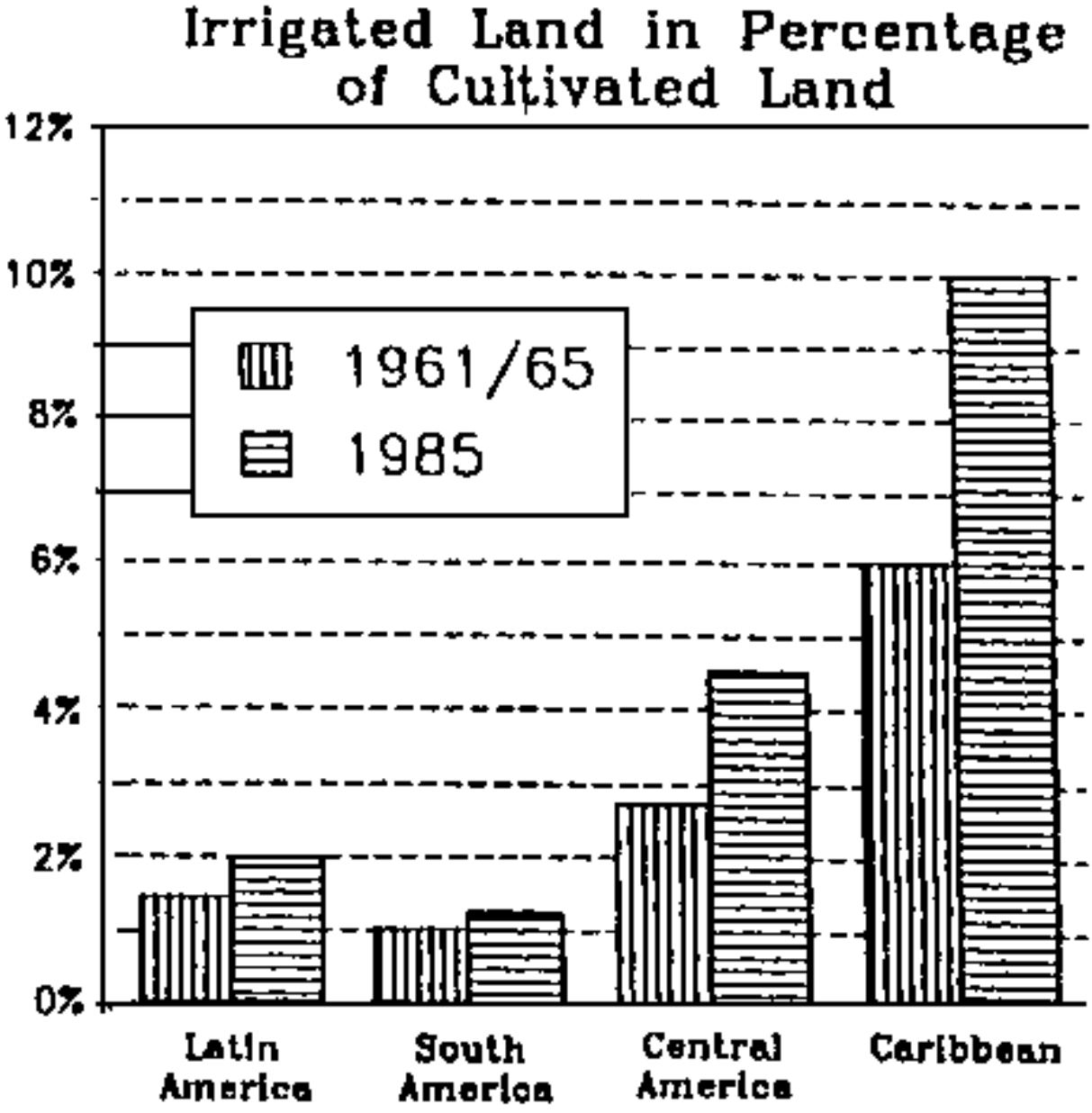
Figure 1: Latin America and the Caribbean Irrigated Land

Source: ECLAC

Figure 2: Latin America and the Caribbean Irrigated Land (Hectares in thousands)




6000
3000
0
Caribbean
Central America
South America
1961/5
1970
1975
1980
1985


Irrigated Land in Percentage of Cultivated Land
12%
10%
8%
6%
4%
2%
0%
1961/65
1985
Latin America
South America
Central America
Caribbean

Source: FAO

Table 1: Irrigated Surface for Latin America and the Caribbean

Country	1961	1970	1980	1987	Increment
Argentina	980	1280	1580	1700	720
Belize	-	1	1	2	2
Bolivia	72	80	140	165	93
Brazil	490	796	1800	2500	2010
Colombia	226	250	400	496	270
Costa Rica	26	26	61	118	92
Cuba	230	450	762	890	660
Chile	1075	1180	1255	1300	225
Ecuador	440	470	520	546	106
El Salvador	18	20	110	117	99
Guatemala	32	56	68	79	47
Guyana	90	115	125	128	38
Haiti	35	60	70	70	35
Honduras	50	70	82	88	38
Jamaica	22	24	33	34	12
Mexico	3000	3583	4980	4900	1900
Nicaragua	18	40	80	84	66
Panama	14	20	28	30	16
Paraguay	30	40	60	66	36
Peru	1016	1106	1160	1200	184
Dominican Rep.	110	125	165	206	96
St. Lucia	1	1	1	1	0
St. Vincent/Grenadines	-	1	1	1	1
Suriname	14	28	42	60	46
Trinidad/Tobago	11	15	21	22	11
Uruguay	27	52	79	100	73
Venezuela	218	284	315	328	110
TOTAL	**8245**	**10173**	**13939**	**15231**	**6986**

Table 2: Watershed Management Status in Latin America

a = Location
b = Watershed management programs
c = Selection criteria
d = Financing sources

Panama

a. Pacific and Caribbean Basins
b. An integrated plan for watershed management does not exist
c. Interest in pilot basin and hydropower projects
d. International cooperation and internal resources

Guatemala

a. Basin in the Caribbean Ocean, Gulf of Mexico and the Pacific
b. An integrated micro-basins program exists
c. Selection is done based on current and future water availability
d. International cooperation and internal resources

Nicaragua

a. Twenty one basins in the Atlantic and Pacific
b. No management plans have been implemented
c. It has planned a methodology for operational plans and small areas

El Salvador

a. Seventeen basins in ten regions

Paraguay

a. Thirty one basins
b. Until 1988, 82 units of watershed management were operational
c. Not reported
d. Central government and municipalities

Honduras

a. Thirty five basins in the Atlantic and Pacific
b. None
c. Methodologies used were developed by FAO, US AID, OAS
d. International cooperation and internal resources

Mexico

a. Thirty seven hydrographic regions, with 139 major basins (Pacific. Gulf of Mexico and Caribbean)

b. Pilot basins in 15 states

c. Methodology follows watershed management plan

d. International cooperation and internal resources

Dominican Republic

a. One hundred and six basins
b. A national plan exists
c. none reported
d. International cooperation and internal resources

Peru

a. Basins in three outlets: Pacific, Atlantic and Lake Titicaca
b. Methodology for basins, sub-basins and micro-basins
c. Projects oriented to soil conservation and increase of productivity
d. International cooperation and internal resources

Bolivia

a. Three main basin: Amazon, El Plata, and Altiplano
b. Prioritization based on water resources available, hydroelectric potential
c. Projects based on flood control and improvement of human life
d. International cooperation and internal resources

Chile

a. Two hundred thirty seven basins
b. Methodology available that assigns priorities to basins
c. Social aspects are considered
d. International cooperation and internal resources

Argentina

a. Watershed management not done in an unified way

b. Projects oriented to maintain infrastructure and protection from floods and other natural phenomena

Uruguay

a. National Committee of Watershed Management
b. Watershed management is related to hydroelectric potential and agricultural production

Venezuela

a. Three kinds of basins at high (most of the rural population), medium and low levels
b. No plans have been implemented
c. Considered all human needs
d. Ministry of the environment finances programs

Source: Report of the Workshop on Evaluation of Programs and Projects of watershed Management. Tegucigalpa, Honduras, 1991.

Hydropower Generation

As stated previously, energy is one of the main elements for development. One of the most practical ways of obtaining it is through hydropower generation by convening hydraulic energy to mechanical and finally to electrical. To obtain this kind of energy not only are economic resources required, but also natural conditions (topography and hydrology). Latin America is very fortunate with the latter. Its high slope mountains and high river flows create an enormous hydropower potential (around 22% of the world), representing 700,000 Megawatts, while the developed (installed) capacity achieved is only 22% of that total (153,500 Megawatts).

Hydropower is the most common way of generating power in the Region (64%), while thermoelectric plants represent 32.4%. The energy generated in 1991 was estimated around 590,000 Gigawatts-hour. The increased demand in the Region is approximately 5% per annum.

The largest hydroelectric plant in Latin America is Itaipu (Brazil), with an installed capacity of 12,600 Megawatts. Second is Guri (Venezuela) and Chingo (Brazil) with 10,000 y 5,000 Megawatts, respectively.

Latin America has a long tradition in hydropower generation. Its benefits with respect to others (thermoelectric plans, nuclear central, etc.) are well known. However, it is important to list some of the problems that must be corrected and priorities that have to be established, in order to increase efficiency and supply energy to a large group of the Region's population.

a. The high initial investment of hydropower plants are incentives for some to use conventional options like thermoelectric centrals. The latter ones require much lower initial investment but have high operation and maintenance costs. Another drawback would be the dependence on some combustible product that might create environmental problems and may not be available in many countries in the Region (Caribbean Islands, for example).

b. The little attention given to operation and maintenance are other causes of concern. Scarce economic resources and the non existence of a serious program of operation and maintenance contribute to affect the life of the equipment, their reservoirs and their water infrastructure.

c. Little attention to the modification and conservation of the environment (fauna and flora) that surrounds hydropower projects. Currently, in an effort to assist in this area, lending institutions require an environmental impact study for each hydroelectric project before any construction is started.

d. Considering the *sui generis* conditions of the Region, it is difficult to select an appropriate technology for the efficient use of hydroelectric power plants. For example, the high concentration and quality of sediments in the sierra regions create severe problems in reservoirs, hydraulic infrastructure and, to hydro-mechanical equipment (e.g. turbines) that are commonly designed to different conditions of solid transport.

e. Existence of the single-purpose hydraulic projects. Though this vision is disappearing, many projects were created with this in mind. This goes against the

modern systems approach theory which states that infrastructure can be used with multipurpose goals: energy, irrigation, flood control, water supply and - something not very well developed in Latin America - recreation, greatly increasing its benefits and reducing its costs.

f. Little attention to hydroelectric planning. This creates uncertainty when long versus short term decisions are evaluated, the construction of small of large plants are analyzed and the implementation of efficient interconnected systems.

One of the best ways to avoid making errors is to learn from past mistakes. It is important to establish mechanisms to connect users and providers together, technical and administrative personnel and legislative organizations of governments. This is the only way to provide a reliable and efficient service and to reach sustainable development.

The Road Ahead

It is evident that in order to achieve the sustainability of water resources, it will be necessary to create a comprehensive overhaul of the existing water management methods. This will require the reversal of the damage to natural systems and provide adequate water supply to satisfy rural and urban needs. If no quick actions are taken in this direction, the natural systems will continue to deteriorate, which will undoubtedly impact the Region's economy and the quality of life.

The use of present technologies and innovative ideas should lead the Region to live in balance with its water resources. It will be essential to achieve a sustainable water resources management for the 21st century since the urban and natural environment, the economy, and the quality of life of the Region depend on it.

Sub-track: Technological Aspects of Multipurpose Water Resources Projects

Water Resources Planning and Management in an Era of Sustainable Development - An Integrated Economic, Engineering, Environmental and Institutional Approach

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INTRODUCTION

A Prediction

The new era of sustainable development that has begun in many parts of the world, including North America, will stimulate water resource professionals to seek better planning and management approaches. One such approach will be to integrate ecology, economics, technology and institutions in the analysis of water quantity and quality problems within a watershed.

A DEFINITION AND RELATED DISCUSSION

Sustainable development may be defined as “Meeting the needs of the present without compromising the ability of future generations to meet their own needs” (World Commission on Environment and Development). A number of recent developments have stimulated water resource professionals to consider the concept of sustainability as a central focus in future planning and management. New scientific knowledge, the increasing world population and the changing global economy are three examples that apply to many nations. The evolving change in water quality management policy in the US is an example restricted to one nation.

New Scientific Knowledge

New scientific knowledge has been gained in many subjects during the past decade. One that has stimulated interest in sustainability is the ecosystem perspective. Water resource professionals have historically planned and managed in a piecemeal manner. With some notable exceptions, water quantity and quality problems have been solved separately. Related land use issues such as urban sprawl have been addressed with a minimum of attention to the impact on adjacent communities or the receiving waters. The ecosystem perspective was introduced into the Great Lakes in the early 1980's as evidence grew of persistent toxics bioaccumulating in fish and fish eating birds (Harris, State of the Bay). Attention to upstream contributions of nutrients, suspended solids and persistent toxics to downstream pollution problems also emphasized the interconnecting features of a watershed ecosystem. Recognition of wetlands as valuable pans of a watershed has also occurred in this time period. Today the ecosystem perspective is generally accepted in many regions as a central part of land and water resource planning and management.

World Population

Water and air are the two absolute essentials for human life. Per capita water use has long been recognized as an important indicator of the quality of life. The rapidly growing world population is causing some nations to consider water as a strategic resource. The Middle East is the most

notable example. Allocation of the region's water resources, e.g. the Nile, the Tigris, the Euphrates and the Jordan Rivers, will become increasingly important as the population grows. Other regions also have limited water and rapidly growing populations (Downey, et. al.). The poverty levels in a particular nation often correlate directly with population density and inversely with the use of water. The concept of sustainable growth may help water planners and policy makers in such problem areas to prepare for the future.

Changing Global Economy

Evidence of a rapidly changing global economy is all around us. The most newsworthy is the North American Free Trade Agreement, NAFTA (Grayson). A more recent, and perhaps more important globally, is the General Agreement on Tariffs and Trade, GATT. The European Union, EU, is another important multinational organization. Each of these agreements is based upon the assumption that reduced trade barriers are beneficial to all participating nations. The increased competition implied is judged to be the primary driving force that will force everyone to be more efficient or go out of business.

The need for more cost effective water resource planning and management will be a natural consequence of these global developments. Interest in sustainability can complement the effort to be cost effective.

A NATIONAL EXAMPLE OF A CHANGING FRAMEWORK FOR WATER RESOURCES PLANNING & MANAGEMENT

The evolving changes in water quality planning and management in the United States have been chosen as an example of combining concepts of sustainability with those of cost effectiveness. For the past three decades improvements in the surface water quality of this nation have been based upon a complex process that could be called Limited Regulatory Management, LRM. The LRM process could be characterized with the following features: technology based abatement of point source, i.e., municipal and industrial, pollution through a regulatory process which included significant construction grants, usually 75%, to municipalities and concern for uniformity of regulation, e.g., all municipal sewage treatment plants to be at the secondary level.

The draft of the latest Clean Water Act, the primary federal law governing surface water pollution abatement, contains several features that indicate LRM will be history soon. Two of them are pollution prevention and watershed based planning. Pollution prevention has been a part of industrial management for decades due to the economic benefits. Now the idea is being applied to entire communities as a cost effective way to reduce water pollution. The watershed has been used as the logical land area for planning and management of water resources in France and in the United Kingdom for many years. Now the idea is being proposed here. The opportunities for achieving more cost effective water pollution abatement make the watershed approach very attractive. The challenge is to find an effective way to integrate ecology, economics, technology and institutions into a framework for the cost effective analysis. The least cost concept is one approach to the integration effort. The result of such an integrated analysis would be a step toward achieving the sustainability of water resources.

The following section is a more detailed description of the least cost concept.

LEAST COST CONCEPT A COST EFFECTIVE APPROACH

The basic approach is to generate information on the costs of different ways to achieve different target sets of desired outputs from a particular land and water region, e.g., a watershed. The target sets would be defined as a particular combination of indicators describing the land and water use to achieve a given level of goods and services (outputs). A typical set of indicators would be: population growth, technological changes in industry and other societal activities, social preferences. Three hypothetical target sets at a particular region are:

> Target Set I - Maintenance of the present level of outputs (given an expected growth in population and economic activity including pollution prevention).
>
> Target Set II - Target Set I activities plus a resumption of swimming at some beaches plus an increase in the harvest of fin and shell fish.
>
> Target Set III - Target Set II activities plus a resumption of swimming at virtually all beaches, rehabilitation of many wetlands for waterfowl habitat and fishery spawning and a significant increase in the harvest of fin and shell fish (both species and quantities).

The first step would be to ask the aquatic biologists what values of various indicators of ambient water and sediment quality, e.g., dissolved oxygen, turbidity, concentrations of heavy metals, concentration of algae, and how many acres of rehabilitated habitat are required to achieve the output levels of fin and shell fish yields and water fowl yields specified by the three target sets. Similarly, the values of the relevant ambient water quality indicators, e.g., turbidity, concentration of fecal coliforms, to achieve the extent of beach swimming specified in the target sets would be identified. For example, what should the Secchi disk measurement, i.e., the depth below the water surface a disk of specified color can be seen, be to permit swimming along the various beaches?

The second step would be to ask the scientists and engineers who have been modeling water and sediment quality in the receiving waters to estimate what reductions in inputs of various materials into the waters would be necessary to achieve the indicated values of the water and sediment quality indicators for each of the target sets. For example, water clarity along the beaches is predominantly affected by suspended sediment concentrations. Using the Secchi disk measurement as the indicator of water clarity, the relationship between the Secchi disk measurement and suspended sediment concentration at each beach would be specified by researchers.

The third step would be to ask the scientists and engineers what reductions in suspended sediment discharge into the waters would be necessary to achieve the suspended sediment concentrations at each beach specified in step 2. The result of that specification is illustrated in Figure 1, showing the Secchi disk reading associated with the three different levels of suspended sediment input reduction necessary to achieve the concentrations required for swimming for the three output levels.

The fourth step would be to divide the drainage area into subareas, representing the various tributaries. Point and nonpoint sources of suspended sediment discharges in each of these subareas arc identified, and the amounts and time patterns of suspended sediment discharges from these sources are estimated. Point sources include municipal wastewater treatment plants and industrial and other activities discharging directly into the receiving waters. Nonpoint sources

include urban storm runoff and storm runoff from nonurban lands, primarily agricultural lands.

For each of the major sources, estimates are made of the costs of reducing suspended sediment discharges by different amounts. That is, for most sources there are several different degrees of discharge reduction which are possible. For example a municipal wastewater treatment plant could reduce suspended sediment discharges by 35%, 65%, 80%. Costs, of course, increase as more and more discharge reduction is achieved, remembering that, in the case of point sources, removing suspended sediment (or any material) from the liquid waste stream results in a semi-solid material, sludge, which itself requires disposal. Capital and annual operation, maintenance, and replacement (OMR) costs are included. Typically annual costs of each alternative are computed, in order to compare the different alternatives (Grant, et. al.). These annual costs are converted into unit costs per ton of reduced suspended sediment discharge into the downstream receiving waters. (This, of course, requires understanding the transport and deposition processes between the discharge location for each source and the downstream area.) The unit costs would be compiled as shown in Table 1. (Note: In that table, all activities in a given subwatershed have been aggregated. In a real analysis, individual sources in each watershed would be identified, except where those sources are individually so small that it is more logical to “lump” them.) The important column for decision making is the last column, which shows the cost per ton of reducing suspended solids discharge from the source into the receiving waters.

The fifth, and last step, would be to select the least cost combination of measures to achieve the level of discharge reduction specified for each target set. One starts with the measure which has the lowest cost per unit of discharge into the downstream receiving waters reduced. This may be a major point source, urban storm runoff from a municipality or some agricultural operations in a particular subwatershed. If the reduction that would be achieved (or is estimated to be achieved) by this source is not sufficient to achieve the designated reduction, then the option with the next lowest cost per unit would be added. The process of adding measures would be continued until the necessary total reduction is achieved. The results for the three target sets would be as compiled in Table 2 and shown in Figure 2.

This process would be repeated for other materials of interest, e.g., organic matter, heavy metals, phosphorus. In so doing what would be found is that some physical measures to reduce discharges of a given material of interest also reduce discharge of one or more other materials of interest. For example, reducing discharges of suspended solids from a wastewater treatment plant often also results in some reduction in discharges of heavy metals.

Figure 1. Relationship Between Reduction in Suspended Sediment Input to Downstream Water and Secchi Disk Reading at an Adjacent Beach

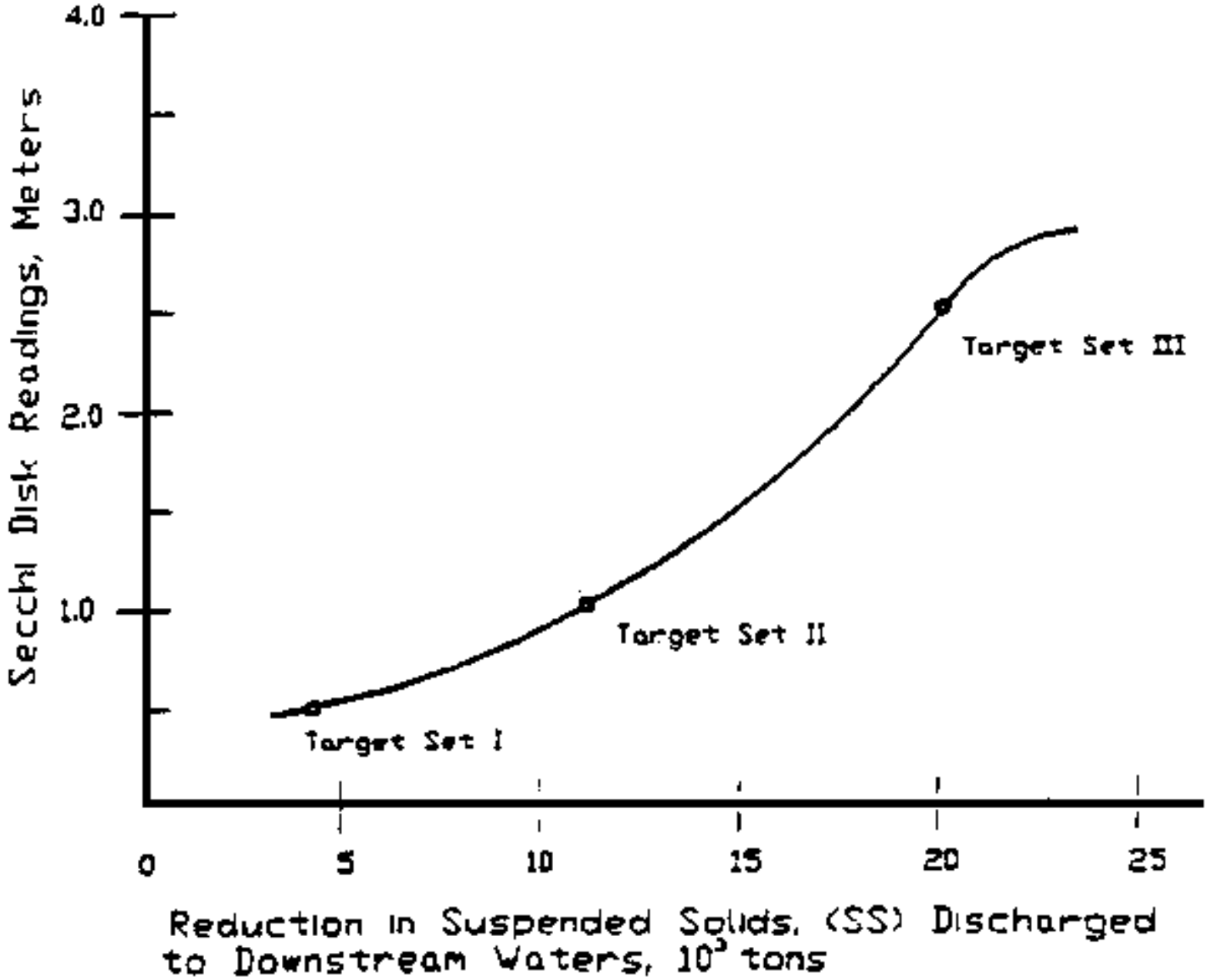


Figure 2. Least Cost combination of Measures to Reduce Suspended Solids (SS) Inputs to Achieve Specified Target Sets

Table 1. Options for Reducing Suspended Sediment, SS, Inputs into Downstream Receiving Waters, Estimated Unit Costs

Aggregated Activities by Sub Watershed	Mean Reduction in SS Inputs to Downstream 10^3 Tons	Capital Costs in 1990 $	Annualized Capital Costs, 10^3 1990 $ (1)	Operation & Maint. Costs, 10^3 1990 $	Total Annual Costs, 10^3 1990 $ (2)	Cost per Unit Reduction in SS Input $ Per Ton
IA	2000				20	10
IB	3000				60	20

IC	6000				180	30
IIA	1000				5	5
IIB	1500				225	15
IIC	4000				100	25
IID	5000				175	35

(1) Annualized Capital Cost = Capital Cost X Capital Recovery Factor, CRF, e.g., 10% at 15 years = CRF of 0.1315; 7.5% at 20 years = CRF of 0.1.

(2) Total costs are net costs, i.e., in some cases measures to reduce discharges result in some savings, such as recovered materials or reduced inputs.

Table 2. Least Cost Combinations of Measures to Achieve the Reduction in Suspended Solids, SS, Inputs Downstream Waters to Achieve Swimming Goal in Each of the Three Target Sets

Target Set	Suspended Solid (SS) Input Reduction Req'd, 10^3 Tons	Reduction Actions in Sub Watershed, 10^3 Tons	Cost/Ton (1990 $)	Costs, 10^3 1990 $
I	4	IIA:1	5	5.0
		IA:2	10	20. 0
		IIIB:1.0	15	15.0
	Total	4		40.0
II	11	Same as I:4		40. 0
		plus		
		IIB:0.5		7.5
		IB:3		60.0
		IIC:4		100. 0
	Total	11.5		207. 5
III	20	Same as II:11.5		207.5
		plus		
		IC:6		180
		IID:2.5		87.5
	Total	20.0		475. 0

Once this information became available, it could be used to help set policy. Legally, the regulating agency would decide what target set should be achieved. Politically, the general public and their elected representatives, would have major responsibilities. How much are the citizens in the watershed willing to pay to achieve desired outputs from the receiving waters? The same set of outputs can be achieved at different costs. Thus, if more efficient ways of achieving cost effective ways of obtaining the outputs are sought and adopted, either higher levels of outputs can be achieved with the same resources or the “saved” resources can be used

for activities in other desired sectors.

What is essential is that the full ranges of physical measures, implementation incentives, institutional arrangements, and financing mechanisms be considered in the analysis process and in the decision process.

Now that the least cost approach is better understood, the practical application of these ideas is considered. Two possible demonstration sites, one in the United States and the other in Mexico, are briefly discussed.

TWO POSSIBLE DEMONSTRATION SITES

Site No. 1 - Fox/Wolf River Watershed In Northeastern Wisconsin And Lake Michigan

The first site for demonstrating a least cost approach to water resource planning and management is the Fox/Wolf River watershed of northeastern Wisconsin. This river system drains approximately 6000 square miles. It is the largest tributary in the Lake Michigan drainage basin, a part of the Laurentian Great Lakes. A map of the area is presented as Figure 3. This watershed has been recognized as a pollution problem area for at least fifty years. Details have been documented previously (Harris, et al).

Today it is the home of approximately 750,000 people, most of whom live in urban areas located in the downstream 10 percent of the basin. The paper industry, historically a serious source of surface water pollution, has been the dominant manufacturing type in the area for a century. Large rural areas are dairy farms.

Efforts to abate water pollution began in earnest in the mid-1970's with attention directed almost exclusively to municipal and industrial point sources. Stimulated by new federal and state laws and massive construction grants to municipalities, near to $500 million has been invested in wastewater treatment plants since then.

The river and bay recovered dramatically and fish returned to many areas where they had been absent for many years. By the early 1980's the evidence that not all was well began to emerge. An awareness of the ecosystem concept emerged at the same time. The algae blooms associated with excessive upstream nutrients continued to plague the lower bay in the summer months. Persistent toxics became apparent in the body flesh of fish and fish eating birds. Bioaccumulation was recognized as a new factor. The entire watershed, including upstream runoff from rural and urban sources as well as contaminated sediments in the river bottom from past industrial practices, was recognized as part of the problem.

What should be done? This was a question asked by many. The answer finally chosen was to use the least cost approach in an investigation of surface water pollution throughout the watershed. A one year framework analysis was funded by a number of local municipalities, industries and private foundations.

The results were very preliminary and did not include all features of the least cost approach. They also did not include all recognized pollutants, e.g., river sediments contaminated with PCB's from past paper mill sludge deposits. The results did show three new pieces of evidence not available previously (Analysis Team):

- The goal of removing 50% of the phosphorus presently entering Green Bay at the

mouth of the river could not be achieved without some reduction of agricultural non point sources.

- The cost of reducing phosphorus and suspended solids from agricultural non point sources was often 1% of the cost to remove the same amount at municipal and industrial point sources.

- A small segment of the agricultural land area contributed the majority of the phosphorus and sediment.

Figure 3. Location of Fox-Wolf Watershed in relation to the Bay of Green Bay and Lake Michigan and the State of Wisconsin.

These preliminary results show clearly that the least cost approach is an improved method to plan the water quality management program for the Fox/Wolf River watershed. Additional study is needed to refine the investigation results.

Site No. 2 - Northern Region of the Yucatán Peninsula and Gulf of Mexico Shoreline

The second site for demonstration of these ideas is located in the Yucatán Peninsula of Mexico. The area includes approximately 4000 square miles of the peninsula northern region located between the coastline and a parallel line drawn through Mérida, about 20 miles south. The region is bounded along the coast by Celestun on the west and Rio Lagartos on the east. A shoreline of approximately 240 miles, largely undeveloped, extends between these two small communities. Approximately one million people live in the area with at least three fourths in the capital city, Mérida. A map of the region is presented in Figure 4.

The two demonstration sites contain similar land areas and populations. Most other features are quite different. The Yucatán site is karstic, i.e., the bedrock is highly fractured and there is little or no top soil. The result is that there is no runoff from the rainfall. The water either evaporates into the atmosphere or infiltrates into the aquifer. The concept of a surface land area serving as a watershed does not apply. There is little or no contaminated surface water inland and most of the brackish shoreline wetlands show little evidence of degradation today. Two national bird sanctuaries and a generally healthy commercial fishery exist along the coast.

The problem is the increasing contamination of the fresh water aquifer in most urban areas with special attention to the Mérida metropolitan region. There is no community wide sewerage system. Most residences have a simple septic tank that drains directly into the shallow aquifer. The aquifer drains very slowly north to the Gulf of Mexico. The karst geology makes it very difficult to predict micro scale groundwater motion. From a regional or macro scale view, the long term result seems quite clear. The shoreline marshes, called *ciénega,* will become the sites of a contaminated shoreline ecosystem. Persistent toxics released into the aquifer near Mérida from a variety of urban sources and elsewhere in developing orange groves, will emerge at the coast and bioaccumulate in the fish and fish eating birds. The value of the shoreline as a natural area and as an area for future development for tourism will be sharply diminished.

The present policies for land and water use are not likely to emerge as significant problems for several years, perhaps more than a decade (Anonymous). An analysis using the least cost approach very soon could reduce expected problems in the future.

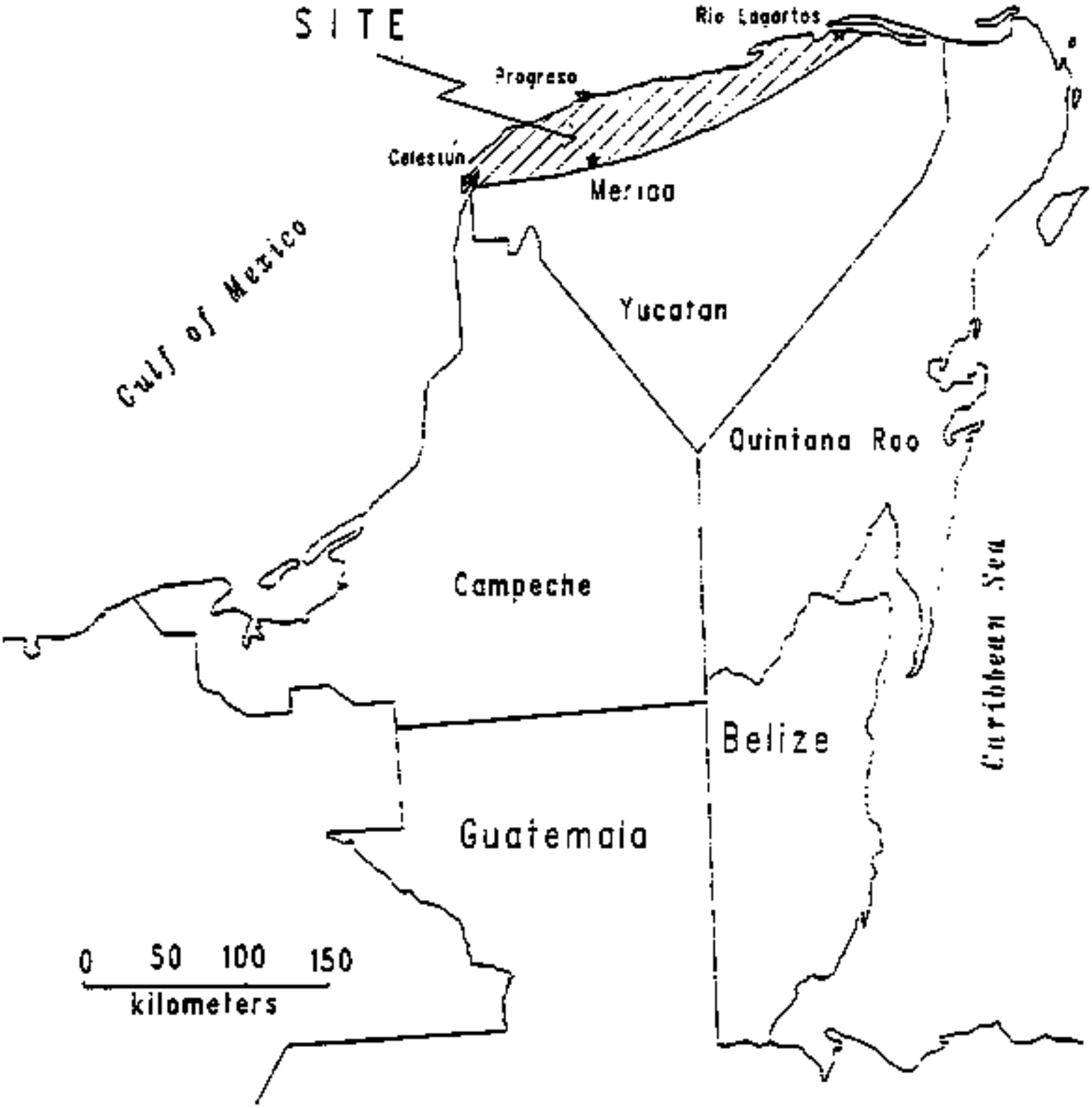
SUMMARY COMMENTS ON THE TWO POSSIBLE DEMONSTRATION SITES

The two sites chosen for this paper have sharp contrasts. The land use, the ecosystem, the institutional arrangements and the technology in use are all quite different. The most significant difference, and the one which makes them very appropriate sites, is that one needs corrective and the other needs preventative actions. They, together, symbolize the wide spectrum of sites that will need attention in the future.

CONCLUSIONS AND RECOMMENDATIONS

The years ahead will bring increasing demand for improvements in the planning and management of our water resources. The concept of sustainable development will stimulate the demand. One alternative for such improvements is to use the least cost mix of actions as the nucleus for an integrated management approach. This approach would invoke the explicit inclusion of ecology, economics, technology and institutions. Many existing features of both water quality and quantity planning and management are part of this integrated approach. The value comes from a synergistic effect of the integration. There is very little experience in the use of this integrated management approach and more is needed.

Figure 4. Demonstration Site No. 2 - Northern Area of the Yucatan Peninsula



Adapted from: Moseley and Terry, Yucatan: A World Apart, University of Alabama Press, 1980, p. 1

The identification of several sites throughout the hemisphere for demonstration of these ideas is recommended. The result would be a trend, in the years ahead, toward more sustainable use of the region's water resources. The InterAmerican Dialogue on Water Resources may serve as the incubator to foster the establishment of several demonstration projects.

ACKNOWLEDGEMENTS

This paper contains many ideas shared with the author by Blair T. Bower, Senior Fellow, World Wildlife Fund, Washington, D.C. Blair has been a source of encouragement in exploring better ways to plan and manage water resources for many years. The section on the least cost concept has been adapted from part of an unpublished report, Management of Large Water Bodies, prepared by members of the Task Committee on Management of Large Water Bodies, Water Resources Planning and Management Division, American Society of Civil Engineers, Chair, H.J. Day, November, 1991.

The Yucatán demonstration site narrative was based upon many visits to the area during the past ten years and discussions on the subject with a number of faculty and research staff of the Facultad de Ingeniería, Universidad Autónoma de Yucatán, Mérida, Yucatán. Ing. Miguel Villasuso Pino has been especially helpful.

Preparation of the manuscript including all figures, was done by the staff of the Green Bay Metropolitan Sewerage District, Green Bay, Wisconsin. The efforts of Ms. Kay Floading have been especially noteworthy.

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A Hemispheric Network Development as a Vehicle to Ensure Education, Training, and Technology Transfer in Water Resources Projects

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ABSTRACT

In response to the freshwater-associated challenges consented in Agenda 21, adopted by the United Nations Conference of Environment and Development (UNCED) in Rio de Janeiro, Brazil, in June 1992, the nations of the Americas should timely take actions to implement water resources projects. These projects must ensure protection of the supply and quality of freshwater for its people and ecosystems within the context of a sustainable development.

Pursuit of concrete action plans that emerged from the conference requires acknowledgement and implementation of a range of programme areas relating to freshwater, such as water resources assessments, integrated water resources development and management, protection of water quality, aquatic ecosystems, and drinking water supply and sanitation, among others. At the onset of a Continental Dialogue, a prime concern in launching an International Water Resources Network is to scope the potential role of such network in education, training, and technology transfer.

Herein, typical initiatives are recognized where networks are positively supporting and catalyzing professional advancement, continuing education, information exchange, and problem-solving through specialized volunteer contributions. Barriers that need be addressed are also identified. A priority list of specific goals and tasks for the development of the network in the Americas is also presented.

FRAMEWORK FROM AGENDA 21

As part of the 1992 United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro, twenty seven principles were proclaimed in the Rio Declaration on Environment and Development (United Nations, 1993). Those principles define a comprehensive and interrelated set of statements and objectives, towards which world communities should move forward, in order to ensure the implementation of the imperative need for sustainable development.

At least four of the principles establish the spirit to implement communication lines, such as a network, that would facilitate flow of information for education, training, and technology transfer in water resources projects.

> *Principle 3. “The right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations.”*

Principle 7. "States shall cooperate in a spirit of global partnership to conserve, protect and restore the health and integrity of the Earth's ecosystem...."

Principle 9. "States should cooperate to strengthen endogenous capacity-building for sustainable development by improving scientific understanding through exchanges of scientific and technological knowledge, and by enhancing the development, adaptation, diffusion and transfer of technologies, including new and innovative technologies."

Principle 10. "Environmental issues are best handled with the participation of all concerned citizens, at the relevant level. At the national level, each individual shall have appropriate access to information concerning the environment that is held by public authorities, including information on hazardous materials and activities in their communities, and the opportunity to participate in decision-making processes. States shall facilitate and encourage public awareness and participation by making information widely available. Effective access to judicial and administrative proceedings, including redress and remedy, shall be provided."

Conclusively, the message is clear. In order to protect our biosphere for all generations of humans, people must become partners that timely exchange information. The message is generic to all priority actions articulated in Agenda 21, but it particularly acquires a much more direct and immediate dimension in the case of freshwater resources projects, considering its vital role in the sustenance of all life forms on Earth.

The establishment of a communication network in the Western hemisphere, with the purpose of launching a comprehensive Inter-American effort to protect the quality and supply of freshwater resources for the people of the Americas, becomes then a prime task to achieve water needs for human development activities in all American communities. The network should stem from due considerations of the functioning of aquatic ecosystems which must reach all locations within the political boundaries of each country, but extending across international borders. The network will focus on information exchange, transfer, and accessibility to address the following major themes (United Nations, 1993):

a) integrated water resources development and management;
b) protection of water resources, water quality and aquatic ecosystems;
c) provision of drinking-water supply and sanitation; and
d) provision of water for sustainable food production and rural development.

Of course, the network can only be possible by assuring, at least, the following critical means:

a) new and additional financial resources; and
b) development of human resources.

PARTNERSHIP EXPERIENCES

In exploring the best approaches to developing a hemispheric network with emphasis on water resources, it is important to review previous experiences which can provide a basis for further efforts. This section describes selected examples of past or current partnerships for networking in the hemisphere.

The UNESCO International Hydrological Initiative

In 1965, UNESCO, as a contribution to the solution of the worldwide problems, began the first worldwide programme of studies of the hydrological cycle, the International Hydrological Decade, IHD, 1965-1974. The research programme included a major effort in the field of hydrological education and training. By the end of the decade, most UNESCO's Member States had built capacity to carry out national priorities and participate in regional and international cooperations. In 1975, UNESCO followed the IHD with the International Hydrological Programme, IHP, 1975-present, a scientific and educational programme which has gradually shifted into a multi-disciplinary approach to the assessment, planning, and rational management of water resources.

After more than twenty-five years (Gilbrich, 1991), the programme's record includes over fifty meetings, two dozen publications, more than a hundred experts participating in working groups and panels, and about ten thousand people who have directly participated in education and training. Indirectly, the programme has brought a worldwide hydrological education and training with technology transfer being channeled in all its facets, from on-the-job training to formal postgraduate education, to the technician and the professor, encompassing both the science and engineering fields. It could be said that hydrological education has been institutionalized in both developed and developing countries.

Overall this program shows a successful outcome in education and training, based on an effective transfer of knowledge and technology, within a framework of cooperative partnerships among developed and developing nations. Financing has resulted from combined allocations of UNESCO and the participating countries to meet needs of the educational and research institutions, and the same time providing fellowships for students from the participating countries.

Water for People, WFP

WFP (AWWA, 1992), an international nonprofit, non-sectarian, and non-governmental organization, was formed by the American Water Works Association, AWWA, one of the largest associations of water professionals in the world, with the purpose to respond to the drinking water and sanitation needs of people in lesser developed countries. The primary mission of WFP is to serve as a channel for volunteers and caring people to express their concerns.

WFP includes the following services: a) volunteer teams from North America and 47 countries; b) accessibility to WATERNET, one of the largest computer water-based information networks in the world; c) printed materials; d) education on potable water and sanitation needs, including global water problems for 7-9th grade students; e) in-kind contributions.

This initiative is an example of partnerships among individuals, corporations, utilities, organizations and agencies, which come together as volunteers in education, training, information transfer, within projects and solutions to specific regional and local problems. Financing taps the caring of people across the world which brings them together in a network of satisfying contributions.

Computer Databases with Latin American Information

Specialized databases on Latin America have been initiated by various academic institutions in the United States. Three examples are INFO-SOUTH, LADB, and CUIDES. Financing has been initially provided through grants which are eventually reinforced by user fees.

INFO-SOUTH Latin American Information System (UM, 1993), an online database produced at the University of Miami, specializes on information about Latin American politics and business. Since 1988, it has covered journal articles, newsmagazine articles and newspaper articles from major publications in Latin America, the Caribbean, North America, and Europe. Summaries of publications in Spanish, Portuguese, French, and Haitian Creole, among others, are available in English. Updating is weekly with about 10,000 new entries every year.

The Latin America Data Base (LADB) was created in 1985 at the University of New Mexico (UNM, 1992). The database has the objective of generating easily and timely, comprehensive information on the regional economic news and analysis easily to scholars, business people, activists, and government officials. It utilizes print media, radio, telecommunications and satellite technologies to report on Latin American events and developments. The base is updated weekly and can be accessed via direct or linked networks (e.g., New Mexico Technet and Dialog).

Data bases, such as INFO-SOUTH and LADB, offer communication linkages between informational sources and a network of users with particular interest in the Americas. Although no information is available on scientific and technological aspects of water resource projects in these bases, they represent a complementary resource and access to groups with interest in economic issues. They can also potentially integrate their users to other populations of customers.

An interesting initiative is CUIDES (The Inter-American University Council for Economics and Social Development) launched by the University of Arkansas (Miller, 1991). Since 1986, CUIDES has been working to establish a mechanism to encourage and facilitate the exchange of water resources expertise and technology in the Americas, a first step toward establishing a focus on water resource management expertise in the Americas. The data base is being used to identify water resource issues, and also individuals and organizations with expertise in water resources who have the willingness to share their expertise internationally. A next step involves exchanges, hemispheric conferences, seminars, and the development of an innovative water resources curriculum. A major aim is to understand ways for cooperative networking among universities, research institutes, businesses, and governments, at an Inter-American level.

Florida Engineering Education Delivery System (FEEDS)

FEEDS (FIU, 1993) is a statewide system whereby graduate level engineering courses are delivered to industrial sites and cooperating centers via telecommunications. The system is an evolving approach to provide quality graduate and continuing education to engineers at their work site in the State of Florida. The system was funded by special action of the Florida Legislature through cooperation of all the universities of the State University System. The universities with graduate programs are Primary Centers, the other universities are Cooperating Centers. In addition there are Industrial FEEDS Centers which have been established at industrial sites.

The system records university graduate classes in videotapes that are then distributed among those who registered in the program. The most common mode is by videocassette. Class sessions on campus are recorded, and videocassettes are shipped by an express service to the off-campus location, where students view the recording at a convenient time in the presence of a tutor. A broadcast system is also available to deliver courses to groups of students by live

television in classrooms at industrial and university sites.

This system provides an interesting experience in delivering distance education, training, and technology transfer opportunities across the State of Florida. Savings in bringing people together without having to leave their own communities or workplaces offer an attractive alternative to traditional formats of graduate education. Financing has been provided by the State of Florida; student tuition and fees match the standard rates of the participating university.

NETWORLDS IN CYBERSPACE

Over the last century and a half, communication technologies have brought fundamental transformation of society (Harasim, 1993). The slow communication alternatives across distance, with place-dependent human encounters (e.g., drums, messengers) have been replaced by fast and reliable computer-based technologies (Ives, 1991) that can simultaneously network people from places all over the world (e.g., telecommunications satellites).

The concept of a “global village,” introduced by M. McLuhan in the 1960's (Clarke, 1992) has become a reality that is being rapidly facilitated by global networking. Soon after ARPANET, the first large-scale packet switched network, was implemented in 1969, electronic mail was possible across the world. Today, global networks carried an overwhelming amount of information to millions of users on the planet. Thus, the telephone, computer, and satellite technologies have effectively combined to produce new modes of human interactions and societal activities. Effects are revolutionizing the fundamental concepts of speed and distance which is affecting the lives of every human being and community. For instance, “face-to-face” meetings can now be replaced by “on-line” meetings or in “cyberspace.”

Global networks (Harasim, 1993) currently include information and opportunities such as electronic mail, bulletin boards, and computer teleconferencing. Users interconnect locally, regionally, and globally for business, research, education, and social interaction. An individual can access a network with a personal computer linked by a modern to a computer network. The reach varies from an office area that has a local area network (LANs) to a wide area network (WANs), the basis of global networks. Their potential is great for electronic mail, computer conferencing, and televirtuality (Elbert, 1992).

Electronic mail or E-mail provides means for one-to-one or one-to-many communication. Main global networks are, among others, Internet, BITNET, USENET, and FidoNet. They are referred to as forming a *matrix.*

Internet connects more than two thousand smaller networks. It provides E-mail, bulletin boards, databases, library catalogs, chat lines, multiuser domains, discussion groups, and access to supercomputers by scientists and engineers. BITNET (Because It's Time Network) links academic institutions in more than thirty countries, supplying mailing lists, E-mail, and short-time interactions. USENET (User's Network) is a worldwide voluntary member network with connections to universities, government, business, and military sites. USENET offers a series of newsgroups or discussion groups. FidoNet is called the “people's network” because is mostly open to anyone at no cost. It connects six continents through E-mail, public conferences, and file transfers.

Computer teleconferencing offers opportunities for groups with various interests to communicate

by text. Multimedia resources, that incorporate graphics, video and sound, are rapidly becoming available. Most interestingly, but still in development, is the potential of televirtuality, namely, the sharing of a three-dimensional space over a telecommunications network.

Overall, understanding the potential of networks is of utmost concern to establishing a hemispheric network to facilitate the implementation of water resources projects within a scope of sustainable development. In fact, education, training, and technology must consider the use of the new places for human interaction created by the connection of computers and computer networks. A new coined term refers to these new spaces as a *networld* (Harasim, 1993).

BARRIERS

The development of a hemispheric network can not happen without overcoming a number of barriers (Kasman, 1992; Maltezou, 1992). Barriers or differences can be generically grouped in four major categories: political, cultural, technical, and financial.

Political barriers are related to the lack of incentive, among country or community leaders and representatives, to acknowledge the importance of water resources projects. These could be particularly difficult in countries or communities where lack of education or other basic priorities and interests handicap governmental action and effective public participation.

Among the cultural barriers, an important issue is the widely spread use of English in current networks. Unless potential users learn English and other common languages or information is effectively translated to as many languages as possible, a very large sector of the continental population will remain isolated. In the American continent Spanish is definitely a priority language, followed by Portuguese.

Lack of formally educated individuals, at all levels of know-how, will create a technical challenge for the proper interpretation and application of easily available scientific and engineering information. Thus, mechanisms to provide education, within traditional formats, will be needed to prepare the human resources capable of implementing the potential of networks.

As Agenda 21 defines it, the developing countries will not be able to meet environmental and development goals without the provision of financial resources. Importantly, the cost of inaction would far outweigh the total financial costs of implementing Agenda 21, and narrow the choices of future generations as well. Conclusively, it has to be assumed that the sources of financing will meet their challenge. Sources include the Official Development Assistance from the developed countries; the International Development Association; regional and subregional development banks; United Nations bodies and other organizations; private funding; and reallocation of resources committed to military resources, among others.

GOALS AND TASKS

Acknowledging that timely and reliable information is essential for a sound management of water resources, a special meeting was organized within the VIIth World Congress on Water Resources held in May, 1991 (IWRA, 1991). The meeting identified a number of critical needs that are central to the development of sound information programs for water resources management. Because, education, training, and technology transfer are direct expressions of information systems, those critical needs can be articulated into a list of basic goals for the

creation of a hemispheric network, as follows:

a) to recognize that a network is an efficient and cost-effective alternative to bring people and information together;

b) to link the hemisphere through existing world networks into a network that focuses on water resources management;

c) to develop and enhance capacity for networking in all nations of the continent with due consideration of political, cultural, technical, and financial barriers;

d) to make current and new information suited for networking as well as accessible at all levels of responsibility and needs in each country;

e) to establish minimum standards of quality and operation for information handling and networking;

f) to increase linkages among potential users, particularly high-level policy makers and technical personnel;

g) to improve cooperation and collaboration among governmental, private, and academic sectors, across disciplines involved in water resources management; and

h) to ensure commitment at the political and management levels, since this is essential for the viability and sustainability of a network, and interagency, interregional, and international exchange and sharing.

An essential requirement to achieve the goals noted above is leadership, particularly at the political level. As a matter of fact, leaders have a major responsibility in the realization of Agenda 21.

Consequently with the goals, the following tasks are presented as immediate steps to take this Inter-American Dialogue into an Inter-American Network on Water Management:

a) to establish a mechanism, such as a Task Force, Working Group or Steering Committee to address the goals noted above;

b) to promote the theme of networks in national and international agendas of water-related congresses, conferences, meetings, and workshops;

c) to promote inter-sectoral and inter-agency collaboration by providing fora to bring sectors and agencies together;

d) to sensitize high-level policy makers on the value of networks at national, regional, and international levels;

e) to develop and improve networking at national and regional levels through professional associations and/or other means;

f) to establish a principle of incorporating a network component as an integral part of all water resources initiatives/projects;

g) to develop guidelines for handling of water resources management information; and

h) to establish a principle of free information exchange.

CONCLUSIONS FOR THE MIAMI DECLARATION

In summary, a network to facilitate and enhance educational, training and technology transfer opportunities in the field of water resources projects is definitely a need. This need must be addressed if the hemisphere is to move forward to a sound management of water resources at the continental level, within a framework of sustainable development.

Attempts and experiences of networking in Latin America by initiatives in the various nations of the continent are encouraging. They also constitute a starting reference for future networking. Global networks offer a valuable resource to communicate across the Americas. They can be used by academia, industry, government, and the private sector to begin a permanent communication on water resources issues.

However, barriers exist that must be acknowledged and positively confronted with solutions. These barriers are of political, cultural, technical, and financial nature. They manifest themselves in lack of governmental priorities, language differences, educated and trained personnel, and above all, financial resources.

A number of goals and tasks are presented with the purpose of focusing efforts to facilitate the establishment of a network to be used in education, training and technology transfer. Efforts should provide opportunities for discussion, partnerships, and actions in support of the establishment of a hemispheric network.

Finally, the following statements are recommended for inclusion in the Miami Declaration:

Considering that

a) the present generations in the Americas have a responsibility to future generations; and
b) the nations of the American continent agreed on Agenda 21;
c) the Americas contain rich and unique freshwater resources;

It is recommended that

a) A continental network must be developed to facilitate and enhance education, training, and technology transfer in the field of water resources;

b) The nations must work to create needed political incentive, simultaneously reducing any cultural, technical and financial barriers, so that the potential of a network is fully developed.

c) Organize a Task Group, Working Group, or Steering Committee whose major responsibility will be to develop a plan of goals and tasks to establish the network. The Group or Committee must have representation from all the participating nations of the American Continent.

The attached Appendix introduces an opportunity to establish an initial link and mailing list at Florida International University. An E-mail address is provided with a message to ensure subscription.

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APPENDIX

In order to continue the Dialogue, Florida International University (FIU) through the Environmental Engineering Program, has created an E-mail address or repository to build an electronic mailing list of interested parties, H2ONET.

To subscribe to the mailing list send a message to the following address:

H2ONET@ENG.FIU.EDU

In the body of the message (not the message subject), type

subscribe to H2ONET.

Professors Fuentes, Tsihrintzis and Jaffe will manage the repository list and mail. Parties (i.e., agencies or individuals) are welcome to send messages in either Spanish, Portuguese, or English. On a case by case basis, the Professors will be willing to hold discussions on issues related to environmental management of aquatic ecosystems, water resources, water quality, and American regulations and rules.

Priority Regions in Latin America for Water Management

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Abstract

When considering the water-management problems of the various regions of Latin America, it is advantageous to establish relative priorities. There are two main reasons for this: (1) The urgency for economic/social development that depends on the water resource is high in some regions but less so in others; and (2) Qualified manpower and funds are in short supply.

In this paper, the author discusses the situation in seven regions that he believes have high priority in the short or medium term. He also reaches some preliminary conclusions with respect to other regions that may have priority in the medium or long term.

The brief descriptions of the seven regions include preliminary answers to the following questions:

- What steps should now be taken?
- What can be learned from the region's history up to the present?
- What help from outside the regions would be useful?

Selection of the Regions

A particular region has been selected for priority if the answers are affirmative to all of the following three questions:

- Is water control critical to sustainable development of the region?
- Does the region contain a large population as compared with other regions in Latin America?
- Is it feasible to achieve substantial progress toward sustainable development in the medium term (10 to 20 years)?

The priority regions selected are:

- Mexico, the Gulf Coast;
- Colombia, the Upper Cauca Valley;
- Ecuador, the Lower Guayas Valley;

- Brazil, the Northeast;
- Peru, the Coast;
- Chile, the Santiago region; and
- Colombia, the lower Cauca and Magdalena Valleys.

The attached table gives figures on areas (gross and arable) and on population (regional and principal cities), and lists the agencies concerned (national as well as international).

The author's judgements regarding the foregoing questions have been based on numerous visits to the regions listed. Except for Brazil, the visits were in the form of “missions” for the World Bank, when he acted as mission leader. The missions were for various purposes including: regional resource planning (as a prelude to specific project planning), project pre-appraisal and appraisal, and agricultural-sector review.

In the case of Brazil, the missions, of which there were four, were on behalf of the Organization of American States (OAS); in two of these, the author was a member of a multi-disciplinary team including economists and agronomists. In the case of Colombia, he resided in Cali 1955-62 when he acted as Chief Engineer for the regional autonomous corporation (see description below); he also headed two subsequent World Bank mission to the country. In the case of Peru, in addition to numerous missions for the World Bank, he was engaged in 1987-88 by the Kreditanstalt fur Wiederaufbau (KfW) of Germany for pre-appraisal of a loan for rehabilitation of a large irrigation project in the Coast; however, despite several months of work, the project was cancelled owing to the ongoing political instability.

Mexico: Gulf Coast

Mexico has 5 million ha under irrigation; these lands are primarily in the semiarid Pacific Coast and the Central Plateau. There is little additional land that Mexico can develop for intensive, irrigated agriculture. Yet, to meet its growing need for food and fiber, both for domestic consumption and for export, it is imperative that Mexico increase its agricultural production.

The tropical-humid Gulf Coast is greatly underutilized. This region has generally good soils and ample rainfall generally exceeding 1500 mm (Comision del Plan Nacional Hidraulico 1981); see Map 1. The first need is for drainage, sometimes with and sometimes without flood control.

The main reason for the current state of underdevelopment is the prevailing landholding pattern. The land is held in large cattle ranches. The ranch owners are enabled by Mexican law to utilize the land at a low carrying capacity per animal. The ranch owners, who exert much political weight, are moreover opposed to water-control projects (whether irrigation or drainage) since under Mexican law, when such projects are financed by the state, there is a limit to the size of landholding - generally not more than 10 or 20 ha.

Mexico completed a first version of a National Water Plan in 1975 with assistance from the World Bank and the United Nations Development Programme (UNDP). In both the 1975 version and an updated one (in 1981) attention was given to the Gulf Coast. A program called “El programa de desarrollo rural integrado para el tropico humedo” (PRODERITH) followed. The World Bank financed a substantial part of it and implementation proceeded beginning in 1978. Technical assistance was provided by the indigenous agricultural-research agencies, by the Soil Conservation Service of the U.S. Department of Agriculture and the by Food and Agriculture

Organization (FAO) of the UN. The first phase of PRODERITH, achieved by 1984, covered 100,000 ha involving 30,000 small farmers. The first phase was judged to be a success and a second phase is under execution (Comision del Plan Nacional Hidraulico 1985). It is judged that the program needs considerable acceleration but this appears to be impeded by continued opposition by the ranchers.

An earlier project in the region called “Plan Chontalpa” was initiated in 1966 with financial assistance from the Inter-American Development Bank. It covered 75,000 ha. The project had mixed success, apparently due to inadequate planning for flood control and drainage.

Most of Mexico's petroleum deposits are in the Gulf Coast and the region already possesses considerable infrastructure in the form of roads and major dams (for hydroelectric generation, for flood control and, to a limited extent, for irrigation).

How could outside help assist Mexico in achieving adequate sustainable development of its Gulf Coast? Bearing in mind that, with respect to human capital, Mexico's engineers, agronomists and economists are first rate, help in these fields is hardly needed. As mentioned above, the impediments are mainly of a socio-economic (and therefore political as well) nature. Outside help should be through the citation of examples showing how these aspects were handled as in the Cauca Valley in Colombia (see below) and in the water management districts of Florida.

Because of their detailed knowledge of the Gulf Coast as well as of the various water-related sectors of Mexico (besides agriculture, these include energy, domestic and industrial water supply and the ecology), staff of the World Bank should be contacted and asked to cooperate.

Colombia: Upper Cauca Valley

The Corporacion Autonoma Regional del Cauca is also known as the CVC, these being the initials of Cauca, Valle and Caldas, the three departamentos (provinces) of Colombia concerned. The thinking in 1954, when CVC was established, was that it would function as a river basin authority along the lines of the Tennessee Valley Authority (TVA) of the United States. David Lilientahl, a former Director of TVA, was called in to advise CVC.

To finance its initial operations, CVC was able to get national and provincial approval for a 4 per mil land tax despite opposition by some of the large landowners in the valley. Electric-utility companies were also opposed as they felt threatened. However, the view of the more forward looking, including many large landowners, prevailed (Posada and Posada 1966). CVC is now viewed by many Latin American pundits as a model to be emulated.

In the 1960s and 1970s, CVC was able to carry out several large-scale and noteworthy projects and was able to secure funding from national and international sources including the World Bank and the government of Japan. The projects included two major dams for hydroelectricity, flood control and water conservation; a high-voltage transmission network; a 5,000 ha drainage and flood control project adjoining Cali that more than doubled the land available for urbanization; and an irrigation and drainage project covering 11,200 ha and which was supported financially by the Instituto Colombiano de la Reforma Agraria (INCORA) (Kirpich/Ospina 1959). See Map 2.

Cali in 1955 was a city of about 250,000. Today its population exceeds 1,600,000. Like many other Latin American cities, the growth of Cali has been explosive owing to in-migration of the

rural poor. As could be expected, problems of sewage and waste disposal have arisen (Ridgley 1989).

The existing dams provide a degree of flood protection which however has to be supplemented by diking as at Cali. Poor drainage of the lower-lying areas also needs further attention. Near the town of Buga, a sizeable lake, which serves as a refuge for migratory birds, needs improvement and preservation. See Map 3.

Further development of the valley needs further detailed studies which become more complex than heretofore owing to competing demands for water, the need to protect water quality and environmental concerns. The latter include the bird refuge and the disposal of wastes from agricultural fertilizers and pesticides, from a large number of sugar refineries and from industries, including a large paper mill and a large tire factory, both near Cali.

The cropping pattern in the fertile Cauca Valley needs upgrading in the medium and long term. Much land is still in low-intensive cattle production, and the large percentage in sugarcane, a high-volume water consumer, should be lowered. The major international agricultural research center CIAT (Centro Internacional para la Agricultura Tropical), which is in the Upper Cauca Valley, could assist in determining the manner and timing of changes in the cropping pattern.

CVC has been in contact - and will no doubt continue - with the agencies listed in the table. With respect to the international banks, the departments of these banks that deal with the environment and with agriculture should, in particular, be contacted. As indicated above, the Upper Cauca Valley of Colombia can be presented as an example, many of whose features can be copied elsewhere in Latin America.

Ecuador: Lower Guayas Valley

Ecuador has basically two agricultural regions: the “Sierra” and the “Costa”. The small valleys in the mountainous Sierra are fully exploited. The flatlands of the Costa, mainly located in the delta of the Guayas River, are greatly underutilized. See Maps 4 and 5.

The two principal urban centers of the country are Quito, the capital, located in the Sierra, and Guayaquil, the country's main port. The latter with a population of over a million is about 50% larger than Quito. Both cities, but especially Guayaquil, are growing rapidly owing to in-migration of the rural poor.

The Comision de Estudios para el Desarrollo de la Cuenca de Guayas (CEDEGE) has been active since about 1970. In the early 1970s, CEDEGE's directors promoted the construction of the Daule-Peripa dam, which they claimed would bring great benefit to the Lower Guayas Valley and to the adjoining but distant Santa Helena peninsula where rainfall is only about 200 mm (compares with about 1500 mm in the Lower Guayas). CEDEGE applied to the World Bank for the financing of the Daule-Peripa dam but was turned down on the grounds that it would be far more beneficial to concentrate on the drainage and flood control problems of the Lower Guayas Valley and that, at a later stage, water for supplemental irrigation could be obtained from groundwater. However, CEDEGE persisted and was able to obtain financing for Daule-Peripa from the Inter-American Development Bank.

The Daule-Peripa dam was completed but the drainage and flooding continued to be serious.

The continued construction of major roads traversing the region, built without consideration of drainage needs, have exacerbated the drainage problems. The clearing of important mangrove forests for construction of shrimp ponds presents another serious environmental problem.

In 1987, based on a grant from the Government of the Netherlands, a consulting firm of that nationality began work on a feasibility study. Time had been lost during the preceding years owing to disagreements between CEDEGE and the Instituto Ecuatoriano de Recursos Hidraulicos (INERHI), mainly with regard to which agency would be responsible for the study. Completion of the study, intended for 1988, was not achieved until 1990; the delay was due in part to environmental concerns which led to the preparation of an environmental impact statement.

The project would constitute a first-phase development of the Lower Guayas Valley. The project would proved flood protection to 184,000 ha, within which: drainage-improvement works for 60,500 ha; an Agricultural Development Plan for about 3,300 smallholders (less than 10 ha) with provisions for on-farm investment and strengthening of small-farmers' organizations; and various environmental and conservation initiatives.

Financing of about two-thirds of the overall cost of the project is expected to be provided by the World Bank and the Government of the Netherlands (Ochs and Wittenberg 1992).

Brazil: The Northeast

Northeast Brazil (see Map 5) covers a vast area, three times the size of France. With a fifth of the area of all of Brazil, the Northeast Region has a population of about 46,000,000 or about 30% of Brazil's population of 158,000,000 (1991).

The region is drought-prone. The 1992-93 drought is the worst in 40 years (Economist 1993). See Map 6. In Pernambuco, the driest of the eight states in the region, reservoirs have not filled since 1960. The drought has impaired not only water quantity but also water quality, causing spread of disease including cholera. Livestock are also suffering greatly.

In the past, families would leave the region at times of drought to work on rubber-tree tapping in the Amazon jungle or would migrate to the industrial cities of the south such as Sao Paulo. These exits are no longer available and, instead, poor peasants drift to the cities and towns of the region where slums are proliferating.

The Sao Francisco Valley, located in the middle of the region, is an exception. Major dams and reservoirs have been constructed, primarily for energy generation but with beneficial side-effects through flood control and irrigation. The World Bank has financed a polder-type project in the delta of the Sao Francisco River. The author visited the region in 1979 on behalf of the OAS when he prepared terms of reference for long-range studies of the Sao Francisco River basin. He was told at the time that the goal was to achieve 819,000 ha of irrigation by the year 2000, although a more realistic goal would be 500,000 ha.

Clearly, the Northeast Region continues to present a serious problem for Brazilian politicians and planners. Its solution is compounded by the large disparity in the size of landholdings, by the high degree of illiteracy and by the variation in physical conditions. Most of the region is semi-arid to arid but there are also sub-regions that suffer from flooding and poor drainage. In

the semi-arid portions of the region, significant studies of water availability have been started only for the Sao Francisco River basin. Elsewhere, there is only anecdotal evidence which indicates that water, whether from surface or underground sources, is likely to be scarce.

Brazilian water-resource planners could benefit from efforts elsewhere in the world under similar physical and socio-economic conditions for which, unfortunately, there are no examples in the Americas. Pertinent examples of adequate size and scope can perhaps be found in China and India.

All of the agencies listed in the table have a strong interest in the development of Brazil's Northeast. The UNDP, in particular, should be invited to play a key role in guiding and financing the numerous studies and negotiations required in order to achieve sound development.

Peru: The Coast

The “Selva” (rainforest in the Amazon River basin) has practically no agricultural value. The “Sierra” (mountains) has some (limited) value but is almost fully exploited. On the border between the Sierra and the Selva, is found a zone devoted to cultivation of coca, a primary source of the cocaine ending up on the streets of the cities of the United States.

The “Costa” of Peru provides over 70% of Peru's marketed agriculture and in the past two decades has absorbed over two-thirds of the public-sector investment in agriculture. There are about 750,000 ha of irrigated land in the Costa of which a third to a half suffers from varying degrees of excess salinity and waterlogging due to poor drainage and misuse of water.

Correction of this condition, and the arrest of further deterioration requires: (a) a program of rehabilitation to remove the most important bottlenecks of infrastructure (basically drainage works); and (b) the establishment of irrigation-district authorities in rehabilitated areas in order to preserve the effectiveness of past investments and carry out effective operation and maintenance.

Concurrent with rehabilitation of the irrigated zones of the Costa, several structural reform Policies are urgent according to several observers. These include:

1. Changing the role of cooperatives (especially the sugar cooperatives from producer to service cooperatives).

2. Removing the uncertainties that still remain with respect to land reform which has severely reduced the role of private enterprise.

3. Improving standards of the Banco Agrario del Peru whereby negative interest rates provide windfall profits to a privileged few.

As part of the rehabilitation effort, thought should be given to possible advantageous changes in the cropping patterns. The area in rice has risen markedly in recent years which is a factor causing water shortages for other crops; a complication is that there are consumer subsidies on rice (also wheat) in order to benefit the urban population. The cultivation of maize (corn) which consume less water than rice could be increased in the Costa. Sugar production has suffered owing to deterioration in cane quality; the harvested area decreased from 55,000 in 1975 to 38,000 in 1981; possibly the decrease in yield was caused in part by the deteriorating drainage situation.

Some irrigation rehabilitation projects were approved by the World Bank while the author was still there in the late 1970s. Relations between Peru and the World Bank deteriorated after that but are now being restored.

Pressure has most likely continued from local interests for construction of mammoth projects for trans-Andean water diversions. An example is the long-debated Majes project that would presumably benefit lands adjacent to the city of Arequipa. Such pressures should be resisted as the priority for Peru should be to rehabilitate and secure the proper operation and use of its existing irrigation projects.

The World Bank in the mid-1970s provided some assistance to Peru in the form of technical assistance for study of a major hydroelectric complex in the Andes Mountains east of Lima and which would be of benefit as well to the city of Lima for augmentation of its domestic water supply.

Peru is important to the United States for several reasons:

- It is a major source of drugs. Its poor social and economic conditions, which have been exploited by the Shining Path guerrillas, have been a source of serious political instability in the hemisphere.
- It could be a major market for U.S. exports.

Assistance to Peru in the water-resources field could materially help the country solve its social and economic problems. It is likely that the agencies listed in the table would all be happy to cooperate.

Chile: Santiago Region

In the mid-1970s, the World Bank was asked to help with respect to water-related problems of the Santiago region. Competition for scarce water was arising between use for domestic water supply and for irrigation. Domestic sewage was being used for irrigation and this was causing health problems.

Following two missions to the country that the author headed, the Bank agreed to finance a feasibility study which was carried out by a U.S. consulting firm.

The region, which includes the three cities listed in the table, is rather complex from a water-planning point of view, and it is doubtful whether the water-related problems have been fully or adequately sorted out. According to the UN as quoted in a recent article (Bartone 1990), the population of the Santiago urban area was 4.2 million in 1985 and is expected to reach 5.3 million in 2000.

Colombia: Lower Cauca/Magdalena Valleys

Despite its extent, Colombia has limited areas of good to high-quality land for agriculture. The Lower Cauca/Magdalena Valleys contain large areas that are either already of good quality or can be raised to that level through artificial means, that is, through flood control and drainage works. In planning such works, it would obviously be essential to consider environmental features with respect to wildlife and pollution.

Some such development, although limited thus far, has already taken place not far from the Caribbean port cities of Barranquilla, Cartagena and Santa Marta. (The upper part of the region is adjacent to Medellin, Colombia's second city, with a population of 2.2 million.) In the late 1970s, the Government of Colombia expressed an interest in development of the region and obtained some technical assistance from the Netherlands Government for this purpose. On that occasion, the World Bank also sent a mission, headed by the author.

A good source of information with respect to the current status of the region would be Carlos S. Ospina, head of a consulting firm “INGETEC” of Bogota. Mr. Ospina is an eminent Colombia engineer recently honored by the American Society of Civil Engineers and has familiarity with all aspects of water-resource Planning in Colombia.

Other Regions

Other regions will no doubt be suggested but are not likely to have a relatively high priority, at least in the short term. These are described briefly in the rest of this paper.

Brazil: The Pantanal

This vast wetland of 469,000 km^2 has an extent about 40 times that of the Everglades! Half of the Pantanal is in a remote southwestern comer of Brazil, with the other half in Paraguay (see Map 7). The Pantanal has rich resources in terms of wildlife, cattle, minerals and potentially highly productive agriculture and is astride of a proposed pipeline linking important natural-gas fields in Bolivia with the industrial centers of Brazil.

The author gained some acquaintance with the Pantanal through participation in 1976 in a 2-week think-tank-type mission on the region in Brazil for the Organization of American States (OAS). An OAS report followed outlining a series of surveys and studies to be carried out. Long isolated from the rest of much of Brazil, the Pantanal is in enormous cattle ranches, some covering as much as 50,000 ha. The landholding pattern is markedly skewed:

Landholding size		**Area**
in ha	**thous. ha**	**Percent**
100 to 1,000	248	1
1,000 to 10,000	7,353	43
over 10,000	9,601	56

Flooding occurs annually for up to 6 months in many areas. Deep flooding of up to 5 m occurs about once in 7 years. There are 3 sizeable lakes with a total area of 75,000 ha.

The proliferation of wildlife, the mineral riches and the possible use of much of the region for intensive agriculture, make the Pantanal of great long-range interest to Brazil, Paraguay and the world at large. Since however its population is small and since its development to a significant extent cannot be expected in the short or even medium term, it appears doubtful that the Pantanal should have priority for the present.

Venezuela, The Orinoco River Delta

The Orinoco, one of South America's great rivers, has high potential for hydroelectricity and, ultimately, for agriculture. But it is sparsely populated and should not therefore have priority for the present. On the other hand, there is little doubt that studies leading to long-range properly-phased sustainable development should continue to be pursued for which advice should be obtainable from various international agencies such as the UNDP and FAO.

The Caribbean

Areas and the affected populations are generally small. The Dominican Republic may be an exception. A sizeable irrigation project already exists - the Yaque del Norte - and development is proposed as well for the eastern part of the republic - the Yuna River basin. The key to sustainable and economic development appears to be the marketing of high-value crops to Puerto Rico and to the United States. Cuba has extensive irrigated zones and may be of interest once normal international relations are achieved.

Central America, The Caribbean Coast

This extensive zone has similarity to the Mexican Gulf Coast but the population affected is relatively small.

Central America, Urban Regions

Areas adjacent to several of the larger cities could be candidates. In Nicaragua, a zone known as Tuma Viejo east of Managua and north of Lake Nicaragua was reconnoitered by the author in 1965 and appeared promising for intensive irrigated agriculture.

Holistic Approach to Planning

Planning of large water-resource development schemes, whether new ones or modification of existing ones, is a complex process. Complexities are caused not only by increased population pressures and scarcity of resources. Cultural and environmental factors now weight heavily - much more than say 40 or 50 years ago.

A holistic approach to planning is now needed (Kirpich 1993) which considers all relevant factors. While time consuming, such an approach is now essential. Of course, the judgement of the planner must be exercised to select the relevant factors, while giving less weight to the less relevant ones.

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PRIORITY REGIONS IN LATIN AMERICA FOR HATER MANAGEMENT

Regional Area (thousand hectares)		Regional Population (approx., thousands)			Principal Cities	approx. population	Agencies concerned
Gross	Arable (a)	Rural	Urban	Total		in thousands	
Mexico: Gulf Coast							
46,000	7,500	10,000	10,000	20,000	Vera Cruz	400	Secretaria de Agricultura y de Recursos
					Tampico	300	Hidraulicos (SARH), Mexico City
					Matamoros	200	World Bank, Washington
Colombia: Upper Cauca Valley							
3,700	400	2,800	3,000	5,800	Cali	1,800	Corporacion Autonoma Regional del Cauca, Cali
					Palmira	200	Instituto Combiano de la Reforma Agraria
					Buenaventura	100	(INCORA), Bogota
					Buga	100	World Bank, Washington

					Cartago	100	Centro Internacional para la Agricultura Tropical (CIAT), Buga
							Inter-American Development Bank, Washington
							World Health Organization (WHO), Washington
Ecuador: Lower Guayas Valley							
2,000	1,000	1,000	1,200	2,200	Guayaquil	1,000	Comision de Estudios para el Desarollo de la Cuenca de Guayas (CEDEGE), Guayaquil
							Instituto Ecuatoriano de Recursos Hidraulicos (INEHRI), Quito
							World Bank, Washington
							Inter-American Development Bank, Washington
Peru: The Coast							
	750	NA	NA	NA			World Bank, Washington
							Inter-American Development Bank, Washington
Brazil: Northeast							
150,000	3,000(b)	31,000	15,000	46,000	Salvador	1,700	Superintendencia de Desenvolvimento do Noreste
					Recife	1,500	(SUDENE), Brasilia and Recife

					Fortaleza	1,500	Departamento Nacional de Obras de Saneamento
					Sao Luis	600	(DNOS), Brasilia
					Natal	500	Companhia de Desenvolvimento do Vale do Sao
					Maceio	500	Francisco (CODEVASF)
					Joao Pessoa	400	Companhia Hidro Electrica do Sao Francisco (CHESF)
							OAS, Washington
							World Bank, Washington
							Inter-American Development Bank, Washington
							FAO, Rome
							UNDP, New York
Chile: Santiago Region							
		1,000	5,000	6,000	Santiago	4,200	World Bank, Washington
					Viña del Mar	330	Inter-American Development Bank, Washington
					Valparaiso	310	WHO, Washington
Colombia: Lower Cauca/Magdalena Valleys							
					Medellin	2,200	World Bank, Washington
					Barranquilla	500	Inter-American Development Bank
					Cartagena	400	INCORA
					Santa Marta	200	

(a) Land with medium to high agricultural potential obtainable primarily through water-control works (some combination of works for flood control, drainage and irrigation) plus management (of the water-control works, of agricultural support services and of institutional changes including land-ownership regulations).

(b) Highly tentative figure. The Sao Franciso River Valley alone has over 800,000 ha

(see text).

Hydrometeorological Networks and Data Management for Prevention of Natural Disasters in Central America

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INTRODUCTION

This work deals with the Meteorological and Hydrological Networks of the Central American Isthmus and their ability to provide information for the management of Disasters Induced by Atmospheric Phenomena-(DIAP).

The Central American Isthmus, due to its geographical situation and topography, is highly vulnerable to the actions of hurricanes, cold fronts, tornadoes, tropical waves, and other atmospheric and hydrologic phenomena. The most visible and conspicuous manifestation of these phenomena are almost always floods, which result from the combination of meteorological, watershed, and river conditions. Though man affects the latter conditions, there is nothing he can do about the meteorological ones. However, he can quantify them and study their probabilistic characteristics to understand them and to eventually prepare preventional measures that mitigate the negative effects of DIAPs. Such a quantification is possible only if there exists a network with well-located and well-designed stations.

This paper presents:

1. A probabilistic analysis of the occurrence of hurricanes, tropical storms and floods, assuming a Poisson distribution for the quantitative estimate of the risks these events present for the Isthmus.

2. A description of the present ability of the network to observe the atmospheric phenomena in Central America, including their geographical and temporal distribution.

3. Description of the present and future (satellite based) meteorological telecommunications systems, that link the Isthmus with the rest of the world.

4. Discussion of the relationship between disaster prevention systems and the availability of meteorological information to predict disasters, particularly related to the measures that should be taken before a disaster hits.

5. Description of the international cooperation and the regional integration mechanisms that exist and presently contribute to the prevention and mitigation of the DIAPs.

6. Conclusions and recommendations.

2. HURRICANES AND FLOODINGS IN THE CENTRAL AMERICAN ISTHMUS

2.1. Hurricanes and Tropical Storms in Central America

From 1887 to 1993, 33 hurricanes and 34 tropical storms have passed over the Isthmus (Lizano, 1993; Belize, 1993). The damages caused by these events are tremendous, the most recent example being Hurricane Joan (October, 1988), which practically demolished the Atlantic coast of Nicaragua, leaving in its path numerous deaths and millions of dollars in economic losses.

To have a probabilistic idea of the occurrence of these events, assuming a Poisson distribution (Benjamin, 1970; Molina, 1986; Bedient, 1992) the following table has been prepared:

PROBABILITY OF OCCURRENCE OF HURRICANES AND TROPICAL STORMS

# of events/year	Hurricanes	Tropical Storms	Hurricanes or tropical storms
0	0.728	0.735	0.487
1	0.231	0.226	0.350
2	0.037	0.035	0.126
3	0.004	0.004	0.030
4	0	0	0.005
5	0	0	0.002
TOTAL	1.000	1.000	1.000

We can see that, for example, the probability of having zero hurricanes or zero tropical storms in any year, is 72.8% and 73.5% respectively, the probability of haying one or more hurricanes, or one or more tropical storms, is 27.2% and 26.5% respectively. On the other hand, if we consider the occurrence of either one of these events, the probability of zero events is 48.7% and the probability of observing one or more events is 51.3% Because the damages caused by either one of these storms are always disastrous, we can see that the economic and social risks presented by these events are very high.

2.2. Floods in Central America

The most conspicuous example of a DIAP is a flood. For this reason, a partial compiling of the floods observed in Costa Rica, El Salvador and Panama has been done to show the magnitude of this risk in the life of the Central American countries.

The following table shows some figures of interest.

NUMBER OF FLOODS

Decade	Costa Rica (Ref.6)	El Salvador (Ref.5)	Panama (Ref.14)
1950-59	18	6	no data
1960-69	26	17	6
1970-79	21	14	8
1980-1989	23	no data	11
TOTAL	88	37	25

We see that Costa Rica has had 88 floods in 40 years, El Salvador has had 37 floods in 30 years and Panama has had 25 floods in 30 years. As with storms, assuming a Poisson distribution, the following flood probabilities can be estimated:

PROBABILITY OF FLOODS

# of events/year	Costa Rica	El Salvador	Panama
0	0.110	0.292	0.436
1	0.244	0.360	0.362
2	0.268	0.221	0.150
3	0.197	0.091	0.041
4	0.108	0.028	0.008
5	0.047	0.007	0.003
6	0.017	0.001	0
7	0.009	0	0
TOTAL	1.000	1.000	1.000

We can see that, for example, the probabilities of zero floods in any year, is only 11 % in Costa Rica. On the contrary, the probabilities of having one or more floods is 89%, 70.8% and 56.4% in Costa Rica, El Salvador and Panama, respectively. These figures show that the risk of floodings in this region is even higher than the risk of hurricanes or tropical storms. The floods considered are the largest floods only, and which have generally produced loss of lives, huge material damages, and interruptions in the economic progress of the countries.

For example, the November 4, 1966 floods in Panama caused 60 deaths, wiped out 36 towns and the losses were more than 1.5 million dollars. Similarly, the floods of June 7, 1973 in Rio Grande San Miguel, El Salvador produced at least three deaths and great damage to the infrastructure of the area. In Costa Rica, because it is the most vulnerable, the number of deaths is also larger. During the last two decades the floods of 1988, 1980, 1979, 1978, 1972 produced a total of 14 Costa Rican deaths.

3. ATMOSPHERIC PHENOMENA AND OBSERVATION NETWORKS

3.1. Geographical and Temporal Concept

The meteorological phenomena are born, develop and dissipate in different lengths of time. This characteristic is called the temporal scale of the phenomena. The other characteristic is that each phenomenon has its own geographic dimension, which is called the geographical scale.

If we apply these two characteristics, an isolated storm-cloud would have a temporal scale of about two hours and a geographical scale of a few square kilometers; but a hurricane's temporal scale includes several days, even weeks, and its special geographical scale includes thousands of square kilometers. A list of the phenomena affecting the Isthmus and relation to their temporal and geographical scale follows:

PHENOMENA	TEMPORAL SCALE	GEOGRAPHIC SCALE
Drought in the whole Isthmus, caused by “El Niño”	about 1.5 years	Tropical Pacific and other extra tropical areas
Hurricanes and tropical storms	days or weeks	thousands of square kilometers
Cold fronts	days or weeks	thousands of square kilometers
Tornadoes	hours	tens of square kilometers
Isolated electric thunder storm	hours	tens of square kilometers

This table implies that the Isthmus hydrometeorological networks should respond to the international need to observe large phenomena such as El Niño, hurricanes, cold fronts and at the same time, detect promptly, any smaller local phenomenon, such as an electrical thunder storm. Thus, the observing hydrometeorological networks must be structured from the smallest to the largest phenomena, and the Isthmus should restructure its networks to quantify the phenomena according the their scale.

The following actions are recommended:

1. Redesign present networks transferring instrumentation from dense areas to lightly covered areas.

2. Introduce modern observing technologies, to allow quick availability of information for timely decisions.

3. Locate new stations, using the temporal and geographical concept of the phenomena to be observed.

4. Link the hydrometeorological network to the data bank, to allow for easy and quick storage of, and access to, the data.

5. Educate governments and society that hydrometeorological observations are a continuous, unlimited process.

3.2. The Observation Networks

They allow for the timely detection of the atmospheric phenomena and their effects as time passes. These networks are composed of satellite image reception stations, radar, radio sound stations (upper air) and conventional and automatic surface stations. Each of these networks has a different function.

For example, high resolution satellite images can alert the Isthmus when a hurricane enters the Caribbean Sea. Coastal radars define in detail the hurricane's characteristics when it is still three hundred kilometers from the coast, while, at the same time, will show the detail behavior of the rain fall, streamflow, and wind along the hurricane's path.

Historically, the installation of networks in the Isthmus, from the beginning of the last century, has not been scientifically done. The placement of instruments was based on logistic reasons or on special interest needs, which is why the first networks were installed along railroads, main highways and areas of hydroelectric or agriculture development (bananas). This resulted is,

small areas being covered by dense networks while large, important areas remained uncovered. A brief description of each network follows.

A. Network of Meteorological Satellite Image Reception Stations

A meteorological satellite image reception station technology allows the largest geographical view. The image of the entire Isthmus and its surroundings can be obtained in a few minutes, and a vision of the earth's atmosphere takes about one hour. This network is the pillar of the weather watch of the Isthmus, because it allows the timely detection of atmospheric phenomena which could produce DIAPs. As of this date, only Panama has such a station. The rest of the countries receive photos by facsimile from the World Meteorological Center in Washington, D.C. These pictures have a poor resolution. FINNIDA Project (Finnida, 1993) is financing the installation in 1994, of two of these high resolution stations: one for Guatemala and the other for Costa Rica. The cost of this type of station is approximately $120,000.

B. Radar Network

Meteorological radar is an instrument to observe the atmosphere and is able to give detailed information up to a radius of 500 kilometers if there are no mountains in the way. This information is more accurate than that provided by satellite images. For example, radar provides a good approximation of the areas of heavy rainfall, thunder storms, winds, and other phenomena. Except for the radar installed in Belize, the rest of the Isthmus is unprotected in this way. The minimum ideal network in the Isthmus to track hurricanes, tropical storms in both oceans and cold fronts from the north, would be stations located in Panama, Atlantic coast of Nicaragua, Pacific Coast of Guatemala and Honduras. A radar station costs approximately $ 1,000,000.

C. Network of Upper Air Radio Sound Stations

The measurement of wind, atmospheric pressure, moisture, and other variables from ground level up to 30 kilometers are very important for forecasting and tracking of severe atmospheric conditions. In the case of Central America, these measures are valid around a radius of 300 kilometers. There are four of these stations in the Isthmus, located in Balboa, Panama, San Jose, Costa Rica, Tegucigalpa, Honduras and Guatemala City. FINNIDA Project provided new equipment for Costa Rica and will install a similar one in Puerto Cabezas, Nicaragua. However, the old stations of Panama, Honduras y Guatemala and the new ones required for Panama and Belize, have no financing. The cost of a equipment is approximately $300,000.

D. Conventional and Intelligent Surface Hydrometeorological Network

These are the networks of the densest concentration in the area. They are on the ground, measuring atmospheric variables highly affected by physiography, and they depict conditions for about ten square kilometers.

However, with the regard to DIAPs, they are very important, because they provide information that allows us to know the behavior of the atmospheric phenomena we see in the satellite and radar images. Thanks to the electronic and modern communication technologies, these stations can now function unmanned in remote areas. That's why they are labeled “intelligent” stations.

Honduras y Panama seven years ago, were the first ones to utilize this technology. FINNIDA

Project is upgrading these stations and installing three new ones: two in Belize and one on Coco Island, in Costa Rica's Pacific side. The project has assigned a considerable amount of money to expand and improve these conventional networks.

E. Real Time Telemetric Networks

“Real Time” means immediate access, in the decision-making center, to measurements being reported from the field. Hydrometeorological telemetry is used for the forecasting of heavy rains, floods, risky lake levels, and draught trends. In our region, only Panama and Costa Rica have installed telemetric networks in watersheds that produce hydroelectrical power. The rest of the Isthmus is unprotected for lack of these stations.

F. Oceanic Data Network

With few exceptions, the Isthmus doesn't do oceanic parametric observations. This is a serious problem, because the influence of the oceans in the atmospheric process is known to be crucial, especially in the case of a small stretch of land lying between two oceans, as is the Isthmus.

4. REGIONAL TELECOMMUNICATION SYSTEM

4.1. CEMET

This telecommunication network allows for meteorological information exchange among the countries of the region and is part of the Global Telecommunication System of the World Meteorological Organization (WMO, 1988). This system presents many problems, because it is based on microwaves and it is a one-way system where the failure of one point interrupts the whole system.

4.2. Satellite-based Telecommunications System

This system uses a satellite to transmit and receive meteorological information according to W.M.O. standards. It is a two-way multi-point system and will allow exchange of information between the countries. (WMO, 1992) This system will replace CEMET and will become operational approximately in April, 1994.

5. DISASTER PREVENTION AND METEOROLOGICAL INFORMATION

5.1. Disaster Prevention

This implies a set of measures that will avoid the negative effects of the atmospheric phenomena on the ground and prevent them from becoming disasters (CNE, 1992). Effective prevention includes:

- Organization
- Resources
- Communications
- Strategies for Action.

The emergency preparedness agencies of each country are in charge of implementing these activities. The role of the meteorological services is to provide information that enables the disaster preparedness crew to design their strategies before the emergency arises. This is done through forecastings. Actions before the emergencies include: 1) alerting the population of the

coming disaster and 2) explanations of how to protect their lives and property. The accuracy of the forecasting depends on the accuracy of the information, which relies on the density of the networks observing the meteorological and hydrological phenomena.

A. Disaster Prevention in case of Tropical Storms, Hurricanes, or Typhoons

The information provided by the following systems is important:

- Images of Meteorological Satellites
- Radar
- Conventional Ground Stations
- Upper Air Radio Sounds
- Ships and Airplanes

The information provided by all these sources, for example, allowed Jamaica, during Hurricane Gilbert (Sept. 12, 1988), to have a relatively low death toll only 45 compared with 152 produced by Hurricane Charlie in 1951, (ODP, 1988; Smith, 1989).

B. Flood Disaster Prevention

This implies (Smith, 1989), measures such as Flood Plain mapping, stream flow analysis, and accurate knowledge of watershed and rainfall characteristics. The Isthmus doesn't have a complete flood prevention system, but DANIDA (Danida, 1993), is providing a flood-forecasting computer software and hardware package that would allow for flood predictions. This project must, however, be complemented with the installation of telemetric systems, which, then, would be an excellent means of reducing damages caused by floods. Panama, El Salvador, Honduras y Costa Rica already plan to install telemetric systems in their flood-prone areas. FINNIDA Project, in this respect, has limited its actions to installing and training in the hydrograph simulation model known as HEC1 and the water surface profiles model known as HEC2.

5.2. International Cooperation

Because a disaster has no boundaries and can cover very large regions as in the case of a hurricane, international cooperation in disaster prevention is essential. Fortunately, the Central American region belongs to a worldwide meteorological networks known as World Weather Watch and the Global Telecommunication System (GTS), which provide instantaneous and systematic exchange of meteorological information.

Concerning floods, expectations are centered on DANIDA Project, this will hopefully, be complemented with a telemetric system that permits monitoring of flood events.

On the other hand, the United Nations International Decade for Natural Disaster Reduction is committed to coordinating the efforts of Emergency Management Agencies.

Also, CEPREDENAC, Center for the Prevention of Natural Disasters in Central America, is coordinating emergency activities and is based in Guatemala City. On the other hand, the Comité Regional de Recursos Hidraulicos (CRRH) based in Costa Rica, groups all the countries of the Isthmus and coordinates the actions of their water resources management and meteorological service agencies in data management, training, and research.

To conclude, we mention that the U.S. Weather Service, (Smith, 1989), has shown how loss of

human lives due to hurricanes has been dramatically reduced (8,100 in 1900-1910, to 160 in 1980-1987) in spite of the increase of coastal populations (Florida: from less than one million to nine million during the same time span) by the development of storm tracking technologies, telecommunications, public education and alert systems.

5.3. Data Control and Prevention of DIAPs

Good data management means efficient utilization of human resources, data-processing, information systems, computer technology, and international cooperation. We are indebted to W.M.O. for introducing this approach 30 years ago, which when properly applied is a means of disaster prevention. It allows for timely collection of pertinent information obtained from the right source. It also implies timely dissemination of processed information and that is what prevention is all about.

Finally, it should be emphasized that the management and processing of atmospheric data in Central America, is becoming more efficient thanks to the FINNIDA Project, which positively affect the regional disaster prevention measures.

6. CONCLUSIONS AND RECOMMENDATIONS

1. The Central American Isthmus is a high risk zone for disasters induced by atmospheric phenomena. Loss of life and property is a yearly occurrence in the area.

2. The network of stations to observe the atmospheric phenomena, such as radar, radio sound, automatic stations, are crucial for accurate forecasting and reducing the negative effects of DIAPs.

3. Numerous International Development Agencies are engaged in projects to produce and disseminate meteorological information that will help reduce the frequency of the DIAPs.

4. On the other hand, agencies and international cooperation institutions are working to promote regional integration and cooperation to develop a technology that mitigates damages caused by DIAPs.

5. However, because of the complexity of the geographical environment, the poor economic development, and the political and social problems that affect the region, there still are many tasks to be undertaken, many problems to be solved, many obstacles to be overcome.

6. It is therefore recommended that the international community continue its support and assistance to the CA countries in their effort to produce reliable meteorological and hydrological information that will allow them more efficiently manage their DIAPs.

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Water Management for the 21st Century

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Introduction

Water is probably the most essential of our natural resources, for without it we cannot live. Continued increases in demand on water resources can be anticipated as the world population expands. Competing and conflicting demands on water supply have raised serious concerns about the long-term reliability of our water resources. Traditional water systems are being stressed by increased demand from domestic, industrial, agricultural, and environmental users. In addition, physical, regulatory, and financial constraints further complicate our ability to meet future demands. Three components that will be required to adequately meet tomorrow's water

demands include:

- Prudent Water Management
- Protection of Resources through Regulations
- Implementation of Innovative New Technologies.

Water Management

Due to the continued growth in demand upon our water resources throughout Florida, prudent water management practices have become, and will continue to be essential in maintaining these resources for domestic, industrial, agricultural and environmental needs. In most instances, the real issue is not lack of water, but rather conflicting and competing demands upon water management policies, infrastructure and agencies. Resolution of these demands is politically complex and sometimes conveys the impression that water management is inadequate or that inadequate water is available. Once this occurs, an urgent need often arises to identify new resources. This situation can be eliminated or deferred if existing resources are managed efficiently.

Prudent water management practices involve conserving existing resources (groundwater and surface water) and balancing them with sometimes overlooked resources such as seasonal floods or reclaimed water, regulating the use of resources, and implementation of innovative new technologies.

South Florida's topography is characterized by low elevations, flat terrain and widespread occurrence of wetlands. Water management has historically focused on flood control until recent years when a severe drought threatened water supplies and the quality of surface waters deteriorated to the point that wastewater treatment and effluent disposal practices had to be changed. Water levels in South Florida have been maintained with control structures throughout the drainage canal system. These canals recharge the surficial aquifer and eventually discharge to the Atlantic Ocean or Florida Bay. The Kissimmee River feeds Lake Okeechobee which, in turn, supplies water to the canal system and also to the Everglades National Park. Water levels in the canals are maintained by water released from Lake Okeechobee during dry months, combined with normal local rainfall which recharges the canals through surface run-off. Most of the available resource is lost to evaporation, seepage and ocean outfalls. Most of the wastewater effluent that was removed from surface waters is now discharged to deep injection wells at depths typically around 900 m. Because the surficial aquifer system cannot accommodate waters that fill the canal system during heavy Florida storm events, Water Management Districts prevent flooding by operating the canal system in a manner that allows this fresh water to pass to the ocean. This results in the loss of a valuable fresh water resource, at least a portion of which could possibly be put to better use if adequate storage could be made available at reasonable cost.

Water availability becomes a serious problem during periods of drought because of the stresses placed on the surficial aquifer in coastal areas. These withdrawals are often greater than the safe yield of the aquifer. Prolonged operation of systems in this manner creates saltwater intrusion which may require shut down of wellfields or substantial reduction in withdrawal. Reduced water availability may also impact environmentally sensitive wetlands. This is of major concern in South Florida during the months of November through April or May when there is less recharge and water demands are high because of the tourist season.

Water managers have learned from this experience and have now shifted their efforts to ensure that a reliable supply exists for all users throughout the year. One of their biggest concerns is that of convening the infrastructure that was constructed for flood control purposes into one that meets more challenging water demands of tomorrow. New management practices will require balancing production and management of ground and surface water resources when available. This will involve protection of the resources through regulation, possible construction of new surface reservoirs, and implementation of new technologies such as Aquifer Storage and Recovery.

Protection of Resources Through Regulation

Part of the Florida approach to meeting water needs has included formation of five regional Water Management Districts, funded primarily by property taxes and governed by individuals appointed by the Governor of Florida to represent a balance of differing water interests. These districts are primarily responsible for management of water quantity issues, while the Florida Department of Environmental Protection is responsible for water quality issues. Activities of the Water Management Districts have included development of water supply policies, plans and regulations to protect conserve and develop fresh and brackish water resources. Activities also include wellhead protection to protect water quality, allocation of quantities that do not degrade the resource, through issuance of permits; and enforcement of regulations.

Wellhead protection involves the designation and classification of areas around a well or wellfield which limit activities that could potentially contaminate or threaten the resource. This policy has been in effect in South Florida since the mid-1980s and has been very successful in protecting wellfield areas. Gross contamination resulting in the loss of a portion of a wellfield, or a complete wellfield, has been greatly reduced as a result of wellhead protection practices.

Safe yield limits for wellfields are established and enforced by the water management districts. Safe yield is generally defined as the volume of water that a wellfield or aquifer can produce that will not result in unacceptable adverse effects or degradation of the supply. Degradation may include saltwater intrusion or contamination by surficial sources such as petroleum products.

One of the most significant regulatory impacts for water resource management is consistent and equitable enforcement of current regulations to implement water management policy. This involves frequent workshops between the different regulators (internal or external) to assure that policy enforcement is being applied consistently among all users.

Florida has complex water management challenges, and conflicting, competing demands for available water supplies. A system of water management has been developed to address these challenges. This system is widely regarded as being one of the best such systems in the United States, including a legal framework, governmental organization, policies, plans and practices that work together to address water supply and water quality challenges.

Implementation of Innovative Technologies

Development of innovative technologies can facilitate improvements in water management and thereby ease political and economic stresses commonly associated with complex water supply issues. New ways of operating old systems must be considered to more efficiently utilize our natural resources. Some of these new technologies include effluent treatment by flow through

wetlands, effluent reuse, stormwater retention and treatment in ponds at each new development site, membrane treatment of brackish water; saltwater intrusion barriers with reclaimed water; aquifer recharge, and Aquifer Storage and Recovery (ASR). Each of these technologies should be considered for their cost effectiveness and environmental benefits.

One of the most successful water management technologies in Florida, the United States, and several other countries is ASR. This technology has been proven feasible in many different hydrogeologic settings as a cost effective means for increasing water supply, and is now being introduced to other countries with water needs. ASR is the underground storage of water through wells in a suitable aquifer when excess supplies are available, and recovery from the same wells when needed to meet seasonal peak, long-term, or emergency demands. Storage zones include fresh, brackish and seawater aquifers. The waters recovered usually do not require retreatment other than disinfection for potable uses. The rapid implementation of ASR reflects its success as a water management tool and also its cost-effectiveness, since water system expansion with ASR typically reduces capital costs by at least 50 percent.

Originally, ASR systems were designed to store potable water but the concept has since been expanded in scope to incorporate storage of untreated ground water, surface water, and reclaimed water. Typical ASR wells may store in excess of 1 million cubic meters (264 million US gallons). However, the storage potential depends on the availability of water for storage and the hydraulic characteristics of the receiving zones, which may be effectively unlimited. These systems have many benefits over conventional storage techniques, however, the greatest benefits are the ability to provide long term storage at a much lower cost with greater flexibility. In Florida, storage is provided in brackish, limestone portions of the upper Floridan Aquifer System. Some of the other benefits are listed below:

- Seasonal storage
- Emergency storage
- Prevention of saltwater intrusion
- Nutrient reduction in agricultural runoff
- Reduction in concentration of disinfection byproducts
- Deferred expansion of water supply/treatment facilities
- Reclaimed water storage for reuse
- Reduction of evapotranspiration and seepage losses
- Minimal above ground land requirements for storage
- Improved reliability and flexibility of water supply system
- Enhanced water management efficiency
- Reduced environmental impacts
- Maintain distribution system flows and pressures

ASR has been combined with existing water treatment facilities in Florida to better manage the resource and is now being considered by the South Florida Water Management District for use with surface water reservoirs as an improved means for managing storm water run-off.

Three principle criteria govern the site specific feasibility of ASR. These criteria are:

- Is there a seasonal variation in water supply/availability, water demand, or both? Typically, when the ratio of maximum day demand to average day demand is equal

to or greater than 1.3 for potable ASR systems, this criterion is met.

- Is there a reasonable scale of water facilities capacity? Balancing economies of scale against the initial cost of developing ASR wells, ASR is usually an appropriate technology if useful recovery capacity is above 4000 CMD (1 million gallons per day). This criterion applies mostly to ASR applications for water utility systems, however economies of scale apply to all ASR water sources.

- Is there a suitable storage zone? Site specific evaluation and testing is required to confirm ASR feasibility.

Of the 18 ASR systems storing drinking water currently operational in the United States, five are in Florida. One of the most recent successful ASR projects in South Florida has been completed for the City of Boynton Beach. The ASR well was completed into a brackish, confined limestone aquifer approximately 800 to 900 feet below land surface. The well currently is storing approximately 230,000 CM (60 million gallons) of drinking water with a recharge/recovery rate of approximately 5.7 Ml/d (1.5 million gallons per day). Greater operational volumes are anticipated. Recovery efficiencies were demonstrated in excess of 90 percent during a recent low rainfall period. Utilizing the well during this period allowed the City to decrease withdrawal rates from its east wellfield where saltwater intrusion is a concern. Saltwater intrusion occurs in the east wellfield during periods of high pumping and low recharge. Figures 1 and 2 illustrate how an ASR system is incorporated with a typical water treatment system in both the wet season storage mode and dry season recovery mode, respectively.

Conclusion

Within the United States, Florida and California are often perceived as leading the development and implementation of new technologies and regulatory practices in water management as well as other areas. Many recognize Florida's Water Management District system, and the water laws and regulations comprising the backbone of this system, as unequaled in the United States. Rapid growth and associated increasing water demands have placed considerable stress upon valued natural systems, the protection of which will require enlightened water management by urban, agricultural and industrial interests. Prudent water management practices, combined with appropriate regulations and their enforcement, can help to achieve broad water management objectives. However innovative technologies such as Aquifer Storage Recovery (ASR) offer a great opportunity to make more efficient use of available water resources to meet future needs, while also protecting the environment and substantially reducing costs.

Many of the water management practices and technologies that have been developed and applied in Florida may also be useful for consideration to address water management needs in Central and South America. In particular, population growth and increasing demands for water, combined with seasonal variability in supply and demand, may provide an excellent opportunity for ASR application to meet future needs while reducing costs and protecting valued natural ecosystems.

Planning - A Must in the Conservation of Natural Resources: The Puerto Rico Experience

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Editor's Note: At the time of publication of these proceedings, the english version of the presentation was not available. The Spanish version of this paper titled "Planificación - Una Necesidad Perentoria en la Conservación de los Recursos Naturales - La Experiencia de Puerto Rico" is available upon request by writing to the authors or from the editor.

ABSTRACT

This paper is an unofficial essay of the situation Puerto Rico is undergoing in the fields of water supply and quality control of water resources from the perspective of two consultants in civil and sanitary engineering. Because of its special relationship with the United States of North America, Puerto Rico is bound to comply with federal regulation in all the fields of control of contamination.

Particular geographic characteristics, high population density, limited natural resources, dependent economy and the fact that it is a developing country (advanced if you will), makes it necessary for Puerto Rico to use the approach of a highly developed country in dealing with the solution of the inherent problems of the management of its natural resources.

The Puerto Rico Aqueduct and Sewer Authority (PRASA), is the agency in charge of the design, construction, operation, and maintenance of the water supply and wastewater collection and treatment systems. PRASA's operation are subject to obtaining a water use permit (in volume) from the Department of Natural Resources and a construction permit from the Environmental Quality Board. It also meets the standards of the Department of Health (which oversees the quality of the water being distributed), and has to comply with the Master Plan of the Planning Board. A NPDES permit from EPA Region II, is necessary as well.

To comply with the U.S. Clean Water Act, PRASA prepared a Comprehensive Water Quality Management Plan for Puerto Rico that proposed the regionalization of the sewerage systems committing in this objective all its economical and human resources, disregarding at the same time the planning, operation, and maintenance of the water supply. On the other hand, the frequent violations of sewerage treatment plants (in many cases overloaded the hydrologically and organically parameter limits, set already by the NPDES discharge permits) led to fines and the ultimate "imprisonment" of a high percentage of them.

This situation hindered the development of the construction industry because the court order did not permit new connection to existing systems. At the same time the suspension of the actualization of the planning for the development of new sources for the potabilization of water and the disregard for proper operation and maintenance of the existing systems led to a water deficit that also did not allow for new connections to the system. This "catch 22" situation led to a drastic emergency action taken by the Governor of Puerto Rico who signed an Executive Order for using the necessary funds in the construction of permanent civil works and also reinstalling the planning role of the agency.

The Puerto Rico case is an example of how not to react to the demands of compliance with water quality standards (more restrictive every day, either for water intake and its potabilization process as for discharges of treated wastewaters to the receiving bodies of water) if the action is not accompanied by comprehensive water quality planning and/or by the updating of the existing one. The lack of planning in this field could create chaotic conditions which may negatively affect the economic and social development of a country.

Appropriate Technologies of Wastewater Treatment for Sustainable Development

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BACKGROUND

Sustainable development has been defined by the World Commission on Environment and Development as that development that meets the needs of the present without compromising the ability of future generations to meet their own needs. In “Our Own Agenda” the Latin American Caribbean Commission on Development and Environment challenges present generations to design a strategy of development in harmony with nature that meets the needs of present and future generations. In other words, Sustainable development requires the adoption of a technology that also meets the basic needs of the population in the areas of health, food and shelter.

Wastewater treatment technologies can be designed “in harmony” within this Sustainable development concept. They can provide low cost sanitation and environmental protection while providing beneficial uses for water reuse. These technologies are mainly **natural systems: aquatic and terrestrial**. These technologies are in existence in United States of America, primarily in small towns or where water reuse is a priority. These appropriate technologies can be suitable for many developing countries and for similar several reasons:

1. Forestation, agriculture, livestock and groundwater recharge are the principal environmental problems associated with the land in Latin America and other developing countries. According to “Our Own Agenda” Report: In South America forty-seven percent of the pasture soil are loosing their fertility. Deforestation reached 0.61 per cent annually for Latin America and the Caribbean and 1.6 percent annually for Central America. The potential for irrigation is 20 million hectares while there are six million hectares under irrigation. Thirty percent of the irrigated land cannot be used because of salinity.

   Wastewater treatment technologies such as terrestrial systems (slow rate, overland flow rapid infiltration) provide beneficial uses to forests, some types of agriculture, pasture for livestock and groundwater recharge.

2. Low capital costs of wastewater treatment plants. According to “Our Own Agenda” report, eighty percent of the illnesses in Latin America are due to deficiencies in wastewater infrastructure while forty percent of the urban population do not have sewer systems. In areas where land values are not at a premium wastewater treatment technologies such as aquatic systems (lagoons and constructed wetlands) can be very attractive while achieving similar protection to the environment and sanitation.

3. Low manpower requirements and low operation and maintenance costs. Some of the socio-economic strategies for the implementation of Sustainable development include the general reduction of costs of production and special attention to technologies that save energy. Natural wastewater treatment systems that include lagoons require half of the manpower of that of a conventional system. In addition, the decrease in the requirements of pumps and other electrical devices reduce the need for energy consumption.

This presentation focuses on appropriate wastewater treatment technologies based on the principle of Sustainable development for Latin America and other developing countries and the recommendation of “Our Own Agenda” of restructuring public expenditures to give priority to the services of low cost and high multiplying effect.

WASTEWATER SYSTEMS FOR SUSTAINABLE DEVELOPMENT

Natural systems (aquatic and terrestrial) have been in use for a number of years in United States of America. They are of two of the three main categories of wastewater treatment systems available to treat domestic waste. In addition to natural systems, mechanical systems do have their use where primarily land suitability and quantity is restricted. Figure 1 presents a summary of these systems.

Aquatic Systems are represented by lagoons: facultative, aerated, and Hydrograph Controlled Release (HCR). These lagoons can be further supplemented in treatment with constructed wetlands, aquaculture, and sand filters. Their main contributions to the sustainable development are their low capital cost and low operational/technical requirements which have an indirect impact to public funds. Lagoons are one of the oldest methods of wastewater treatment and are commonly in use in USA. Many of these lagoons are serving small communities in USA and are accompanied by additional treatment provided by constructed wetlands, sand filters and aquaculture systems. They are used to treat a wide variety of wastewaters, and function under a wide range of weather conditions. Their main advantages, as it will be shown later, are its low cost, low operation and maintenance and low technical manpower requirement.

Facultative lagoons are the most common form of lagoons currently in use. The water layer near the surface is aerobic while the bottom layer which includes sludge deposits is anaerobic. The intermediate layer is aerobic near the top, and anaerobic near the bottom, and termed the facultative zone. The main advantage of the facultative lagoon is its low cost of operation and maintenance as well as the low technical operational requirements. Aerated Lagoons are smaller and deeper than facultative lagoons. These systems evolved from stabilization ponds when aeration devices were added to counteract odors arising from septic conditions. The aeration devices can be mechanical or diffused air systems. The advantage of the aerated lagoon is less land requirement; however, it introduces mechanical devices which will require higher technical

manpower requirement. The chief disadvantage of lagoons is high effluent solids which can exceed 100 mg/l. Hydrograph Controlled Release (HCR) lagoons are a recent innovative process. In this system, wastewater is discharged only during periods when the stream flow is adequate to prevent water quality degradation. When stream conditions prohibit discharge, wastewater is accumulated in a storage lagoon.

Constructed wetlands, aquacultures, and sand filters have been the most successful methods of polishing wastewater from lagoons; These systems have also been used with other primary devices other than lagoons, such as Imhoff tanks, septic tanks, and primary clarifiers. Their main advantage is to provide a treatment beyond secondary where required.

Constructed Wetlands have been utilized during the past few years in two designs, free-water surface (FWS), and subsurface flow (SF). Both systems utilize plants' roots to provide for attached bacteria growth and oxygen transfer. Bacteria do the bulk of the work in these systems although there is some nitrogen uptake by the plants. The FWS system more closely approximates a natural wetland. Typically, these systems are long, narrow basins with depths less than 2 feet, planted with typical vegetation such as bulrush or cattails. SF systems use a gravel or sand medium approximately eighteen inches deep through which the wastewater flows.

Aquaculture systems are distinguished by the type of plant grown, they are primarily water hyacinths, or duckweed. These systems are basically shallow ponds covered with floating plants with detention times of several days. The plants main purpose is to provide a suitable environment for bacteria which remove the vast majority of dissolved nutrients.

Sand Filters have been used for wastewater treatment for at least a hundred years in USA. The two types commonly used, intermittent and recirculating, differ mainly in the method of application of the wastewater. Intermittent filters are dosed by flooding and allowed to completely drain before the next application. Recirculating filters utilize a pump to recirculate the filter effluent at a ratio of from 3 to 5 to 1. Both types of filters use a sand media with a depth of from 2 to 3 feet underlaid by a collection system consisting of perforated or open join pipes enclosed within a graded gravel medium. These are primarily biological processes though straining and sedimentation of suspended solids between sand grains and chemical sorption on the grain surfaces plays a role in the process efficiency.

Terrestrial systems are represented by slow-rate, overland flow, and rapid infiltration. Their individual contribution to sustainable development, in addition to wastewater treatment and low maintenance cost consist of: groundwater recharge (water conservation), reforestation, agriculture, and livestock feed. These systems depend upon physical, chemical, and biological reactions on and within the soil. Slow rate and overland flow require vegetation. Slow-rate, subsurface infiltration, and usually rapid infiltration are zero discharge systems. Each system has different constraints regarding soil permeability.

Although slow rate systems are the most costly systems of the natural systems their advantage is the positive impact on sustainable development. In addition of treating wastewater they provide an economic return from the reuse of water and nutrients to produce marketable crops for some agriculture products and livestock, and reforestation. In slow-rate systems, either primary or secondary wastewater is applied at a controlled rate to a vegetated land surface of moderate to slow permeability. Application is by means of either sprinklers or flooding of furrows.

Wastewater is treated as it passes through the soil by filtration, adsorption, ion exchange, precipitation, microbial action, and plant uptake. Vegetation is a critical component of the process and serves to extract nutrients, reduce erosion, and maintain soil permeability.

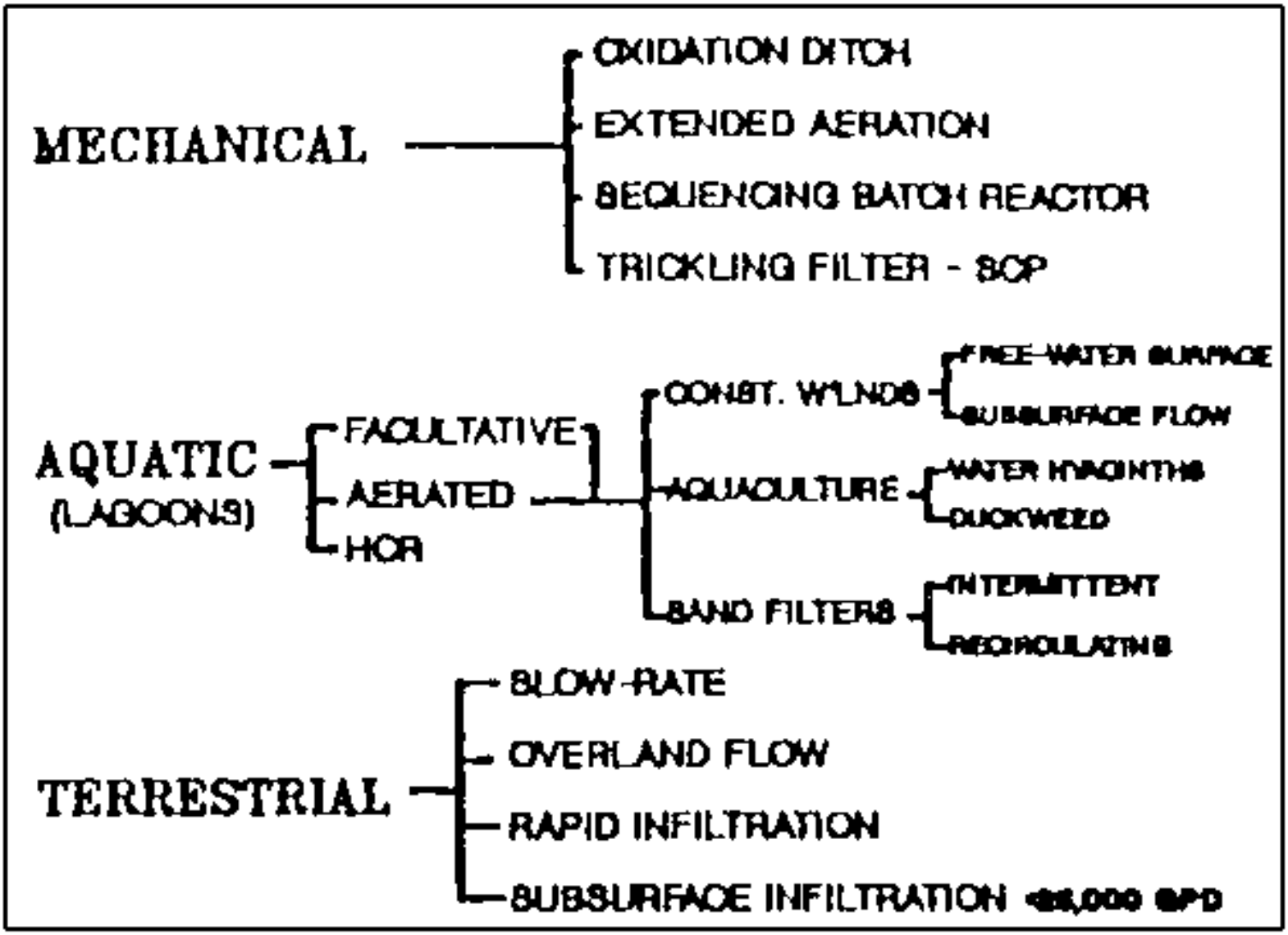
Overland Flow systems is a land application method of wastewater treatment with point discharge to a surface water. Its main contribution toward sustainable development would be its low maintenance and low technical manpower requirements when nitrogen removal is required in very low permeable soils. Wastewater is applied intermittently across the top of terraces and allowed to sheet flow over the vegetated surface to the runoff collection channel. Treatment is achieved primarily through sedimentation, filtration, and biochemical activity as the wastewater flows through the vegetation on the terraced slope. Loading rates and cycles are designed to maintain active microorganism growth on the soil. The rate and length of application is controlled to minimize severe anaerobic conditions and the resting period should be long enough to prevent surface ponding, yet short enough to keep the microorganisms in an active state.

In rapid infiltration systems most of the applied wastewater percolates through the soil, and the treated effluent drains naturally to surface waters or joins the ground water. Rapid infiltration contributes to sustainable development by providing groundwater recharge as well as low cost and low manpower technical required maintenance wastewater treatment. The applied soils are moderately and highly permeable. The wastewater is applied by spreading in basins or by sprinkling as is treated as it travels through the soil. Vegetation is not necessary but does not cause a problem either. The major treatment goal is conversion of ammonia nitrogen to nitrate nitrogen prior to discharge to receiving water.

Subsurface infiltration systems are designed for municipalities of less than 2,500 people. They are usually designed for individual homes (septic tanks) but they can be designed for clusters of homes. Although they do require specific site conditions, they can be low cost methods of disposal.

Mechanical systems utilize a combination of physical, biological and chemical processes. In order to achieve treatment objectives, a series of tanks along with pumps, blowers, screens, grinders, and other mechanical components in conjunction with various types of instrumentation are utilized. Sequencing Batch Reactors (SBR), Oxidation Ditches, and Extended Aeration systems are all variations of the Activated Sludge process, a suspended growth system. The Trickling Filter Solids Contact Process (TFSCP) in Figure 1 is a modification to the conventional standard rate process, an attached-growth system. These mechanical systems are effective where land is at a premium.

FIGURE 1



TREATMENT PERFORMANCE

Natural systems are capable of producing an effluent equal to mechanical systems. Figure 2 is a depiction of the treatment performance of each of the systems. All of the systems can meet secondary limits defined as Biological Oxygen Demand (BOD) and Total Suspended Solids (TSS) less than 30 mg/l. All systems except for lagoons are viable under the category of advanced treatment which is defined as BOD and Total Solids less than 20 mg/l.

FIGURE 2

TREATMENT PERFORMANCE

	2ND	ADV	NH3	TP	TN
Mechanical	●	●	●	●	●
Lagoons	●	⊗	⊗	⊗	⊗
Sand Filters	●	●	●	⊗	⊗
Const Wlands	●	●	○	⊗	⊗
Aquaculture	●	●	○	⊗	⊗
Slow Rate	●	●	●	●	●
Overland Flow	●	●	●	⊗	⊗
Rapid Infl.	●	●	●	⊗	⊗
Sub Infl	●	●	○	●	⊗

● -YES ○ -MAYBE ⊗ -NO

2ND-30,30; BOD,TS ADV<20, 20; BOD,TS NH3<2 TP<2 TN<2

UNITS- mg/l

The last three columns, NH3 (ammonia conversion), TP (total phosphorus), and TN (total nitrogen), show the efficiency of some of the systems to produce advanced waste treatment. An ammonia limit of 2 or less is consistently achievable by six of the systems; mechanical, sand filters, and the land application systems. Constructed wetland and aquaculture systems have shown promise in providing low ammonia effluents, but currently lack a concrete design which can deliver consistent results.

A low phosphorus limit will exclude all but three systems; mechanical, slow rate, and subsurface infiltration. If the soil is favorable, rapid infiltration can achieve significant phosphorus removals. A low total nitrogen limit eliminates all but two options; mechanical or slow rate. If groundwater contamination is not a risk, rapid infiltration will also be an available.

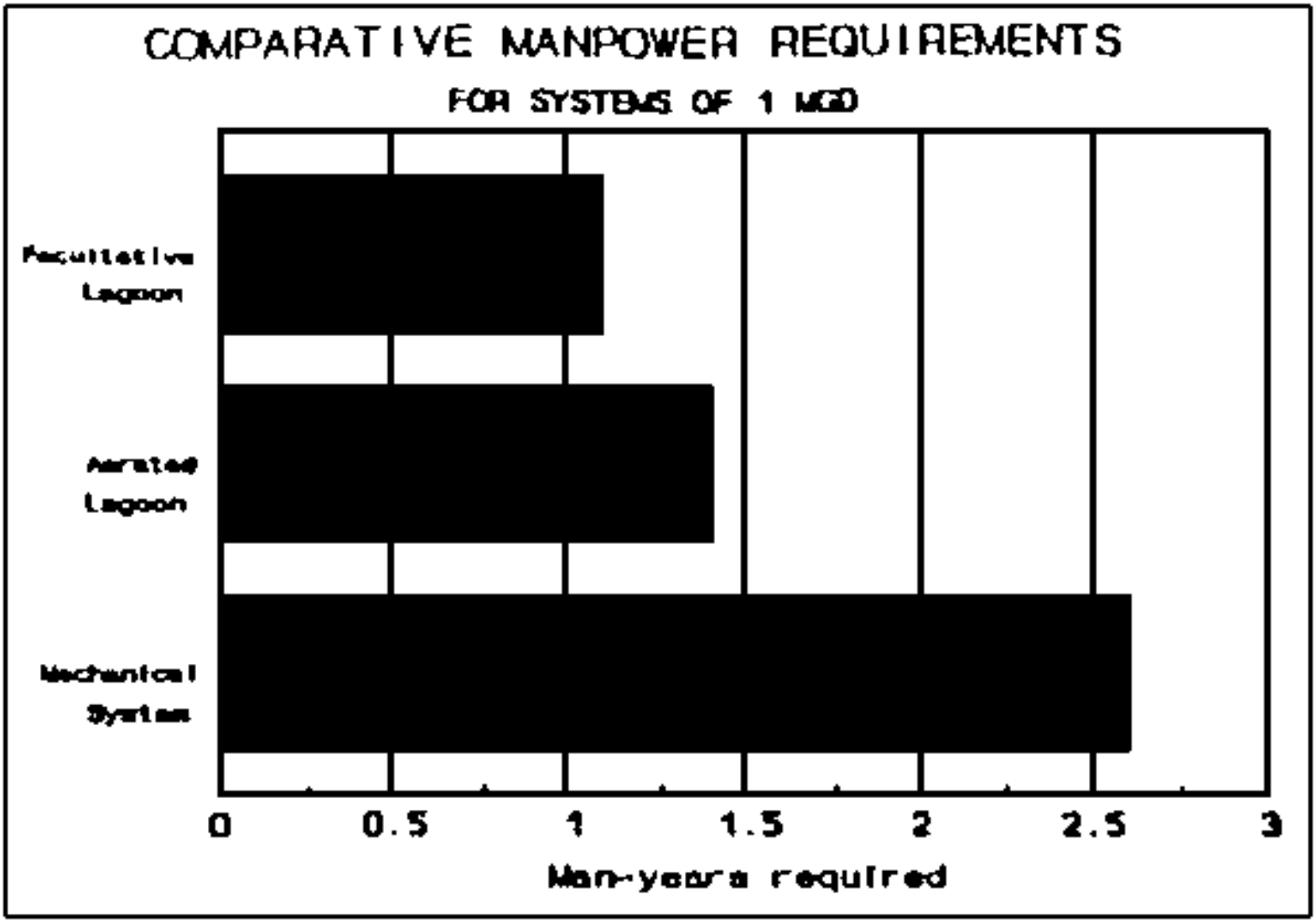
Treatment performance is the critical factor in determining process viability. Though mechanical systems are shown as capable of meeting all treatment performance criteria depicted, this performance will require additional expenditures of initial capital cost and operation and

maintenance; primarily of chemicals and tanks. The costs for these additions are not included in the cost data presented below.

MANPOWER REQUIREMENTS

Figure 3 compares manpower requirements for mechanical and lagoon systems of 1 mgd capacity. These figures were derived from tables in the EPA publication *Estimating Staffing for Municipal Wastewater Treatment Facilities.* The simplicity of operations for lagoon systems is reflected in manpower needs of approximately half that needed in a mechanical system.

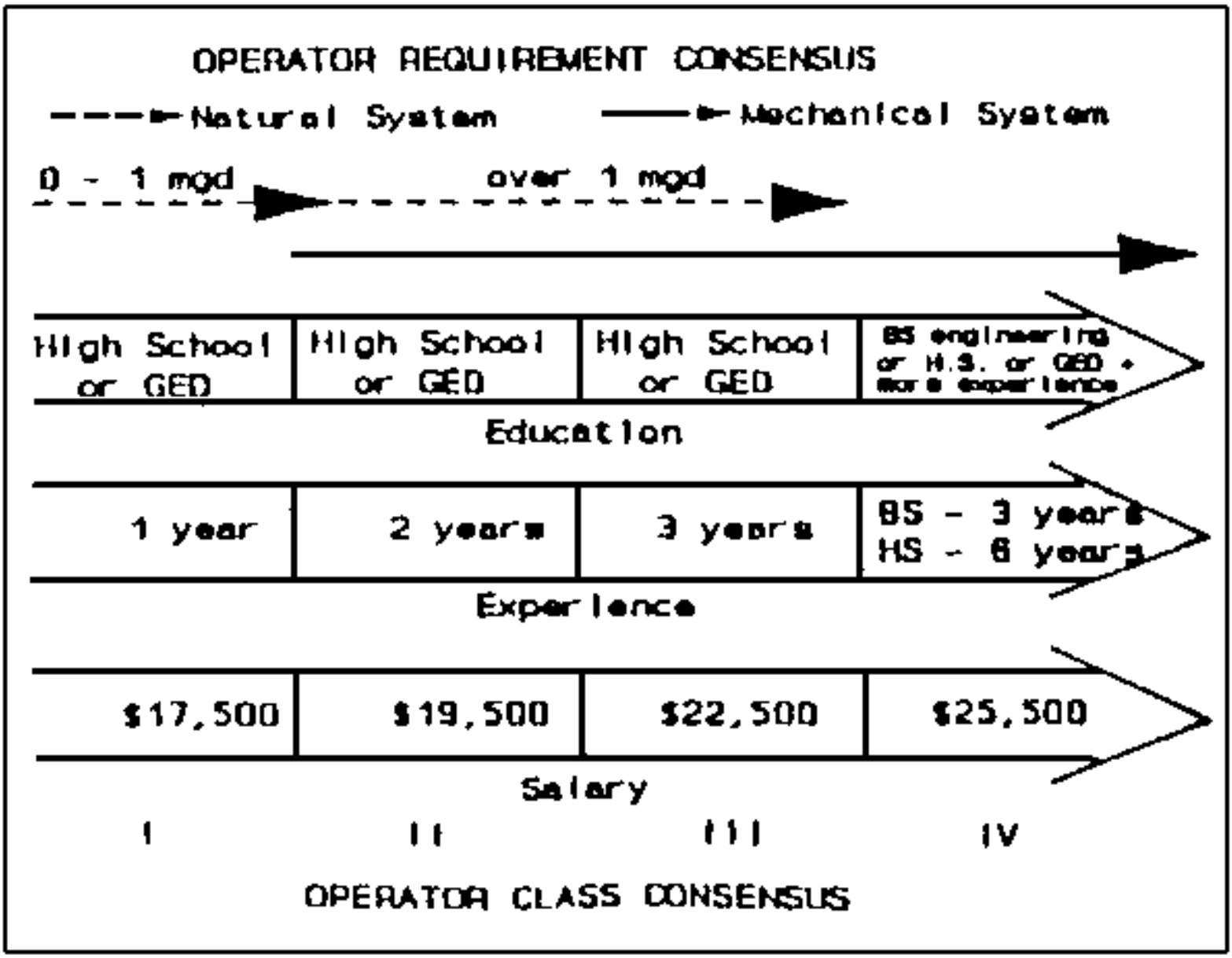
FIGURE 3



A survey of treatment plant and operator classifications was conducted by USEPA Region IV of the southeastern states in USA for purposes of comparison.

A consensus of education, experience, and salary levels for natural versus mechanical systems is indicated in Figure 4. In general, a natural system will require an operator one grade lower than that required by a mechanical system. This helps alleviate the burden of finding higher level operators with larger salary demands. There is a recent trend of these states to require a minimum of a high school diploma in order to be considered for certification on any level.

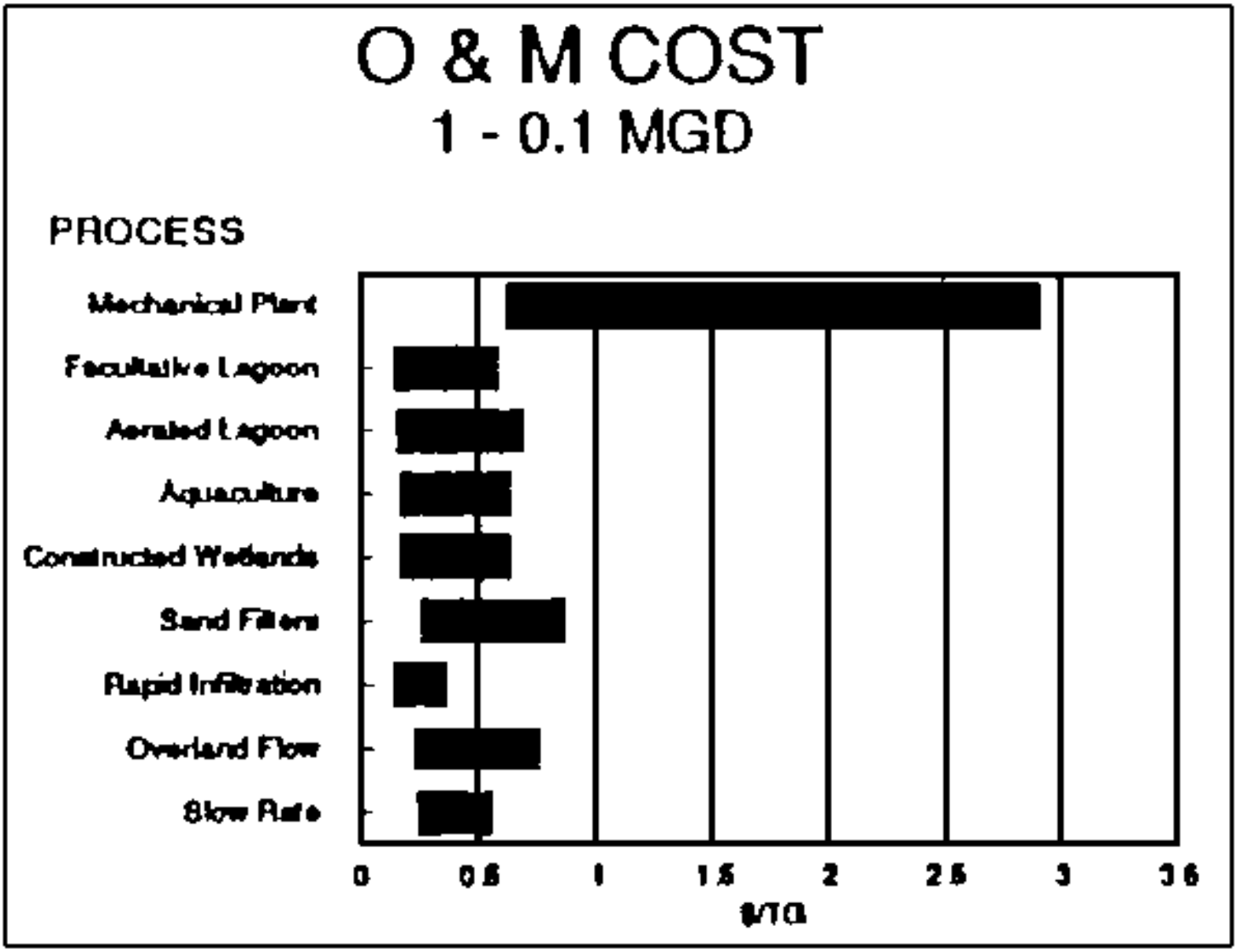
FIGURE 4



O & M COST

Figure 5 is a graph of the operating and maintenance (O&M) costs for the various systems from 1 to 0.1 mgd treatment capacity. All costs were obtained from the referenced manual in the next section. Costs have been indexed to EPA's *Operation, Maintenance and Repair Index of Direct Cost* for the first quarter of 1993 (4.3). Costs included are labor, energy, chemicals, and materials such as replacement equipment and parts.

FIGURE 5

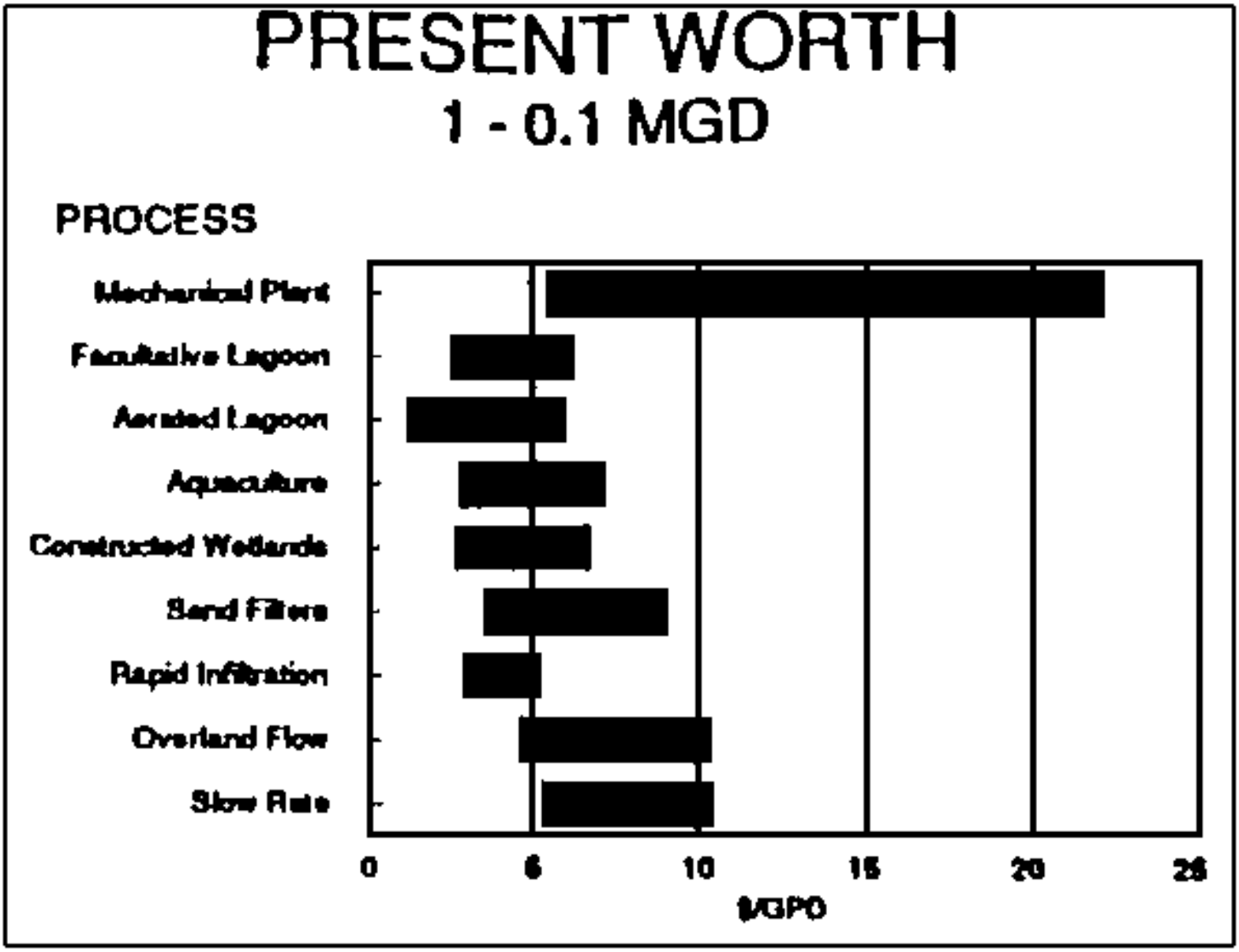


All costs are presented in dollars per thousand gallons of treated wastewater. The O&M cost for mechanical systems is significantly larger than any of the other systems particularly at the smaller flow. The cost for harvesting of aquaculture systems is not included. This could be a significant cost for some systems.

CAPITAL COST

Figure 6 is a graph of the capital cost of these processes. Cost is represented as cost per unit of capacity, which in this case is gallons per day. Cost data for this graph was obtained from the EPA publication, *Innovative and Alternative Technology Assessment Manual,* with the exception of wetland and aquaculture data, which was obtained from more recent sources. All costs were inflated to March, 1993 (ENR CCI 5100).

FIGURE 6



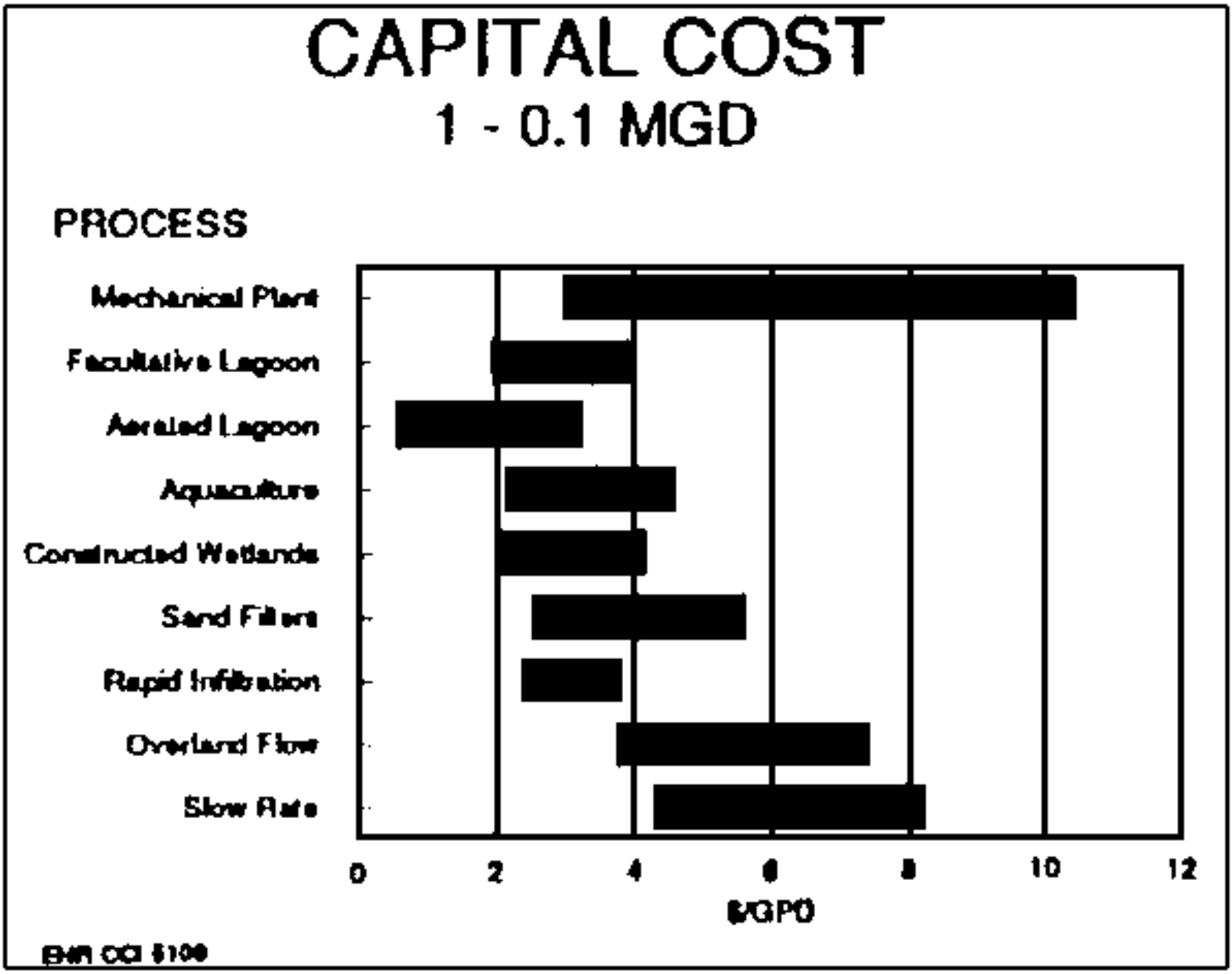
All costs exclude the cost of land. All natural systems have a facultative lagoon as a primary unit. The cost for chlorination/dechlorination is included for all systems except slow rate and rapid infiltration. The cost of liners is not included for any of the aquatic systems.

The mechanical system represented, was derived from costs for an oxidation ditch. Included in this cost are clarifiers, oxidation ditch, pumps, building, laboratory, and sludge drying beds. These costs include the cost of engineering, and construction management, in addition to the costs for piping, electrical, instrumentation, and site preparation not included in the construction cost curves.

PRESENT WORTH

The Present Worth costs depicted in Figure 7 were derived from the previous two graphs. Present worth represents costs as an equivalent cost that is the current investment required to satisfy all project costs over its lifetime. The annual O&M cost was convened using the uniform-series present worth factor at an interest rate of 6.5% for 20 years, and added to the capital cost. Cost data is presented in dollars per gpd of treatment capacity and within a treatment capacity range of 1 to 0.1 mgd.

FIGURE 7



All natural systems are significantly more cost effective than mechanical systems, particularly at the lower flow depicted. This is an overly simplistic evaluation and a rigorous present worth analysis would include many more factors to be evaluated. It does, however, allow us to view O&M costs in the same perspective as our capital costs, and although a more detailed analysis will most likely change the numbers, it is doubtful that it would alter the conclusion.

TREATMENT SYSTEMS IMPACT ON SUSTAINABLE DEVELOPMENT

Many communities around the world, in both the developed and developing world, are reaching the limits of their available water supplies; consequently, water reclamation and reuse has become an attractive option for conserving water. Figure 8 outlines the relative importance of the natural systems contributions toward sustainable development in addition to their role as a treatment process.

FIGURE 8

Impact on Sustainable Development

	Low cost	Low Man Power	ground water rechrg	foresta-tion	agri-culture
Lagoons	○	○			
Sand Filters	●	●			
Const Wetlands	●	●			
Agriculture	●	●			
Slow Irrig.	●	●	●	○	○
Overland Flow	●	●			●
Rapid Infiltration	●	●	○		

○ Important ● Some Importance

These systems can be grouped into three categories relative to their contribution to sustainable development in developing countries:

1. Relative low operational and capital cost and low technical manpower requirements while capable of achieving high degree of treatment: lagoons supplemented by sand filters, constructed wetlands, aquacultures, and overland flow systems.

2. Groundwater recharge: Rapid infiltration and to lesser extent slow rate systems.

3. Reforestation, pasture and crop irrigation: Slow rate systems.

Costs and manpower requirements were discuss previously. Some of the reforestation, pasture and crop irrigation potential are shown on Figure 9. Specifically, slow rate systems can provide an economic return from the reuse of wastewater to irrigate marketable crops, reforestation and pasture for livestock. The crop is a critical component in the slow rate process. It removes nutrient, reduces erosion, maintains or increases infiltration rates, and produces revenues.

FIGURE 9

RELATIVE COMPARISON OF CROP CHARACTERISTICS				
	Potential			
	Revenue Producer	**Water User**	**Nitrogen User**	**Moisture Tolerance**
FIELD CROPS				
Corn	exc.	mod.	exc.	mod.
Cotton-lint	good	mod.	marg.	low
Rice	exc.	high	poor	high
Wheat	good	mod.	good	low
FORAGE CROP				
Reed Canary Grass	poor	high	exc.	high
Alfalfa	exc.	high	good	low
Tall Fescue	good	high	good	high
FOREST CROP				
Hardwood	exc.	high	good	high
Pine	exc.	high	good	mod.

This table was taken from the EPA process design manual: **Land Treatment of Municipal Wastewater.**

One of the most critical steps in any reuse program is to assure health protection of the field workers and consumers. The principal infectious agents that may be present in wastewater are: pathogenic microorganisms and chemical constituents. Secondary treatment maybe acceptable for reuse application for such systems as irrigation of non-food crops. Also, the most important process for the destruction of microorganisms is disinfection by such methods as chlorine. Figure 10 presents typical survival times for potential pathogens in water.

FIGURE 10

TYPICAL PATHOGEN SURVIVAL TIMES AT 20-30°C			
	Survival Time (days)		
Pathogen	**Fresh Water and Sewage**	**Crops**	**Soil**
Viruses	<120 but usually <50	<60 but usually <15	<100 but usually <20
Bacteria	<60 but usually <30	<30 but usually <15	<70 but usually <20
Protozoa	<30 but usually <15	<10 but usually <2	<20 but usually <10
Helminths	Many months	<60 but usually <30	Many months

This table was taken from the EPA manual: **Guidelines for Water Reuse.**

In United States of America, the use of reclaimed water for irrigation of food crops is prohibited in some states, while others allow irrigation of food crops with reclaimed water only if the crop is to be processed and not eaten raw. The less stringent requirements are for irrigation of non-food crops. Figure 11 shows suggested guidelines for water reuse for categories critical for

sustainable development in developing countries. For example, if food crops are surface irrigated such that there is no contact between the edible portion of the crop and the reclaimed water, a disinfected, secondary-treated effluent is acceptable. For crops that are eaten raw and not commercially processed water reuse is more restrictive and less economically attractive.

FIGURE 11

SUGGESTED GUIDELINES FOR WATER REUSE				
Types of Reuse	**Treatment**	**Reclaimed Water Quality**	**Reclaimed Water Monitoring**	**Setback Distances**
Agricultural Reuse • Food Crops Commercially Processed • Orchards and Vineyards	• Secondary • Disinfection	• pH = 6-9 • ≤30mg/l BOD • ≤30mg/l SS • ≤200 fecal coli/100ml • 1mg/l Cl_2 residual min.	• pH-weekly • BOD-weekly • SS-daily • Coli.-daily • Cl_2 residual-continuous	• 300 ft(90m) to potable water supply wells • 100 ft(30m) to areas accessible to public
Pasture • Pasture for milk* animals and livestock	• Secondary • Disinfection	• pH = 6-9 • ≤30mg/l BOD • ≤30mg/l SS • ≤200 fecal coli/100ml • 1mg/l Cl_2 residual min.	• pH-weekly • BOD-weekly • SS-daily • Coli.-daily • Cl_2 residual-continuous	• 300 ft(90m) to potable water supply wells • 100 ft (30m) to areas accessible to public
Forestation	• Secondary • Disinfection	• pH = 6-9 • ≤30mg/l BOD • ≤30mg/l SS • ≤200 fecal coli/100ml • 1mg/l Cl_2 residual min.	• pH-weekly • BOD-weekly • SS-daily • Coli.-daily • Cl_2 residual-continuous	• 300 ft(90m) to potable water supply wells • 100 ft(30m) to areas accessible to public
Agriculture • Food crops not commercially processed	• Secondary • Filtration • Disinfection	• pH = 6-9 • ≤10mg/l BOD • ≤2 NTU • No Detectable fecal coli per 100ml • 1mg/l Cl_2 residual min.	• pH-weekly • BOD-weekly • Turbidity-daily • Coli.-daily • Cl_2 residual-continuous	• 50 ft(15m) to potable water supply wells

Groundwater Recharge	• Site specific and use dependent	• Site specific and use dependent	• Depends on treatment and use	• Site specific

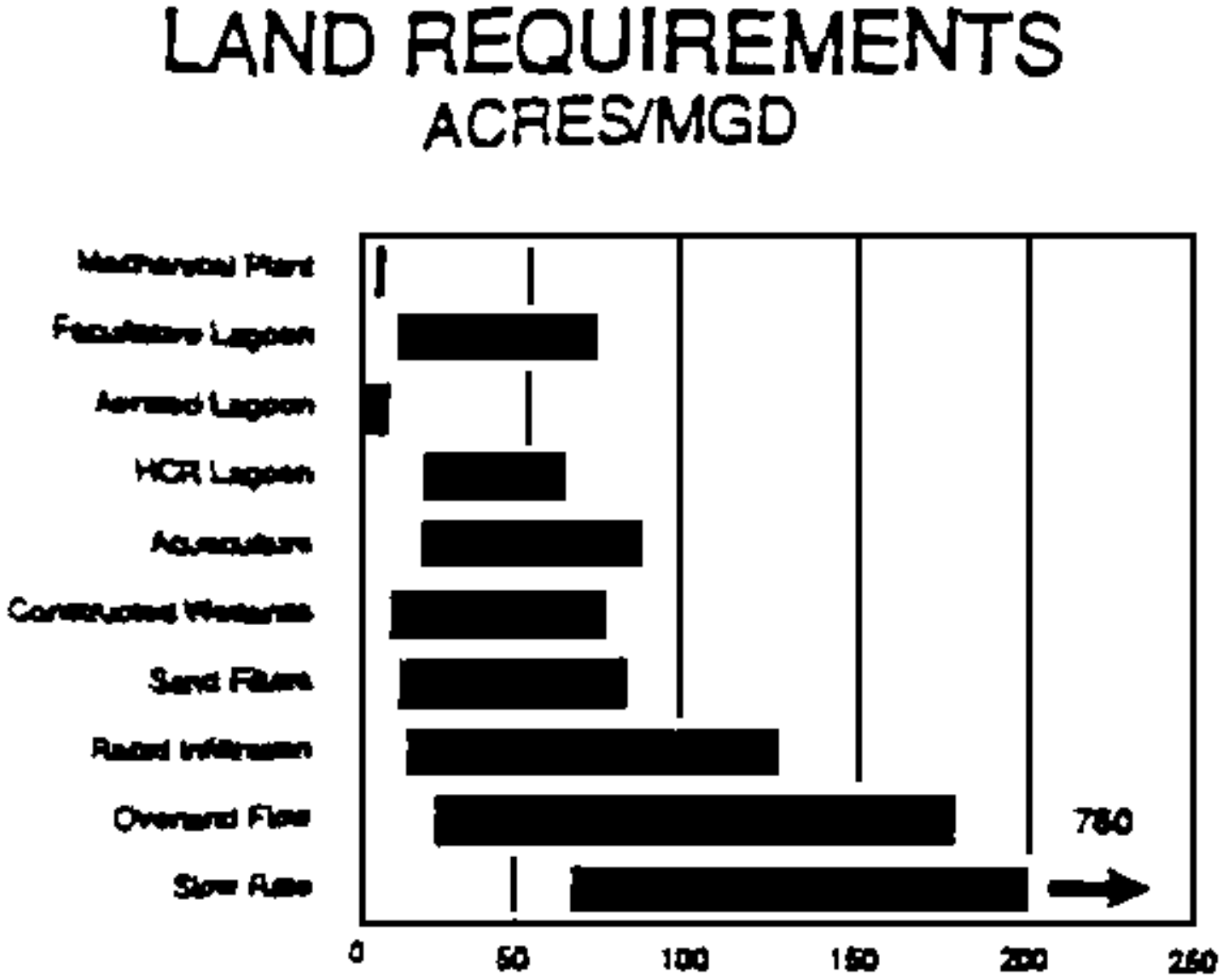
This table was taken from the EPA manual: **Guidelines for Water Reuse.**

* Milking animals should be prohibited from grazing for 15 days after irrigation ceases. A higher level of disinfection, to achieve 14 fecal coli/100 ml or less, should be provided if this waiting period is not adhered to.

LAND REQUIREMENTS

Figure 12 is a depiction of the range of acres of land required per mgd of treatment capacity. All of natural systems include a facultative lagoon as a primary treatment unit. Slow rate systems require as much as 760 acres, while mechanical plants are the least land intensive with very small requirements. The high end of these ranges represents the worst case scenario. In making a preliminary evaluation, the midpoint of these ranges should be used. It will be necessary to make a better determination prior to final process selection.

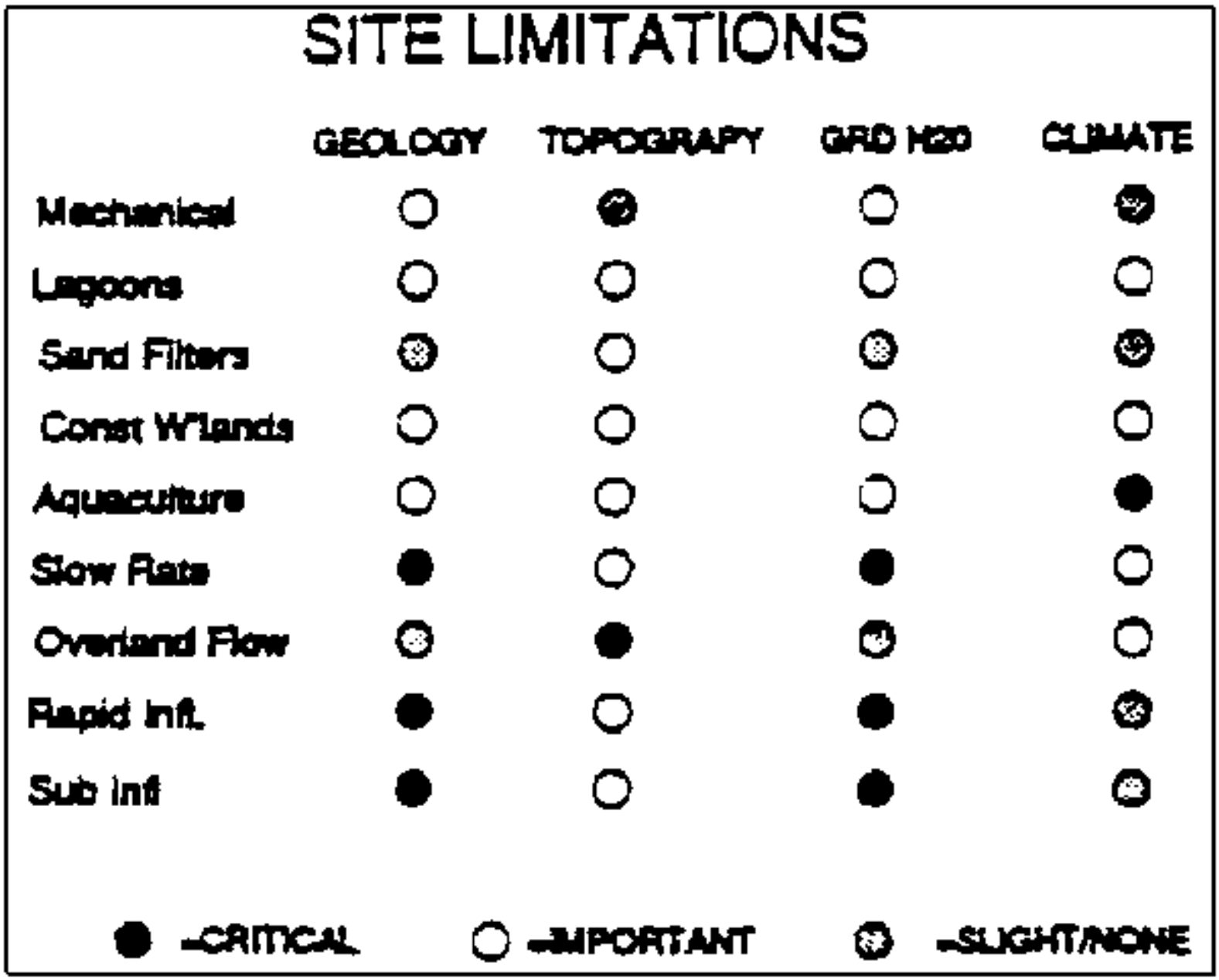
FIGURE 12



SITE LIMITATIONS

Figure 13 examines each process with respect to geology, topography, ground water, and climate. The rating system of *critical, important,* and *slight/none,* is used in relative terms.

FIGURE 13



Critical, means that the limitation may be so unfavorable, that it may not be possible to construct that process. An example would be slopes greatly in excess of 6% for a site considered for overland flow. Although it is not impossible that this limitation could be overcome, the additional cost would most likely render this option moot when compared with more viable options.

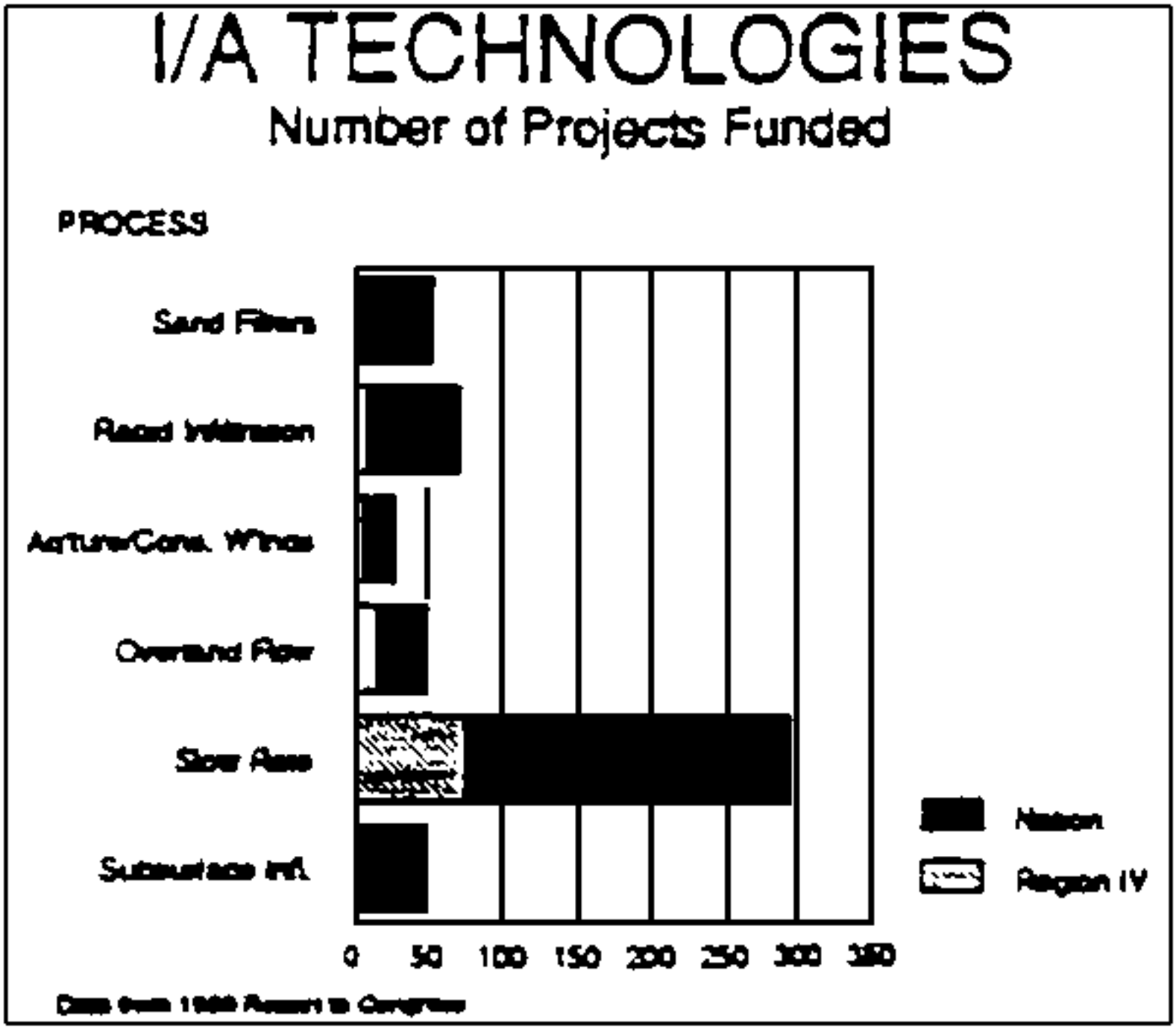
A rating of *important* signifies that the limitation, though not severe enough to preclude the process, may require significant increases in cost in order to overcome the limitation. By assigning a rating of *slight/none,* it is not intended that this limitation be overlooked. In general, this rating implies that the limitation can easily be overcome with little or no increase in cost.

NATURAL SYSTEM USAGE

EPA's innovative and alternative (I/A) program was very successful at promoting the development and application of more cost effective, environmentally sound wastewater treatment technologies. Through financial incentives, an active research and development effort, and an aggressive technology transfer program, the I/A program significantly advanced professional and public acceptance of natural systems.

Figure 14 is a graph showing the number of projects funded in some of the categories discussed. This data was taken from a 1989 report to congress. This does not represent the total number of active systems, only those that received federal funding. Since the conclusion of the I/A program, these systems continue to increase in usage and acceptability. For instance, a survey conducted in USEPA Region IV in 1991 identified 48 constructed wetland systems currently in use in the region.

FIGURE 14



CONCLUSION

This paper focused on appropriate technologies for wastewater treatment based on the principle of sustainable development. Treatment performance, costs and personnel requirements were

compared competitively to conventional systems of wastewater treatment.

In addition to wastewater treatment these systems also show good economic potential for water reuse in the areas of reforestation, agriculture, pasture, and water conservation where there is sufficient land available. In United States of America there are hundreds of these systems in use.

It must be emphasized that in order for a water reuse program to be successful with these technologies stringent regulations, monitoring and control of water quality must be exercised in order to protect the field worker and the consumer.

ACKNOWLEDGEMENTS

Wastewater options described in this paper were obtained from EPA references listed at the end of this abstract. Contributions were also made by John Harkins, Bruce Henry P.E., Hector Danois, and Jim Adcock members of the Technology Transfer staff.

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Appendix A

TYPICAL DESIGN FEATURES FOR AQUATIC TREATMENT UNITS				
Concept	**Treatment goal**	**Detention time, days**	**Depth**	**Organic loading**
Oxidation pond	Secondary	10-40	3-4.5 ft (1-1.5m)	36-110 lb/ac x d (40-120 kg/ha x d)
Facultative pond	Secondary	25-180	4.5-7.5 ft (1.5-2.5m)	20-60 lb/ac x d (22-67 kg/ha x d)
Aerated pond	Secondary & polishing	7-20	6-18 ft (2-6m)	45-180 lb/ac x d (50-120 kg/ha x d)
Storage & HCR ponds	Secondary & storage & polishing	100-200	9-15 ft (3-5m)	20-60 lb/ac x d (22-67 kg/ha x d)
Hyacinth* pond	Secondary	30-50	<4.5 ft (<1.5m)	<45 lb/ac x d (<50 kg/ha x d)

The above table is taken from **Natural Systems for Waste Management and Treatment,** by S.C. Reed, E.J. Middlebrooks, and R.W. Crites, McGraw Hill Book Co. NY, 1988.

* Water hyacinth systems are sensitive to freezing; year round use is restricted to the warm temperate climates of the southern states.

TYPICAL DESIGN FEATURES FOR CONSTRUCTED WETLANDS		
Design Factor	**Free-water surface**	**Submerged bed**
Min. Size Requirement	23-115 ac/1 mgd (2.5-12.3 ha/1000 m^3 x d)	2.3-46 ac/1 mgd (.25-4.9 ha/1000 m^3 x d)
Max. Water Depth	Relatively shallow	Water level below ground surface

Bed Depth	NA	12-30 inches (30-76 cm)
Min. Hydraulic Residence Time in Days	7	7
Max. Hydraulic Loading Rate per Day	.2-1.0 gpd/sq ft (10-40 L/m²/d)	5-10 gpd/sq ft (.02-.4 m³/m²/d)
Min. Pretreatment	Primary (Secondary opt)	Primary
Range of Organic Loading as BOD	9-18 lb/ac x d (10-20 kg/ha x d)	1.8-140 lb/ac x d (2-160 kg/ha x d)

The above table is taken from the EPA Manual No. EPA/625/R-92/005, September, 1992: **Wastewater Treatment/Disposal for Small Communities.**

Appendix A

TYPICAL DESIGN FEATURES FOR SAND FILTERS			
Design Factor	**Buried**	**Open**	**Recirculating**
Pretreatment	Minimum of Sedimentation		
Media Material	Washed, Durable Granular Material		
Effective Size	.40-1.00 mm	.40-1.00 mm	.40-1.00 mm
Unit. Coeff.	<4	<4	<4
Depth	24-36 inches (61-91 cm)	24-36 inches (61-91 cm)	24-36 inches (61-91 cm)
Hydraulic Loading	<1.5 gpd/ft^2 (<6.1 cm/day)	2-5 gpd/ft^2 (8.2-20.4 cm/day)	3-5 gpd/ft^2 (12.2-20.4 cm/day)
Organic Loading	< 5 x 10^{-3} lbs. BOD_5/day/ft^2 (< 2.4 x 10^{-2} kg. BOD_5/day/m^2)		
Media Temp.	>5°C		
Dosing Frequency	>2 per day	>2 per day	5-10 min./30 min.
Recirculation Ratio	NA	NA	3:1 to 5:1

The above table is taken from the EPA publication of April, 1985: **Technology Assessment of Intermittent Sand Filters.**

TYPICAL DESIGN AND PERFORMANCE FOR LAND APPLICATION SYSTEMS FOR DOMESTIC WASTEWATER				
Feature	**Slow Rate**	**Rapid Infiltration**	**Subsurface Infiltration**	**Overland Flow**
Pretreatment	**Primary**	**Primary**	**Primary**	**Primary**
Average daily loading depth or in 1,000 gal/ac	.5-.6 inches (1.2-1.5 cm) 13.6-16.3	.6-4 inches (1.5-10 cm) 16.3-109	.1-1.6 inches (.2-4.0 cm) 2.7-43.4	.4-2.4 inches (1.0-6.0 cm) 10.9-65.2
BOD_5 (mg/l)	5	10	5	15

SS (mg/l)	5	5	5	20
TN (mg/l)	3-8	10-20	25-35	5-10
TP (mg/l)	.1-.4	1-2	.1-.5	4-5
Fecal Colif. (per 100 ml.)	<10	<200	<10	<2000
Virus, log removal ave.	=3+	=2	=3	< 1
Metals, (%) removal	High	Medium	High	Low
SITE CONSTRAINTS FOR LAND APPLICATION				
Feature	**Slow Rate**	**Rapid Infiltration**	**Subsurface Infiltration**	**Overland Flow**
Soil texture	Sandy loam to day loam	Sands & sandy loam	Sandy to day loam	Silt loams & day loam
Depth to groundwater	3 ft. (1 m)	3 ft. (1 m)	3 ft. (1 m)	Not critical
Vegetation	Required	Optional	Not applicable	Required
Climatic restrictions	Growing season	None	None	Growing season
Slope	<20% cult. land <40% uncult.	Not critical	N/A	Finished slopes 2-8%

The above tables are taken from the EPA Manual No. EPA/625/R-92/005, September, 1992: **Wastewater Treatment/Disposal for Small Communities.**

Sub-track: Economics and Financing

Water Management Problems and the World Bank's New Water Policy

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With the growing water problems facing many countries in the developing world, new ways are needed to manage this valuable economic resource. Just because water is essential for human survival doesn't mean that governments must deliver all water services to the individual consumer. It is time to consider a change in the traditional role of government in the water sector from that of a builder and provider of all water services to one of a facilitator, and regulator of service providers. In the first part of this paper I will outline the growing demands for water and the serious water problems this poses for developing countries and explain why it is time to consider changing government's role in the water sector. In the second part, I will outline the World Bank's new water policy that we developed to help address these problems.

Water Use and Future Demands

Human use of water has increased more than 35-fold over the past three centuries and 4-fold since 1940. Recently, water withdrawals have been increasing 4-8 percent per year, with the bulk of the demand arising in the developing world. Sixty-nine percent is used for agriculture, 23 percent for industry, and 8 percent for domestic uses. In Asia and Africa, over 85 percent of the water is used for agriculture. Average consumption rates vary widely with per capita consumption in North and Central American being over twice Europe's, three times that in Asia's and seven times that of Africa.

With the world's population growing to at least 8 billion by 2025, and assuming steadily rising living standards, the demand for water will increase dramatically. Much of the population growth will be concentrated in urban areas. By the year 2000, seventeen of the world's twenty-four cities with over ten million inhabitants will be in developing countries, compared to only one in 1960. Feeding and providing cheap, clean and reliable water supplies to these numbers will place new demands on the world's water resources.

Food Production

One-third of the total world's food production comes from irrigated land. Since 1950, the irrigated area has grown by 2.5 times - a key factor in allowing food production to keep up with the growth in food demand. Over the past 25 years, the expansion of irrigation has accounted for over one-half the increase in global food production. But it is now becoming increasingly difficult to sustain this expansion. Irrigable land and water are becoming increasingly scarce. Costs of new irrigation are rising rapidly and there are growing environmental concerns about large water projects and the overexploitation of groundwater. Although an estimated additional 110 million ha in developing countries are potentially irrigable, it is likely that location disadvantages, and high investment and operational costs will greatly reduce future expansion. In fact, the expansion of the area irrigated in the 1970s was at only about half the 1960's rate. Thus it appears that the strategy adopted by the World Bank and other international agencies, over the past twenty-five years, of expanding agricultural production by increasing irrigated area, high yielding varieties, and fertilizer use is no longer sustainable. New irrigated areas are not likely to be the major

source of new food supplies; rather the focus must be on more efficient utilization of water in existing irrigation systems. This challenge is particularly acute in countries with mature water systems and where some of the water currently used for irrigation will need to be reallocated to higher valued uses.

Domestic and Industrial Uses

With regard to domestic needs, about 1 billion people in developing countries do not have access to potable water, particularly the rural poor, and 1.7 billion have inadequate sanitation facilities. As a result waterborne diseases, which constitute 80 percent of all diseases in developing countries, contaminated water impose a huge burden on many countries. Unsafe water is implicated in the deaths of more than 3 million people, mostly children, from diarrhea and causes about 900 million episodes of illness each year. A safe water supply is thus literally a life and death issue. Improving access to water and sanitation makes good economic sense. For example, in just the first ten weeks of the cholera epidemic in Peru, losses from reduced agricultural exports and tourism were estimated at $1 billion - more than three times the amount that the country had invested in water supply and sanitation services in the 1980s.

Box: 1. Increasing Costs of Water Supply

Many cities convey water over long distances and make extensive use of high-cost pumping. In addition, intensive water use has created the necessity for additional water treatment due to a decline in water quality or rejection of the existing source because of the irreversible damage caused to its quality.

Amman: When the water supply system was based on groundwater, the average incremental cost (AIC) was estimated at $0.41 per cubic meter, but chronic shortages of groundwater led to the use of surface water sources. This raised the AIC to $1.33 per cubic meter. The most recent works involve pumping water up 1,200 meters from a site about 40 kilometers from the city. The next scheme contemplates the construction of a dam and a conveyor, at an estimated cost of $1.5 per cubic meter, which is also about the cost of desalinating sea water of $1 to $2 per cubic meter.

Shenyang (China): The cost of new water supplies would rise between 1988 and 2000 from $0.04 to $0.11 per cubic meter, almost a 200 percent increase. The main reason is that groundwater from the Hun Valley Alluvium, the current water source, has to be rejected as a source of potable water for reasons of water quality. As a result, water will have to be conveyed to Shenyang by gravity from a surface source 51 kilometers from the city. In Yingkuo, the AIC of water diverted from the nearby Daliao River is about $0.16 per cubic meter. However, because of the heavy pollution, this source cannot be used for domestic purposes. As a result, water is currently being transported into the city from the more distant Bi Liu River at a cost of $0.30 per cubic meter.

Lima: During 1981, the AIC of a project to meet short- to medium-term needs, based in part both on a surface source from the Rimac River and on groundwater supplies, was $0.25 per cubic meter. Since the aquifer has been severely depleted, groundwater sources cannot be used to satisfy needs beyond the early 1990s. To meet long-term urban needs, a transfer of water from the Atlantic watershed is being planned, the AIC of which has been estimated at $0.53 per cubic meter.

Mexico City: Water is currently being pumped over an elevation of 1,000 meters into the Mexico Valley from the Cutzamala River through a pipeline about 180 kilometer long. The AIC of water from this source is $0.82 per cubic meter, almost 55 percent more than the previous source, the Mexico Valley aquifer. The former source has been restricted due to the problems of land subsidence, the lowering of the water table, and the deterioration in water quality. The newly designed water supply project for the city is expected to be even more costly, since it will have a longer transmission line, and water will be pumped over an elevation of 2,000 meters to the city.

* Costs exclude treatment and distribution.

The time devoted to fetching water for domestic use often represents a heavy cost for rural households and imposes a terrible burden on women. In some areas women spend over 15 percent of their time in this activity. The benefits of rural water supply projects can be enormous. In the case of a Mozambique village, a water supply project reduced the average time that women spent collecting water from 120 to 25 minutes a day. The time saved can be spent on better child care, food production, and other economic activities.

In the urban areas, both domestic and industrial users are facing steeply rising costs of new supplies - sometimes twice or three times previous costs. For example, for Amman (Jordan) new supplies cost over three times present costs (Box 1). In Lima (Peru), to meet their long term needs, they will have to transfer water from an Atlantic watershed at over twice the current costs.

Water Quality Requirements

Besides supplying water to domestic, industrial and agricultural users, countries are increasingly faced with major environmental problems related to the management of water resources. For example, many fisheries and wetlands depend on continuous river flows of reasonable quality and are threatened by growing water withdrawals. Currently, in numerous countries, the quantities and qualities of water being allocated for instream and flooding uses are inadequate to sustain valuable water dependent ecosystems.

Moreover, in many places, groundwater resources are seriously at risk from overexploitation and contamination by urban and agricultural pollutants and salt water intrusion. In the case of non-renewable groundwater, greater attention needs to be given to possible future uses for these resources before they become exhausted or polluted. There are cases where non-renewable groundwater that could be an important source of water for future domestic or industrial use is currently being pumped to irrigate low-valued crops. Where the over pumping involves international or interstate aquifers, managing the water extraction becomes a difficult political task. For example, Saudi Arabia's uses groundwater for irrigation from the same aquifer that Jordan would like to save for future urban use (Box 2).

Box: 2. Water Scarcity in Jordan

Water resources in Jordan are scarce and expensive to exploit. But their effective management is key to meeting the needs of irrigated agriculture, which accounts for 19 percent of exports, and those of industry and the population. Jordan's economy has been transformed since the early 1950s, when its population was only 0.6 million, with agriculture largely confined to rainfed farming and livestock raising. Population is currently 3.2 million, increasing at 3.8 percent per annum, and increasing urbanization (currently 70 percent of the population) and rising incomes have brought about increasing demands for water. Approximately 48,500 hectares have been brought under irrigation in the Jordan Valley, the northern highlands, and the Disi wells area in south-east Jordan. This has raised increasing concerns about the balance of water use between irrigation and municipal and industrial (M&I) purposes.

Jordan's water resources have been relatively well studied. The long-term safe yield of groundwater within Jordanian territory, excluding fossil aquifers, is estimated at about 356Mm^3 per year. Surface water resources are estimated at 540Mm^3 per year. Present surface water consumption is estimated at 336Mm^3 per year, of which almost all is used for irrigation. The topography and geological features of the valleys have required construction of expensive storage facilities to use surface water effectively. The strategy in the past has been to use surface water principally for irrigation and groundwater for both M&I and irrigation. This strategy has been rational given the better quality of groundwater and its concentration in the uplands where the majority of the population live. However, water scarcities are such that this strategy is being modified.

Municipal and industrial (M&I) water currently accounts for about 25 percent of total water use, and water consumption is modest for a country with Jordan's per capita income. Water is metered and charges are high by the region's standards. However, as the population is expected to increase from 3.2 million in 1990 to 7.4 million in 2015, even with modest consumption rates, M&I water demand is expected to increase so that by 2015, it will account for about 40 percent of total water demand. In response to the growing scarcity, irrigation is now done by sprinkler and drip irrigation pressure pipe systems that have largely replaced surface irrigation.

There are three remaining under-exploited sources of water in Jordan. These are (a) water which would be made available by construction of a storage facility on the Yarmouk River, known as Wahdeh (or Unity) Dam, with a yield of 149Mm^3 annually; (b) water from the Disi wells in south-east Jordan with an estimated safe yield of 110Mm^3 for 100 years; and (c) treated sewage effluent, which will be increasingly available for collection and re-use for irrigation (about 165Mm^3 per year in 2015).

Water planning strategies in the 1980s envisaged using all the water from the proposed Wahdeh dam for irrigation, permitting an expansion of irrigated area in the Jordan Valley. Licenses were also granted for development of the Disi aquifer for irrigated agriculture. Increasing awareness by the government of water scarcities, however, brought about a revision of this strategy. It was realized that the Disi aquifer should be regarded as a strategic reserve, to be used for M&I water as the need arose, and that “mining” this water source for agriculture was not in the interests of the country. An additional complication arises because the Disi aquifer is also being mined for irrigation by Saudi Arabia. Thus, this source of future M&I water may only be saved through an international agreement between Jordan and Saudi Arabia.

Source: World Bank Water Resources Management Policy Paper, 1993.

Water Management Problems

All these considerations has lead to the conclusion that water resources must be better managed. Current practices are not sustainable from either an economic or an environmental perspective. Presently in many countries, low-valued uses consume a significant share of the water resources while high-value uses face shortages. Furthermore, unaccounted-for water is unacceptably high in many urban areas. For example, it amounts to 58 percent of the water delivered in Manila's water supply system and about 40 percent of the water delivered in most Latin American cities as compared to only 8 percent in Singapore. In Algeria, distribution losses alone are as high as 40 percent. Some of the losses are due to poor system design and management, while others arise from the low price charged for water. For example, a recent review of World Bank-financed water supply projects showed that the effective price charged for water was only about 35 percent of the average cost of supply, while for irrigation, the water charges cover a much smaller share of average cost and are generally not based on the volume taken.

Let me briefly summarize the current weakness in water management practices that have caused misallocation, pollution, and waste of water resources:

- Fragmented water resources management (Box 3).
- Excessive reliance on over-extended governmental agencies lacking the proper incentive structure.
- Failure to decentralize the delivery of water services and the lack of stakeholder, community, and private-sector involvement.
- Inadequate coordination of international and interstate water resource use and development.
- Underpricing of water and lack of cost recovery.
- Inadequate delivery of water and sewage services, especially for the poor.
- The neglect of water quality, health, and environment concerns in water resources management.

Box: 3. Fragmented Water Resources Management: Examples from South India

Over-development of water resources has already occurred in a number of countries primarily due to fragmented decision-making. One example is provided by the Chittar River in South India. Its highly variable flows have traditionally been diverted at many points into small reservoirs (tanks) used to irrigate the main rice crop, following monsoon rains. Diversion channels are large to accommodate flood flows. Thus, when a storage dam was constructed, the uppermost channel was able to absorb essentially all the regulated flow. The upper tanks now tend to remain full throughout the year, concentrating benefits and adding to evaporation losses. The more extensive lower areas have largely reverted to uncertain rainfed cultivation. Construction of the storage dam without adequate considerations of downstream users and of the storage capacity already m the basin is a good example of how individual project development in isolation can cause significant economic losses.

The construction of the Sathanur Dam in Tamil Nadu on the Ponnair River to serve a left bank command area deprived the traditional and production delta areas of irrigation water. The rights of downstream irrigators are recognized in the dam operating rules, but most of the regulated flow below the dam is diverted into the upper channels, depriving those lower down. Losses have greatly increased in the wide sandy bed, and no surface water has reached the sea for twenty or more years. Continued spills in about 50 percent of all years were used to justify subsequent construction of the right bank irrigation command, further aggravating shortages in the delta and leading to endless conflict between the two Sathanur commands. Moreover, additional storage dams on upstream tributaries are adding to evaporation losses in what was already fully developed basin. Irrigation intensities in the productive delta have been further affected, and the Sathanur command areas m turn are suffering. High return cropping is replaced by cultivation on inherently less productive lands, served by tributaries that are inherently more variable than was the main river previously.

The Amaravarthy River is a tributary of the Cauvery which is the most disputed major river in India. In the absence of Cauvery agreement, Kamataka (the upstream riparian state) has steadily developed massive irrigation schemes, depriving the delta (Tamil Nadu's rice bowl) of its accustomed supplies. Moreover, Tamil Nadu has been developing the Amaravarthy. As at Santhanur, releases are made from the Amaravarthy Dam for the traditional areas, but these areas are far downstream, and substitution of regulated flows has been encouraged the development of private pumps along the river bank. New electric connections have now been banned, but little can be done to control illegal connections or diesel pump, and little water now reaches the lower command areas, let alone the Cauvery. Finally, new storage dams are being constructed on tributaries both in Kerela and Tamil Nadu, further depriving not only the old lands but also the new lands and the pump areas of water source.

The Bank's New Policy

In response to these past weaknesses in water policies and problems of government failure, many countries, as well as international agencies such as the World Bank, have taken a critical look at their activities in the water resources sector. For the World Bank, it resulted in a new water resources management policy that was approved by the World Bank Board of Directors on May 25, 1993 and published in September, 1993. This was the culmination of a process that started officially with a June 1991 workshop involving representatives from many borrowing and

donor countries. This workshop identified major issues that the participants thought should be addressed in the water policy. They were especially concerned about:

- intersectoral water allocation and pricing issues.
- environmental and health problems, and
- international and interstate water resources conflicts.

As you would expect, all of these issues have been addressed in the Bank water policy along with a number of additional concerns. The policy has been revised extensively based on comments from both within and outside the Bank. Reviewers include UNDP, FAO, UNEP, and WHO, as well as NGOs from developing and developed countries.

At the core of the new policy is the adoption of a comprehensive management framework which calls for water to be treated as an economic good. It recommends a more decentralized system of service delivery, greater reliance on pricing, and financial autonomous service entities, along with fuller participation of water users in the management of water resource systems. It encourages countries to develop national water strategies with coherent and consistent policies and regulations across sectors. Let me briefly underline the main features:

- Countries need to develop a *comprehensive analytical framework* for water resources management that is suitable for a country's needs, resources and capabilities. Such a framework will allow the incorporation of cross-sectoral and environmental considerations in the design of investments and policies, by recognizing the interactions between the various elements of a river basin's ecosystem.

- Countries should place greater emphasis on *incentives* for efficient water use and on financial accountability of water entities. They should increase the reliance on pricing as a management device which reflects resource scarcity and encourages efficient utilization of the resource.

- Governments will need to establish a *strong legal and regulatory framework* for dealing with the pricing, monopoly organizations, environmental protection, and other aspects of water management which are not adequately handled by unrestrained market forces.

- Governments need to *decentralize* water service delivery responsibilities to the private sector, to financially autonomous entities, and to community organizations, such as water user associations.

- Countries should encourage the *participation* of stakeholders in planning, designing, implementing, and managing of water resource activities.

- Governments must take on an active role in *protecting, enhancing, and restoring water quality and water dependent ecosystems, and to abate water pollution.*

- Countries must give greater priority to providing adequate water and sanitation *services for the poor,* thus helping to stop the spread of disease in crowded low-income areas.

- The Bank will be more proactive in helping countries resolve *international water*

resources issues and in sharing information concerning these water resources (Box 4).

Box 4: The Indus Waters Treaty

When the subcontinent was partitioned in 1947, the political boundary abruptly cut off two irrigation canal systems of Pakistan from their source in India. The dispute started in 1948, when India stopped the supplies and claimed propriety rights over the waters flowing through its territory. In 1951 the former chairman of the TVA warned that the dispute was dangerous and suggested that the World Bank help the countries to develop the Indus system. The Bank President promptly offered assistance, and the delegations from the two countries met in Washington in May 1952 to prepare a joint plan. They differed too sharply in their views, however, to pursue joint planning. The Bank suggested that each side should present a plan of its own. Again, their plans were too far apart to be reconciled. They agreed, however, to the Bank's offer to present its own proposal.

In February 1954, the Bank presented a proposal that allocated the eastern rivers (the Ravi, Beas and Sutlej) to India and the western rivers (the Indus, Jhelum and Chenab) to Pakistan. This proposal envisaged construction of a system of link canals from the western rivers to replace Pakistan's uses on the eastern rivers, a transition period to allow Pakistan to complete these projects, and the need for India to pay the project costs and to continue sending the supplies during the transition period. The Bank said its proposal was simple, workable, and fair. This division would meet the uses of both sides and leave each free to develop new supplies. India accepted the proposal. Pakistan's acceptance was conditional; it contended that there was not enough surplus in the western rivers to replace its uses on the eastern rivers.

The delegations met again in Washington in December 1954 to work on the Bank's proposal. After extensive studies of the available flow supplies and river losses and gains, the Bank issued an aide-memoir in May 1954 that confirmed that the surplus supplies in the western rivers would be insufficient to meet Pakistan's replacement needs in certain periods and that its original proposal had to be modified to include storage works. Pakistan accepted the modified proposal, but India said its financial liability should be limited to the original Bank proposal.

The next four years of negotiations to reconcile differences on several issues were difficult. During this time, the Bank was also able to mobilize the support of Australia, Canada, New Zealand, the United Kingdom, and the United States for financial assistance. Thus, after long, intensive, and sensitive discussions, the Indus Water Treaty was finally signed on September 19, 1960.

The Bank's success was due to its recognized technical expertise and neutrality along with its ability to provide financial assistance. The Indus Waters Treaty is a landmark in the Bank's role as an international mediator. It suggest both the difficulty of negotiation agreements and the need for greater involvement of international agencies, such as the Bank, in helping countries negotiate agreements for managing international water resources.

World Bank's Lending and Future Financial Needs

The Bank, from its early days, has had a very active assistance program for water resources

management. By the end of 1991, the Bank had lent over US$40 billion for water projects, almost half of which was for irrigation. Present lending plans envisage a continued active involvement in water resources management: US$18.3 billion are projected to be lent for water resource investments by the Bank during 1993-98.

Yet the financial requirements to meet future demands for irrigation, hydropower, water supply and sanitation investments in development countries, estimated to be US$600-700 billion over the next decade, are much larger than the Bank's lending capacities. Thus, the Bank will only be able to finance a small share of the demands. A greater part of the capital will have to come from water users themselves. This implies that the much greater emphasis on cost recovery, financial accountability, user participation, and private sector involvement, promoted in the new Bank policy, will be absolutely necessary if countries are to meet their domestic water and food supply needs in the next century.

Implementation

This is an ambitious agenda. In most countries its implementation will be gradual, dealing first with priority issues which differ from country to country. Programs need to be tailored to the institutional capacity of the country. In many cases, capacity will need to be enhanced, and this takes time. Implementation of the policy recommendations within the Bank will take time too, as staff skills must be upgraded, skills mixes adjusted and procedures developed and improved.

Some progress have already been made as a number of countries are in the process or have adopted water policies that reflect some of the basic features of the Bank's policy. Countries such as Sri Lanka, the Philippines, and Indonesia have adopted the approach of promoting and expanding the role of water user associations (WUAs) in water management and system ownership. Other countries such as Chile and Mexico have taken the additional step of using water markets as another mechanism to decentralize and improve water management. Still others, including Pakistan and Peru, are in the process of considering radical changes in their current water management.

Conclusion

As proposed in the World Bank's new water policy, countries need to develop a two-pronged approach to their water resources management. First, they need to emphasize over-all water resource planning and second, they must work towards decentralizing the actual delivery of water services. How they do this will vary from county to country and should reflect each country's goals and objectives. For example, some countries may want to turn over the delivery of water services to the private sector, while others may use financial autonomous public utilities. The key component is to make those delivering the services accountable to the water users.

To compliment these efforts to improve the delivery of water service, countries must develop mechanisms to coordinate their water planning and development activities. Most countries can no longer afford the luxury of independent agencies developing water for their own purposes such as hydropower, irrigation, or urban water support, without concern for other potential uses. Water resources must be considered as an economic good in an overall river basin context so that the interdependencies in water use are taken into account right from the early planning stages.

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Financing Investments in Water Supply and Sanitation

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INTRODUCTION

The reintroduction of cholera into Latin America since 1991 has focused attention on the deplorable state of excreta disposal in most of the cities in the region. The proportion of the population provided with sewerage has increased in recent years, but not to the same extent as has the provision of water supply (ECLAC, 1990a). The lack of sewerage is compounded by the absence of sewage treatment. Only 10 percent of sewage systems provide even partial treatment before discharge (PAHO, 1990). As a result, there is widespread contamination of the water bodies into which urban sewage is discharged and the facile transmission of diarrheal diseases through water or food is always a menacing possibility (ECLAC, 1992).

Financing investments in water supply and sanitation has been a perennial problem in all countries of Latin America and the Caribbean. Traditionally, the contribution to capital funding derived from the income of operating companies has been very small, a direct consequence of unrealistically low tariffs. Instead, financing for investments has been obtained largely from general government revenues through either direct contributions or through the underwriting of loans, especially the multilateral development banks. The levels of financial support obtained and the share of the different sources has changed in recent years, particularly as the contribution from general tax revenues has declined.

The financing needs are not limited to the initial capital investment, but include the need to generate funds for the operation and maintenance of the systems once built. Moreover, the financial demands of water supply and sewerage systems are growing as population increases and water sources grow more distant and as it becomes increasingly necessary to dispose of human and industrial wastes safely.

A recent study shows that “the funding of capital investments in water-related projects is mainly provided from national sources” (ECLAC, 1990b). In the last decade more than 70% of capital funding for the expansion of water supply and sanitation services has come directly from national sources (PAHO, 1987). During the International Water Supply and Sanitation Decade, the share of external funding, including loans, in capital investment in water supply and sanitation services has been lower for the countries of Latin America and the Caribbean, as a whole, than in the countries of Africa and Asia (WHO, 1987). There is no reason to expect that the proportion of capital funding provided from external sources to water supply and sanitation systems will increase in the 1990's.

This paper on the basis of recent studies conducted in ECLAC (Lee and Jouravlev, 1992) and

elsewhere, explores the practicability of the self-financing of water supply and sanitation services, including sewage treatment, through the income derived from tariffs. If this is to be achieved then it is important that the whole population pay for services: an issue of some importance given the unequal distribution of income in most cities of the region.

FINANCING DRINKING WATER SUPPLY AND SANITATION SERVICES

By 1980, at the beginning of the International Drinking Water Supply and Sanitation Decade (IDWSSD), the population of Latin America and the Caribbean was relatively well provided with drinking water supply and sanitation facilities compared with the population of other regions of the developing world. There had been two decades of special investment programmes in and general development of drinking water supply and excreta disposal services in the region. Relatively well organized water supply and sanitation institutions were operating in most countries. In urban areas, high levels of service had been achieved, particularly in drinking water supply where 71 % of the population was served with house connections, but only 59% of the urban population was connected to sewerage systems or provided with other forms of sanitary excreta disposal (PAHO, 1987). In rural areas less progress had been made although, in many pans of the region piped drinking water supply systems were being installed in the larger rural settlements.

In the 1980's, the rate of improvement in the levels of service in the region slackened. Between 1980 and 1990, the proportion of the urban population with access to a protected drinking water supply rose only from 83% to 86%, and the proportion with access to sewerage services and excreta disposal facilities only from 59% to 60%. In rural areas more was achieved, with access to water supply rising from 40% to 45%, and to sanitation services from 11 % to 15%. In general, the goals of the IDWSSD were not met.

In most countries of the region, the financing of water supply and sewerage systems is inadequate either to keep up with the needs of capital expansion for the growing urban population or for the maintenance of the existing systems. It is true that the provision of drinking water and sewerage to the urban population has increased in nominal terms, but the service provided is often very irregular and of questionable quality (PAHO 1990). Not all countries have even managed to maintain the nominal levels of service reached in the past. In Buenos Aires, the proportion of the population served by the system operated by Obras Sanitarias de la Nación (OSN) has steadily declined over the last fifty years. In 1947, 94% of the population lived in a dwelling with a connection to the water supply system, in 1960 only 76% and by 1980 less than 60%. In the absence of the provision of drinking water by OSN, the population of Buenos Aires has had to shift for itself. Sometimes this has led to the creation of local water supply systems providing good service, but in many cases the result has been recurrence to sources of dubious quality and an over reliance on individual excreta disposal systems with a high potential for contaminating aquifers (Brunstein, 1988).

Income from the Provision of Water Supply and Sewerage

Historically, the contribution to the funding of water supply and sanitation projects derived from the income of operating companies has usually been very small. Cost recovery policy has seldom been applied in water supply and sanitation services, even in urban areas. It is not surprising to find, therefore, that the bulk of capital funding for water supply and sanitation has

come, in most countries, from general government revenues, either directly or in the form of government guarantees to loans from the World Bank or the Inter-American Development Bank (ECLAC, 1990b). This source of capital funding has always fluctuated considerably with changes in political priorities and suffered from the effects of macroeconomic mismanagement. The severe recession between 1982 and 1983, the effects of which continue to be felt in many countries of the region, resulted in efforts to reduce the size of the public deficit, and this has reduced the flow of funds from general government revenues. At the same time, there has been a region-wide change in the perception of the role of the public sector in the economy which has led to a general reduction in the scope of government activities. In particular, increasing consideration is being given to the need for potentially revenue generating public services to become either self-financing or to be transferred to the private sector.

Until very recently, public water supply and sanitation companies have been incapable of compensating the reduction in government contributions to capital financing by generating more funds from revenues. The resulting shortfall in capital funding has severely affected not only expansion programmes, but also the operation and maintenance of existing systems (Israel, 1992). The poor financial state of many utilities can, to a considerable extent, be directly attributed to the failure to adopt a tariff policy which would generate revenues sufficient to recover the total costs of the provision of service. In Mexico, for example, the total cost of providing drinking water through house connections has been estimated at about 240 pesos/m^3, whereas consumers are billed only some 40 pesos/m^3 (Mexico, 1989).

Some countries have managed to improve the financial situation of water supply and sanitation companies by following sound tariff policies. In Chile, 56% of the funds invested in water supply and sanitation services by the Servicio Nacional de Obras Sanitarias (SENDOS) over the period 1985-1989 were generated from tariff revenues and more recently a tariff policy has been applied to permit the services to meet all their investment needs from income (Chile, 1993). In Brazil, the sector has been partially self-financing since the adoption of the “Plan Nacional de Saneamiento” (PLANASA) in 1971 (World Bank, 1989). Political difficulties led to a serious reduction in the self-sufficiency of the plan for a number of years, but in 1990 almost 80% of the capital needs of the sector were provided from the rotating funds, replenished from tariff revenues, as established under PLANASA (World Bank, 1989).

It is not, however, the level of tariffs alone that determines the contribution of revenues to capital funding. Water pumped, but not accounted for, reduces revenues and can also inflate the need for new investments. The experience of most water supply companies in the region indicates that high values of unaccounted for water are more often the result of deficiencies in commercial management, mainly problems in billing and the collection of payment and inadequate policies for dealing with overdue accounts, than solely due to high rates of leakage in distribution systems (Yepes, 1990). For example, it has been estimated in Mexico that of each 100 litres pumped in a typical distribution network, the user receives 60, is billed for 40, and finally only pays for 30. In addition, tariff collection has been characterized by delays in billing of some 6-9 months (Mexico, 1989).

Reducing commercial losses does not usually involve high capital expenses, but it may require changes in management practice which are difficult to introduce in a bureaucratic environment. Better commercial management, however, can replace or postpone the need for new capital

investments and also reduce production, pumping and treatment costs. A reduction of unaccounted for water from 60% to 30% in a city growing at 3.5% per year would postpone investments in new production facilities by up to 16 years.

One of the more serious consequences of inadequate tariff structures, and an additional argument for adopting tariffs that fully reflect costs, is that low tariffs for drinking water supply and sewerage do not, as a rule, benefit the poor. It is usually the poor who, through the lack of investment, do not have adequate access to public drinking water supply and, as a result, are forced to buy water from private water sellers at prices far exceeding those charged by water supply companies. It has been estimated that the cost of water bought from water sellers is 17 times higher in Lima, Peru, from 17 to 100 times higher in Port-au-Prince, Haiti, and from 16 to 34 times higher in Tegucigalpa, Honduras than the price charged by the utility (World Bank, 1988). In Quito, Ecuador, households without connection to the public supply paid US$ 4.31 for 4 cubic meters while the water supply company would provide 50 cubic meters for that price (USAID, 1991).

Sources of Finance for Water Supply and Sanitation Investments

The funding structure for investments in water supply and sanitation projects has varied considerably among the countries of the region. In Bolivia, for example, external sources have traditionally accounted for an estimated 77% of total funds. The share of internal funds has been relatively higher in the rural areas, whereas external sources of financing accounted for an estimated 79% of investment funds in urban areas (Bolivia, 1988).

In Colombia, however, the main sources of funds for investments over the recent past have been generated internally. External borrowing only accounted for some 45% of funding, while 30% came from central government revenues, 15% from the revenues of operating companies, and the remaining 10% from other local sources. Companies in large cities relied mostly on external loans which accounted for about 50% of their total investment while operating revenues accounted for a further 35%. In contrast, the financing of drinking water supply and sanitation in medium and small cities and in rural areas depended more on contributions from the central government which accounted for 45% of total funding while external loans provided 40% (Colombia, 1988).

In Mexico, funds for drinking water supply and sanitation investments come largely from the Federal Government whose contributions are estimated to have accounted for almost 84% of the total. State governments have contributed with an additional 4% to investments and only 10% has been provided from external sources. Federal investments were reduced after 1984, as a result of the economic problems affecting the country. This reduction was accompanied by the increasing role of internal and external borrowings in investment funding. The dependence on borrowed funds and subsidies is now being reduced through a combination of policies, including better management, the setting of tariffs in accordance with marginal costs, and other measures aimed at making operating companies financially independent. In addition, there is an effort to increase sector financing through a better and more flexible combination of federal and other resources and through the promotion of private investment and community participation (Mexico, 1989).

In Peru, the contribution of national sources to investment funding has been around 69% in

recent years. Due to the decrease in the volume of external funding, the share of financing provided from national sources increased from 51% in 1985 to about 80% in 1987 (Mendoza and Sanchez, 1988). About 61% of the total investment was channelled to urban areas, including 30% to Lima, and only 10% to rural areas (Prialé, 1989). An analysis of the 1986-1995 investment programme indicates that the financing of investments in urban areas comes mainly from operational revenues and community and user contributions, and only to a lesser extent from general government revenues and external borrowings. The financing of investments in rural areas, in contrast, comes predominantly from external borrowings and general government revenues (Mendoza and Sanchez, 1988).

In Uruguay, national sources accounted for 63% of investment financing for water supply and sanitation between 1985 and 1989 with 32% coming from operating revenues, slightly more than 15% from the central government and 16% from miscellaneous sources including equipment suppliers and users. The remaining 37% of funding was provided from IDB and World Bank loans.

There are a few private water supply and sanitation companies in the region. In these companies, in contrast with most public water supply and sanitation companies, capital investments are financed almost entirely from tariff revenues either directly or through borrowing.

SELF-FINANCING WATER SUPPLY AND SANITATION SYSTEMS

Self-financing water supply and sanitation systems can be defined as those in which tariff revenues meet the total costs of operating and maintaining existing installations, the capital costs of expanding coverage to remove the existing deficit in service and to supply the increase in population, provide a reasonable rate of return on the capital invested and also cover the associated costs of providing adequate treatment before discharge to the environment. The adoption of such criteria for water supply and sanitation system management would not mean that companies could not borrow money from either national banks, the multi-lateral development banks or from any other lending institutions. It would mean, however, that the total costs of loans would be paid from the revenues received from the sale of water and sewerage services. It would not preclude subsidies either, but any subsidies would be clearly explicit transfers for reasons of social policy. The adoption of such criteria would lay the foundation for the companies to issue bonds or shares to the general investing public, as is now being done in Chile (El Mercurio, 1992).

The tariff charged to customers would depend on long term average and marginal costs, the rate of interest for loans, the amortization period, the rate at which any existing deficit in the provision of service is made up, the rate at which the population to be served grows and the costs of operating and maintaining the existing works, among other factors.

Can tariffs be set to meet all costs?

In order to explore the possibilities for financing water supply and sanitation services from tariffs a recent study by ECLAC estimated what tariffs would be necessary, on the basis of the known per capita unit costs of providing urban drinking water supply and urban sewerage by house connections (WHO, 1987). It was assumed that every customer would pay the full cost of both maintenance and operation. The amortized capital cost was calculated using different real rates of interest, 2% and 10%, and different repayment periods, 25, 50 and 75 years. The calculations

were made individually for each country in terms of the lowest, highest and average charges which would be required (Table 1).

Table 1. THE RANGE OF MONTHLY CHARGES REQUIRED TO COVER THE CAPITAL COSTS OF PROVIDING DRINKING WATER SUPPLY AND SEWERAGE THROUGH HOUSE CONNECTIONS

(Cost in US$ per person served)

Country	Drinking Water Supply			Sewerage		
	Minimum	Average	Maximum	Minimum	Average	Maximum
Argentina	0.39	1.05	1.64	0.43	1.16	1.82
Bolivia	0.28	0.75	1.18	0.32	0.87	1.36
Brazil	0.32	0.87	1.36	0.36	0.99	1.54
Chile	0.32	0.87	1.36	0.36	0.99	1.54
Colombia	0.28	0.75	1.18	0.32	0.87	1.36
Costa Rica	0.28	0.75	1.18	0.32	0.87	1.36
Dominican Republic	0.32	0.87	1.36	0.36	0.99	1.54
Ecuador	0.28	0.75	1.18	0.32	0.87	1.36
El Salvador	0.28	0.75	1.18	0.32	0.87	1.36
Guatemala	0.28	0.75	1.18	0.32	0.87	1.36
Haiti	0.26	0.70	1.09	0.26	0.70	1.09
Honduras	0.28	0.75	1.18	0.32	0.87	1.36
Mexico	0.32	0.87	1.36	0.36	0.99	1.54
Nicaragua	0.28	0.75	1.18	0.32	0.87	1.36
Panama	0.32	0.87	1.36	0.36	0.99	1.54
Paraguay	0.28	0.75	1.18	0.32	0.87	1.36
Peru	0.28	0.75	1.18	0.32	0.87	1.36
Uruguay	0.28	0.75	1.18	0.32	0.87	1.36
Venezuela	0.43	1.16	1.82	0.43	1.16	1.82
Average	**0.32**	**0.87**	**1.36**	**0.36**	**0.98**	**1.53**

Source: Lee and Jouravlev, 1992.

Note: Minimum - interest rate 2%, amortization period 75 years, average - average of all rates and periods, maximum - interest rate 10%, amortization period 25 years.

In making these calculations, it was assumed that new customers would be connected proportionately in each year to the end of the century and that, as the new customers receive a connection, they would begin to pay on the same basis as the population connected at the beginning of the period. It was also assumed that everyone already connected would begin paying the full capital cost of his connection in 1989, the base year for the calculations. The

tariffs calculated would only meet amortized capital costs of existing installations. The total costs of achieving final self-sufficiency would be approximately 26% higher, so as to include other items than capital investment. The total cost of services includes, as well as the replacement cost of existing connections, a series of additional items. These include capital investments providing services to new customers, the rehabilitation of existing systems, many of which are in very bad condition, the costs of training staff and of institutional modernization and, finally, the cost of waste treatment. It is assumed that the cost of water treatment is included in the per capita estimates of the costs of providing drinking water supply.

The new capital investment which would be required for expansion of systems to achieve complete coverage of the urban population varies considerably among countries depending on the level of existing service and the expected growth in population. It is estimated that it would range to 48.2% of the total cost of providing service in Uruguay to 85% in the Dominican Republic and Haiti, the countries where the existing levels of provision of services are the lowest and where population growth is expected to be high.

The expansion of systems in order to achieve universal coverage by the year 2000 and maintaining and rehabilitating existing services would mean the need to include in the tariff an average charge per person of almost US$ 2.00 a month in addition to the previously estimated amortized capital costs of the existing urban water supply and sanitation installations. The cost and, therefore, the amount of the additional charge, would, however, again vary considerably among the countries depending on the existing level of service (Table 2).

Table 2. COST OF CAPITAL INVESTMENT IN EXPANDED SYSTEMS TO ACHIEVE UNIVERSAL COVERAGE BY THE YEAR 2000[1]

(Cost in US$ per person per month)

Country	Monthly charge
Argentina	3.13
Bolivia	2.10
Brazil	2.33
Chile	2.41
Colombia	2.11
Costa Rica	2.06
Dominican Republic	2.32
Ecuador	2.13
El Salvador	2.10
Guatemala	2.10
Haiti	1.87
Honduras	2.10
Mexico	2.37
Nicaragua	2.06

Panama	2.38
Paraguay	2.07
Peru	2.41
Uruguay	2.45
Venezuela	2.78

Source: Lee and Jouravlev

Note: [1] - Includes the capital cost of drinking water supply and sewerage services through house connections, major rehabilitation costs of existing systems, expansion of waste water treatment and the costs of training and institutional modernization.

NECESSARY CONSIDERATIONS IN THE APPLICATION OF A TARIFF

If tariff based financing of water supply and sewerage systems is to become a reality, the tariffs established must be paid regularly by all users. This does not mean that, necessarily, all users must pay the same tariff. Tariff discrimination is both acceptable and necessary for the effective provision of such significant social services. Services should not, however, be provided free to even the poorest customers.

In setting the tariffs, it is unrealistic not to take into account the existence of considerable inequalities of income in most countries and the large proportion of the population living in poverty, estimated to have been more than 195 millions in 1990 of whom 115 millions lived in urban areas (ECLAC, 1993). The tariffs must be reasonable, therefore, in relation to incomes as well as to the costs of installation, operation and maintenance of services.

It is generally accepted that the cost of water and sewerage services should not, for the poorest sections of the population exceed more than a small proportion, 1 or 2 percent, of their incomes. For example, in the OECD countries the cost of water and sewerage services are estimated to be equal to 1 percent of the average household disposable income (OECD, 1987). In Chile, however, subsidies are paid when charges exceed 5 % of family income. It is not easy to establish the incomes of the poor in most Latin American societies where many of the poor receive much of their income in kind and their cash income may be derived from a variety of sources rather than from a single wage paid by one employer.

It is necessary, therefore, to use other indicators to obtain an idea of the possible incidence of the water and sewerage tariff on income. Information is available on the official minimum wages for a number of countries. The official minimum wage in the late 1980's ranged from US$ 50 to US$ 110 for those countries for which information is available, although in most cases additional bonuses are also paid. The minimum wage represents gross income not net income, it does not include the payment of social security contributions or any other deductions. The impact of such deductions is very variable, however, not just between countries, but from employer to employer depending on the nature of the employment contract. It is not possible, therefore, to use other than these gross amounts for comparisons. Additionally, the proportion of the population receiving the minimum wage is very variable. In some countries, such as Uruguay, the typical wage is considerably higher while in others it is lower.

From the estimations of the cost of providing water supply and sewerage services, it is possible

to estimate the proportion of both the monthly minimum income and of the average manufacturing wage that these costs represent (Table 3). It is only in the minimum estimates that the costs of providing both water supply and sewerage through house connections fall generally within the 1-2% range of the minimum wage. In some of the poorer countries, the estimated cost of water supply and sanitation tariffs, even for the minimum cost case, is more than 2% of the average manufacturing wage. The costs of providing water supply and sewerage are the lowest proportion of the minimum wage in Uruguay, 1.75 percent for the minimum cost case and 3.91 percent for the maximum cost case. As a proportion of the average manufacturing wage, the costs are lowest in Venezuela, Chile and Colombia. The costs are the highest proportion of the minimum wage in Ecuador and Colombia.

Two major qualifying comments can be made to the results of the analysis that have been presented here:

- It is not possible to know what the real cost of replacing existing installations might be. The estimated cost for a new connection is probably, however, an overestimate of the real cost of replacing an existing installation... The monthly charge for amortizing this investment could be expected to be lower than the estimated charges used in the analysis.

- The distribution of water consumption is very skewed. The poor tend to consume very much less than the average consumption in any urban system.

Table 3. MONTHLY CHARGES FOR DRINKING WATER SUPPLY AND SEWERAGE AS A PERCENTAGE OF THE MINIMUM WAGE AND OF THE AVERAGE MANUFACTURING WAGE[1]

Country	Average manufacturing wage			Minimum wage		
	Minimum cost	Average cost	Maximum cost	Minimum cost	Average cost	Maximum cost
Argentina	0.67	1.20	1.68	2.17	3.91	5.47
Bolivia	0.63	1.23	1.77	...	...	...
Brazil	...	...	...	1.16	2.33	3.38
Chile	0.39	0.75	1.08	2.07	4.02	5.77
Colombia	0.26	0.51	0.74	1.21	2.34	3.37
Costa Rica	0.57	1.14	1.65	...	...	...
Dominican Republic	0.55	1.11	1.61	...	...	...
Ecuador	0.50	0.97	1.39	2.21	4.26	6.09
El Salvador	0.40	0.78	1.12	...	...	...
Guatemala	0.57	1.11	1.59	...	...	...
Honduras	0.47	0.91	1.31	...	...	...
Mexico	0.44	0.88	1.27	1.09	2.15	3.11
Panama	0.34	0.68	0.98	...	...	...

Peru	1.73	3.01	4.16	1.98	3.44	4.76
Uruguay	0.71	1.23	1.69	1.59	2.73	3.75
Venezuela	0.21	0.44	0.65	1.46	3.08	4.54

Source: Lee and Jouravlev.

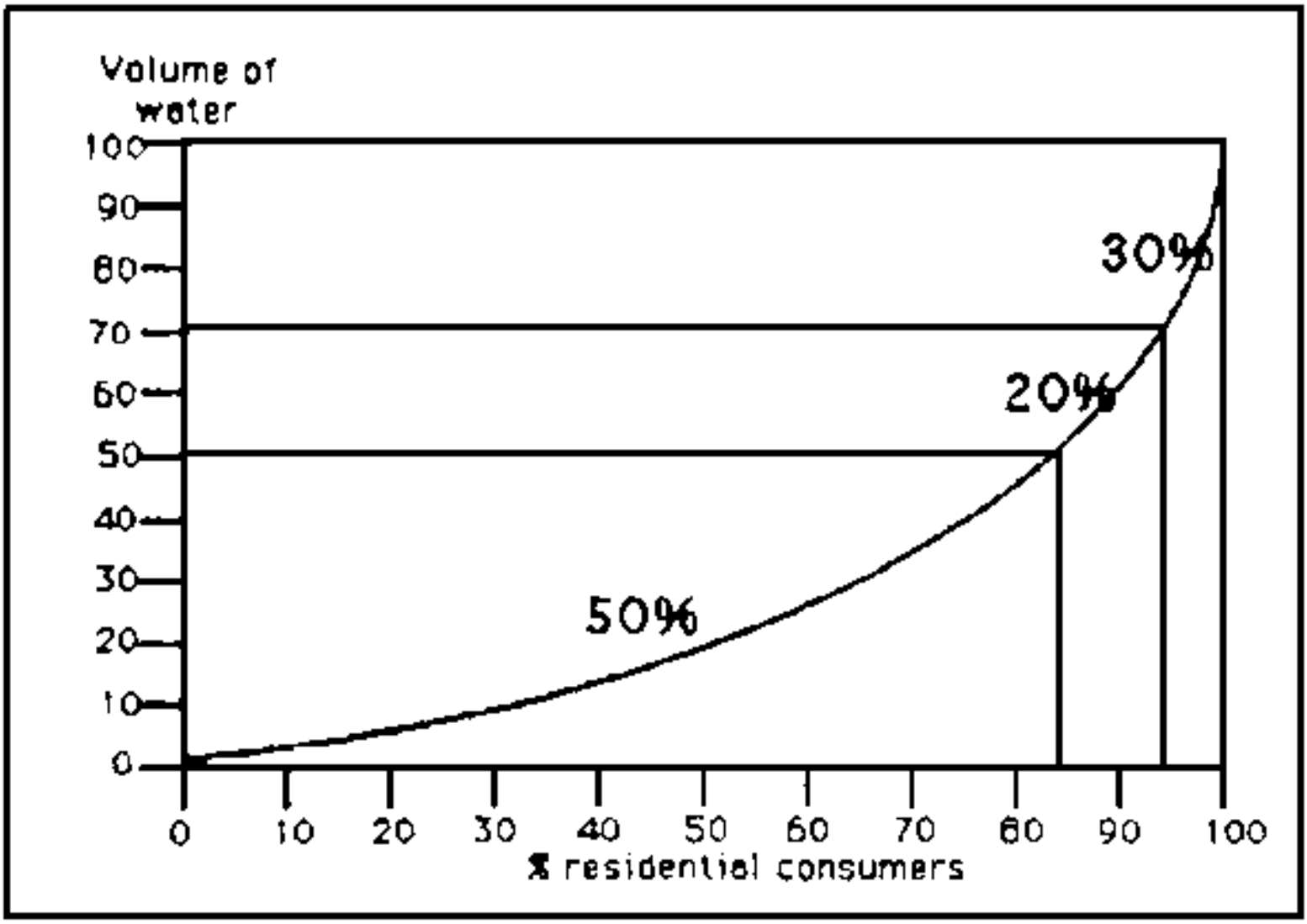
Note: [1] - Includes the capital cost of drinking water supply and sewerage services through house connections, major rehabilitation costs of existing systems, expansion of waste water treatment and the costs of training and institutional modernization.

Poorer households consume less water for a variety of reasons, mainly, however, because in all households the use of water for drinking and cooking is only a small proportion of the total demand (Gibbons, 1986). In a recent study of the demand for water in Mexico, the authors present histograms of water consumption in a number of Mexican cities (Saavedra et al, 1991). The histograms all show similar distributions of water demand with the 30 percent of households with the highest incomes consuming half the total. The concentration of consumption is even greater in some of the cities included in the study, for example in the city of Victoria, Tamaulipas, 2% of residential users consume 40% of the water. This was the most extreme case in the sample, but similar concentrations of water consumption were observed in Juárez, Chihuahua and La Paz, Baja California Sur. In general, in all cities the skew and concentration in the distribution of water consumption was remarkably similar (Figure 1).

Data on the consumption of water for Santiago, Chile also show a relationship between income and consumption, although the information is less precise. The population of metropolitan Santiago has universal access to drinking water through house connections. Within the metropolitan area, however, there are considerable differences in apparent per capita water consumption by municipality. In the municipalities with high income households consumption is between 500 and 600 litres per capita a day. In municipalities where average household incomes are lower the per capita consumption is between 100 and 200 litres (Icaza and Rodriguez, 1988).

The Mexican study and the Santiago data confirm the pattern of residential water consumption found in other earlier studies in quite disparate social and economic situations. The *Johns Hopkins University Residential Water Use Project* showed, for the United States, a clear relationship between the level of household income and the demand for water (Howe and Linaweaver, 1967). The influence of income on the residential demand for water, it was concluded, is expressed through the greater use of water using appliances, more bathrooms per household and for lawn sprinkling. A similar relationship between residential water demand and the level of household income was observed in New Delhi, India (Lee, 1969).

Figure 1. Distribution of Water Consumption in Mexican Cities



Source: Saavedra et al

The consequences for tariff policy of this skewed pattern of residential water demand lie in the possibilities it raises for subsidies to poor households. Moreover, it raises the possibility of applying discriminatory tariffs to increase economic efficiency in the provision water supply and sewerage services; that is, such a policy would raise the social benefits by more than it would decrease private benefits.

An example of the possibilities is provided by the tariff policies applied in Chile. The basis of the policy is that the water supply and sanitation companies should be self-financing and capable of attracting private investors and that all consumers should pay for water. In its present form the policy has only been in force since 1990, but the impact on the finances of the water supply and sanitation utilities has been spectacular. In 1992, the 13 publicly owned companies achieved an overall profit of US$ 10,000,000 after meeting the costs of debt service. In the same year, the companies invested over US$ 150,000,000 (Table 4).

Table 4. WATER SUPPLY AND SANITATION COMPANIES IN CHILE, OPERATIONAL RESULTS, 1991 Y 1992

(Millions of pesos of 1992)

	1991	1992

Company	Income	Operating Profit/Loss	Total Profit/Loss	Income	Operating Profit/Loss	Total Profit/Loss
ESSAT	2,424	(162)	(607)	2,378	(406)	(823)
ESSAN	3,156	(500)	(1,841)	3,570	496	(912)
EMSAT	979	(282)	(439)	1,084	(220)	(368)
ESSCO	1,829	(659)	(712)	2,063	(132)	(335)
ESVAL	6,489	409	212	7,333	1,340	1,378
ESSEL	1,678	17	25	2,197	302	128
ESSAM	2,016	(837)	(856)	2,298	(380)	(727)
ESSBIO	4,642	(514)	(1,116)	5,497	662	31
ESSAR	1,779	19	(165)	2,201	277	96
ESSAL	1,968	(206)	(655)	2,242	(261)	(514)
EMSSA	336	(166)	(305)	391	(222)	(292)
ESMAG	771	(613)	(693)	918	(489)	(562)
EMOS	20,254	4,497	5,091	23,460	7,118	6,545
All	48,231	1,003	(2,061)	55,632	8,085	3,645

Source: CORFO.

The other aspect of the tariff policy is the subsidy of low income households for a consumption of up to 15 m^3 a month. This subsidy of 75% of the charge is paid through the municipalities to water companies for all households where the cost 15 m^3 a month exceeds 5% of household income. The subsidy is to be modified to raise the limit of consumption to 20 m^3 a month and increase the subsidy to a maximum of 80%. In 1992 on average, 346,881 household received subsidies equivalent to 14% of the total number of connections at a cost of slightly more than US$ 6,000,000. It is anticipated that with the new regulations, the number of households receiving subsidies will increase to over 700,000 and the cost to US$ 11,000,000.

SOME POLICY RECOMMENDATIONS

Great efforts have been made, since the adoption in 1961 of the Punte del Este charter, to improve the provision of water supply and sewerage to the urban population of Latin America and the Caribbean. These efforts, however, have consistently fallen short of whatever goals were established (ECLAC, 1990a). One of the major restraints on achievement has been the weak financial situation of publicly owned water supply and sanitation companies. The lack of financial resources has been compounded by generally poor management. The consequences of these two factors have led in many cities to a failure to maintain levels of service in keeping with the growth in population, and even, in some cases, to a decline in the provision of service. Poor management and limited operating incomes have been a considerable restraint even for those systems that have shown the best performance. There is, therefore, ample reason to look for new approaches to the provision of water supply and sanitation in urban areas.

Moving towards self-financing of water supply and sewerage services is a major challenge for the countries of Latin America. The removal of the financial restraint is possible, even in the

poorest countries of the region, through the establishment of tariff systems which would generate sufficient revenues to cover the total cost of providing house connections for both water supply and sewerage to the whole population. The application of such tariff structures would not be easy, however, and would require a considerable change in management attitudes and practices in the water supply and sanitation sector: a change which may not be possible without drastic institutional change.

The need for institutional innovation is the most potent argument for the privatization of water supply and sewerage services, although other types of institutional change may be as effective. Privatization does not have to take the form of the sale of whole systems to private entrepreneurs, although in many cases this may be the preferred alternative (Coing and Montano, 1989). The concession of the partial or total provision of services, as in Chile and Mexico, may be just as potent an innovating force and would equally demand that tariffs cover the whole costs of providing service, including an appropriate return on capital.

What must be achieved, however, is not privatization *per se,* but that the urban water supply and sanitation services of the region become self-financing public utilities whoever owns them. Unless systems are self-financing, no matter what other reforms are made, investment and the provision of service will remain in deficit and the quality of service will remain deficient. The achievement of financial self-sufficiency is the great challenge not only for water supply and sanitation policy in Latin America and the Caribbean during this, the last decade of the Twentieth Century, but for water management policy as a whole. Unless water supply and sanitation companies can achieve financial independence then the water bodies in the vicinity of the cities of Latin America and the Caribbean will undeniably continue to be polluted; a situation which is bound to endanger any effort to improve the quality of the environment in general in the countries of the region.

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Mechanisms for Financing the Development of Public Work Infrastructure

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PURPOSE

The purpose of this paper is to describe with reference to Puerto Rico various economic principles that can be used to determine who should pay for public work services and several

financing mechanisms to implement those principles.

IMPORTANCE OF INVESTING IN INFRASTRUCTURE

An important measure of a nation's well-being is the quality and extent of services provided by its public works. Water supply and sanitation facilities help determine the quality of public health. Highway and transportation facilities influence to a great extent spatial development.

Economic growth and development depend on the advantages a location offers; firms look for areas offering greater opportunities for profit. In this context, public works investments can be considered as production factors such as capital and labor for private firms; but in this case, these production inputs are paid indirectly through taxes or directly through user fees. Thus, public capital can increase a firm's productivity either by complementing private investment, like in the case of transportation, or by directly contributing to production, like in the case of power or water.

Trends in infrastructure capital accumulation and level of spending indicate that public works investment has declined relative to total government spending, to the value of the total annual production of goods and services, and even in respect to private investment. These trends point towards a major gap between demand and supply that is seriously impacting the volume and quality of services being provided.

In order to provide level of service necessary to remove deficits and meet future demand, there must be a commitment to increase capacity of public works. Capacity can increase by improving maintenance of existing stock, more efficient use of existing facilities, implementing low-cost alternative service delivery systems, and finally through more investment. Any strategy towards this goal should include meeting public works financing needs by increasing the share of costs borne by those who benefit.

WHO SHOULD PAY FOR PUBLIC WORKS?

In private markets, the sale of goods and services finances their production. Consumer demand, together with available technology, determines the firm's scale of operation and production levels. Users could finance a greater proportion of many public works facilities in such areas as transportation, water supply, wastewater treatment, electric power, and solid waste systems. Since these facilities serve consumers that can be identified, how much they use can be measured and priced; those who do not pay can be refused services or if in need their use can be subsidized.

Charging beneficiaries directly for the cost of services has advantages. One such advantage is that all beneficiaries can be made to pay their fair share. This allocation of charges can help avoid the overbuilding that may come with the perception that anything “public” is free or should be underpriced.

Financing mechanisms that reflect cost can help solve a major financing problem deriving from the nature of public works facilities. Long-lived facilities with slow deterioration, which is the case of many of these facilities, require large, intermittent building or replacement expenditures. Resources to accomplish these expenditures must be available in a timely manner.

Use of public works facilities, on the other hand, is generally continuous. For example, water is

used daily, trips to work are regular, and goods are shipped on a predictable basis. If financing is linked to use, revenue can become steadier and more predictable, encouraging better maintenance, rehabilitation, and replacement.

The beneficiary finance principle has some limitations. If revenues are not set at a level needed to finance the service or facility, they will not send the correct resource-allocation signals. Also, if there are beneficiaries who cannot afford to cover the full cost of the service, general fund subsidies may be required.

IMPLEMENTING THE BENEFIT PRINCIPLE IN PUBLIC WORKS FINANCE

Earmarked taxes, user fees, and the creation of special districts or authorities are three use-based financing techniques. Each is a different way to relate payments with benefits and to segregate these payments from other public funds, a process facilitated by trust funds. Each technique has certain advantages and limitations as a financing tool.

Earmarked Taxes

Earmarked taxes are used for specific public spending programs or projects. When such taxes, are tied to the benefits provided, the tax functions as a user fee. For example, gasoline taxes and motor vehicle licenses are generally seen as indirect fees for highway use.

Earmarking has many advantages for public works financing. It can be a way to introduce new spending programs or taxes in spite of fiscal austerity. Legislatures are often more likely to approve a new tax if they can see that a clear benefit from it will derive from its application.

Though in Puerto Rico the highway program is relatively large, with total spending far in excess of the earmarked amounts, these funds have a significant effect on the level of spending for that program for they are used to issue debt.

The narrower a designated revenue is, the greater the spending effect on the program involved. For example, earmarking local landfill revenues will have a greater impact on that facility's operation than a statewide tax dedicated to a broad range of environmental improvements.

Earmarking does not always lead to increased spending if the legislature must appropriate earmarked funds. For example, The U.S. Congress has for budget purposes deferred appropriations from earmarked federal infrastructure trust funds. In other places earmarked funds not appropriated for specified projects or programs are placed hi the general fund.

Whether or not they actually increase spending, earmarking provisions can encourage improved program planning and management. A consistent and reliable revenue stream can help assure that funds are available when public works needs arise. This stability can compensate for the prevalence of short-term budgeting at all levels of government. Generally, the political system encourage a focus of short-term needs at the expense of long term planning. Earmarking provides some certainty in financing so that the agencies in charge of delivering the service can take a long term perspective.

However, earmarking also has some limitations. If earmarking provisions are very pervasive, they may result in serious fiscal management problems for the state. Also, earmarked taxes often produce less than the amount of revenue necessary for optimal designated function.

Therefore, in some cases earmarking may not have a clear advantage over the ordinary appropriations as a public works support tool. When earmarking does not limit budgeting decisions, it is relative ineffective for it results in substituting dedicated funds for other funds that would have been expanded at any event.

Puerto Rico does not use extensively earmarked taxes for financing public works facilities or services. Some public corporations, however, received considerable amount of resources appropriated from the general fund. One of the largest earmarked tax is on gasoline. These funds go to the P.R. Highway Authority.

Availability of these funds has allowed the Highway Authority to undertake a vigorous and extensive highway construction program, subsidizing part of the P.R. Department of Transportation and Public Works program as well as part of San Juan's mass transit system. The P.R. Highway Authority is also planning construction for the late part of this decade of a light rail train for the San Juan Metropolitan Area.

User Fees

User fees are payments by households, firms, or other consumers to a governmental body or other public works provider for services. Public works user fees generally do not cover the full costs of providing services.

The way and level a user fee is established affects decisions about the use and expansion of capacity. A poorly designed user fee may provide a constant flow of revenue, but will not encourage the efficient use of available public works services. Services prices that are set to cover the cost of providing services can be used to allocate costs fairly and efficiently among different users and classes of users.

Two mechanisms are common in setting user fees. Average-cost pricing sets fees by taking the estimated budget of the facility and/or total service, less expected subsidies, and dividing by units of output or by users. A second method adjusts for operating deficits through rate increases, other internal revenue sources, or subsidies. Two rarely used methods which can result in efficient use and expansion decisions are pricing based on the marginal cost of providing an additional unit of service and pricing based on the cost of providing services during peak load periods.

Most of the public work corporations in Puerto Rico based their pricing or rates structure on the average cost method. The rates are set to cover most of the operating and maintenance costs and to generate funds for capital improvements. However, the rates have to be revised periodically because they do not adjust automatically for all cost increases, particularly wage increases resulting from collective bargaining with the labor unions. Rate revision for public services is one of the most difficult political decision on the island. Some corporations run operational deficits year after year before being allowed to revise their rates. In some cases financing corporations have been established to channelize funds from other sources to trouble public corporations. Efforts at maximizing operating agency income by timely collection of debts, elimination of illegal or unrecorded corrections, accurate consumption metering, cost control and productivity increase have not had much success.

In several public services areas expanded user fees could help manage facilities use and make

certain facilities self-supporting. Airport user fees could help manage traffic and expand the capacity use of existing facilities to include those of competing airports. Some airports use higher peak-hour fees to curb general aviation use of busy airports or have then going to other airports.

Full cost pricing of water supply and wastewater treatment facilities could pay for a larger proportion of these services. To encourage full-cost pricing, the U.S. Environmental Protection Agency's loans from the revolving fund created under the 1987 amendments to the Clean Water Act in the U.S. could require that sewer rates cover operating expenses, debt retirement, and a capital reserve fund for future rehabilitation of facilities.

User fees can provide useful signals about capacity needs. When the U.S. Army Corps of Engineers implemented cost-sharing in 1986, several projects were redesigned at lower initial costs.

In some cases, users should probably be charged less than the full cost of services. For example, mass transit benefits both users and motorists who use less congested roads. To account for this it would be appropriate to supplement user fees with a general tax source, such as a regional sales tax or an earmarked gasoline tax so that indirect beneficiaries and direct users can help pay the costs. The share of revenue provided from general taxes should reflect the share of benefits accruing to indirect beneficiaries.

Financing public works to recover full costs through user fees also has potential disadvantages and socially undesirable outcomes. The poor and those living in hard-to-serve areas might find public works services unaffordable if the services are priced at full cost. Society has an interest in making sure that the environment is protected and that water and sanitation facilities are universally available, even if a particular facility cannot be supported solely by its users. Selective general-funds subsidies can help make services affordable when necessary. For example, in Puerto Rico expansion of water supply in rural areas is subsidized from the general fund, and until 1992 poor families consuming less than 400 Kv. per hour per month were also subsidized from the general fund.

A special application of the user-fee concept has emerged in public works financing in growing areas. Local requirements governing new development have long included the provision of on site infrastructure such as a power, telephone, sewer, and water connections. In the last decade, many localities have also begun to require developers to finance offsite infrastructure expansion or construction. Such requirements are implemented through development fees and exactions. Development fees are established or negotiated charges imposed on developers to finance infrastructure, while exactions are facilities built by developers and dedicated to the city or public corporation providing service.

Development fees and exactions are controversial public finance tools. Those opposing their use argue that providing community-wide infrastructure is a local government responsibility for which everyone should pay, and that newcomers to an area should not bear the major cost of correcting problems created before their arrival. They also claim that these fees increase housing costs considerably.

On the other hand, those calling for their implementation argue that these fees are needed to avoid an inequitable distribution of the infrastructure burden created by new development. New development, they argue, generally leads to higher taxes and utility bills when needed

infrastructure is financed from traditional revenue sources, even though new homeowners pay taxes and utility bills just like everyone else.

While these fees raise difficult administrative, legal, political, and technical problems, their size suggests that they are on the local-finance scene to stay. The P.R. Aqueducts and Sewers Authority has been implementing, though in a limited scale, some of these financing mechanisms, while at the P.R. Electric Power Authority they have been establishing practices for servicing industrial parks and other private facilities.

Despite their size, these fees, however, are not a solution for localities struggling to pay for public works for generally they do not cover most of the costs of providing public works for new development.

Special Districts and Authorities

Special districts are limited-purpose governmental units with the power to levy taxes, user charges, and other fees. Public authorities perform similar functions but are not considered units of government for the purposes of debt liability or state constitutional restrictions. Both offer a way to shift infrastructure financing away from all taxpayers to those directly served.

Special districts for public works allow localities to finance public facilities that they might not be able to finance through general-purpose governments.

Special districts also offer a way for governments to cooperate in dealing with public works issues that affect more than one government. Special districts that transcend jurisdictional boundaries can help ensure that a facility is constructed and operated on an optimal scale.

Some special districts are better able than general-purpose governments to maintain existing facilities in good repair, but this advantage is not universal. The maintenance and rehabilitation record of districts and authorities ranges from excellent to poor, as it does for cities and other governments. In cities with budget problems and deferred public works maintenance, facilities operated by districts and authorities also suffer from disinvestment. This suggests that an area's economic vitality has at least as much effect on its public works' condition as the area's governmental structures.

Districts and authorities that have not deferred maintenance are those with strong and independent sources of income that are protected from cuts In times of tight budgets. Profitable facilities tend to be better maintained than those that produce deficits, such as mass transit systems. Earmarked taxes associated with bond issues can protect operating budgets, while dependence on operating subsidies from general purpose governments makes them move vulnerable.

In summary, special districts and authorities for public works provision can offer ways to transcend the fiscal, bureaucratic and geographic limitations of general-purpose governments. Since their revenue streams are segregated from competing priorities, districts theoretically could make better scale, pricing, and maintenance decisions.

In practice, however, the fact that most districts are not self-supporting means that they are not insulated from the funding problems of general-purpose governments. Inadequate techniques for setting prices and political limitations on the scale of operations further limit the advantages of

districts and authorities. Inadequate accountability and coordination with general-purpose governments can also limit the effectiveness of special districts. Where these districts are used, care should be taken to assure that they are accountable to voters or to the general-purpose governments that create the districts.

Puerto Rico began to develop its infrastructure in a centralized way since the early 1940's. To accomplish it, public authority or corporations were created. The first public corporations were part of political and social movements which main purpose was to eliminate the extreme poverty characteristic of most of the island at that time.

The public corporations were to develop their own resources, hired the best managerial and technical people, be separated from the political decision making and flexible and innovative in their organization.

The experience with the first corporations was very good. Therefore, new corporations were established to take on other public services and even some poorly managed private services.

In fiscal year 1992 half of the government's budget, which amounted to about $6,500 million, was with the public corporations which employ over 60,000 persons. The 1993 operational budget only for those public corporations responsible for public works facilities was almost $2,500 million, while their budget for capital improvements amounted to another $1,400 million. The value of their physical assets was estimated at almost $10,000 million and they are employing approximately 30,500 persons.

Each public corporation has a board of directors named by the Governor. In the case of the P.R. Aqueducts and Sewers Authority and P.R. Electric Power Authority, two of the Board members are elected by their respective customers. These boards meet periodically. They name in coordination with the Governor the executive director, establish and monitor the corporation's vision, goals, and objectives, its annual budget and capital investment program. The direction and control of the corporation is the responsibility of the executive director.

The coordination and integration of the programs and projects of each corporation is accomplished by the Puerto Rico Planning Board, the Office of Management and Budget, and the Government Development Bank, which is the fiscal agent for the corporations.

The Planning Board is responsible for preparing and recommending to the Governor a Plan of Integral Development and the Four Years Investment Program. This latter documents consists of:

- Delineation of socioeconomic goals and objectives to pursue for the four year period and activities to be undertaken by the various corporations to accomplish those goals and objectives.

- Delineation of urban and rural development patterns and goals and objectives for protecting and enhancing the environment.

- Estimates of resources for the program and potential sources of funding.

The central government annual operating budget and capital improvement program prepared by the Office of Management and Budget must be in consonance with the plan of Integral Development and the Four Years Investment Program of the Planning Board.

Privatization

In recent years, many governments have involved private firms in the financing, design, construction, and operation of public facilities and services. These arrangements bring tax benefits to the private firms and cost reductions to the governments.

Arrangements with the private sector sometimes offer potential advantages.

- Maintenance. State and local government fiscal pressures have contributed to undermaintenance. Private firms have an incentive to maintain facilities, since maintenance costs are operating expenses that are tax-deductible.

- Setting priorities. Governments must weigh public works against other spending priorities. As a result, capital improvements and maintenance are often postponed in favor of operating expenses. Private firms, in contrast, have fewer competing responsibilities. This should encourage more efficient construction, maintenance, and operating decisions.

- Performance sanctions. Private firms can lose contracts or profitability for inadequate performance. Equivalent sanctions general do not exist for public agencies.

During the last few years practically every public corporation in Puerto Rico has taken initiatives towards privatizing some of their services. The P.R. Highway Authority established a precedent for being the first entity under the U.S. jurisdiction to have a private firm design, build, and operate a $100 million plus toll highway project. The project connects the airport with the central business district. The P.R. Ports Authority privatized the operation and maintenance of several pier facilities in the San Juan Harbor. The P.R. Aqueducts and Sewers Authority is entering into agreements with some private firms to operate and manage some of its regional wastewater treatment plants. The P.R. Electric Power Authority is also considering various proposals from private firms for energy regeneration projects based on gas and coal. The previous administration engaged for about two years in talks with international companies to sell its Telephone Company in order to establish two permanent funds, one for education and another for infrastructure development. Unfortunately, no agreement was reached except for the sale of a subsidiary that manages long distance calls.

CONCLUSIONS AND POLICY OPTIONS

Infrastructure finance policy debates revolve around three questions:

- How much should we spend?
- Who should pay?
- How should spending be financed?

The answers to these questions are interdependent. How much to spend depends on who will pay and how the charges will be collected. The financing method chosen, in turn, will determine whether the revenues are adequate and reliable.

Public works services should be priced so that direct users, indirect beneficiaries, and producers of wastes pay the costs of services. If prices reflect costs, the public's use of a facility and its willingness to pay for cervices will indicate the appropriate scale and distribution of public works.

Using such an approach will be easier with better information about the relationship between use patterns and charges. More sophisticated pricing techniques can then be developed. Nevertheless, general-fund subsidies will still be necessary to promote society's interest in the quality of services and to retain fair and affordable distribution of services.

The various dedicated financing techniques mentioned above can improve public works management. Public works lend themselves particularly well to dedicated financing techniques because of their long lives, need for continued maintenance, and the unevenness of their replacement and rehabilitation expenditures. In addition, a clear benefit-cost connection often promotes easier acceptance of new spending programs by voters and legislatures. Making this connection clear could become particularly important for financing new needs such as solid waste disposal.

However, these techniques are not foolproof. At all levels, the political process responds to changing public priorities regardless of institutional rigidities and constraints. Legislatures can fail to appropriate already collected trust-fund balances; earmarked revenues can be offset by reduced general-fund spending' and special districts or authorities can fail to carry out their mission because of their financial dependence on general-purpose governments.

Designing Appropriate Financial Arrangements to Ensure the Proper Operation and Maintenance of Water Supply Facilities

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1. Introduction

The operation and maintenance of water supply facilities may be considered as the cornerstone of the planning, design and implementation of water resources infrastructure. However, while the developed countries have addressed their goals to an appropriate operation and maintenance of such systems, the developing countries have concentrated their efforts on the building of water resources systems programs.

In the case of developed nations, the operation and maintenance of water resources systems is successful because it is conceived in a global way. Operating rules are defined at the planning stage and are “tuned up” when infrastructure is designed and again when it is built. The same situation occurs with maintenance, which represents a key factor in achieving efficient operation of a water supply system.

The situation in the developing countries not only has generated a discontinuity in the water resource planning and management process, but also has provoked high social and economic cost. The break in these processes, and the complications that arise inherently, at times prove to be more expensive than the original problem.

Latin America, namely Perú, has not been the exception to the lack of those aforementioned programs. Issues like the financial difficulties, the lack of integrated responsibilities of the various sectors, institutional problems either in the government sector or in the water users sector have

contributed to worsening the crisis.

The amazing reduction of life expectancy for hydraulic structures such as reservoirs, hydroelectric plants, drainage and irrigation systems, and urban water supply systems, define the necessity for a new approach in operation and maintenance practices. Financial alternatives to the planning process which would allow Latin America to fulfill the requirements of an operation and maintenance program should be analyzed, evaluated, and implemented.

2. Description of the Problem

2.1 Investment in Hydraulic Infrastructure

In general, along the Latin American Region, operational and maintenance planning is almost non-existent. The belief is that a job is practically finished when the infrastructure is completed and operation and maintenance (O&M) is approached as a secondary duty.

The trend in the last 25 years has been to have an active government's participation in the planning and management of water resources systems. It is quite common to find considerable political support for building infrastructure rather than for O&M. Also, the utilities companies have not been prepared to afford an adequate operation and maintenance of water supply facilities. Thus, in most of the cases O&M decisions have followed political initiatives, paying little attention to technical decisions.

For instance, in the case of Perú, Table 1 shows the percentage of hydraulic infrastructure investment in irrigation projects from 1975 to 1986. The highest percentages of investment were made from 1975 to 1981, which coincides with the 1969-1980 military government. The lowest investment percentage was 42% in 1985, which corresponds to the ending of a civil presidential period.

Table 1: Percentage of Hydraulic Infrastructure Investment in Irrigation Projects. Government of Perú (1975-1986)

Year	% of Total Investment
1975	93.85
1976	88.51
1977	91.51
1978	85.63
1979	85.30
1980	77.52
1981	81.64
1982	68.87
1983	66.05
1984	57.79
1985	41.70
1986	56.31

Source: Instituto Nacional de Desarrollo, INADE (Perú)

Table 2 shows the invested amount - through 1992 - by projects. The total cost of the main projects is an estimated $9.5 billion dollars, in which $2.6 billion have already been invested (approximately 27% of the total). Of the nine water resources projects considered, six of them are located in the north coast. The ones that are closer to completion are Chira-Piura and Jequetepeque in the north, and Majes in the south.

Table 2: Investments in the Main Water Resources Projects for the Government of Perú.

Project	Location	Total Cost $10E6	Invested 12/92 $10E6	Current Situation
1. Puyango-Tumbes	North Coast	254.25	13.32	Design
2. Chira-Piura	North Coast	888.60	660.14	Operation
3. Olmos-Tinajones	North Coast	2202.17	227.17	Operation
4. Jequetepeque	North Coast	484.80	226.42	Operation
5. Chavimochic	North Coast	2134.15	541.50	Operation
6. Chinecas	North Coast	308.81	15.48	Design
7. Majes	South Coast	2396.27	809.72	Operation
8. Pasto Grande	South Coast	285.54	55.12	Operation
9. Tacna	South Coast	554.50	38.84	Operation
	Total	**9504.13**	**2587.66**	

Source: INADE (Perú)

2.2 Financial Arrangements in Operation and Maintenance of Water Supply facilities

2.2.1 Water Price

The price of water represents a way of how the operation, maintenance and amortization of the infrastructure may be financed. Developed countries consider this approach in the planning stage and implement it in the operational stage of a such a project. Hence, institutional arrangements and cost sharing are carried out so that a successful operation and maintenance is assured through the application of a fair water tariff.

Developing countries lie the responsibility of the O&M activities in the government sector, which at the present in most of the Latin American countries face tremendous institutional and economic problems. In addition, the lack of effective institutional arrangement and cost sharing makes the achievement of operational and maintenance targets more difficult, hence, water tariffs usually do not represent the real O&M costs.

Most utilities and water companies in the region have tariffs for water and energy that are far below the real break even prices. This lack of funding causes side effects, producing an extremely inefficient service that users sometimes refuse to pay for.

In the case of Perú, according to Water Law 17752 issued in 1969, article No. 12 states: “The water users of each Irrigation District will pay the water tariff, which will be calculated for each use based on a volumetric unit. Those tariffs will be used to cover operation and maintenance

expenses and also to finance studies and construction of new hydraulic infrastructure needed for regional development".

In addition the Water Law establishes the water tariff will be divided into three components:

a. Water users association
b. Water canon
c. Amortization component

The users association component is used to finance the administrative activities of this organization. The water canon component is used by the government as a payment for the use of the water. The amortization component is used to recover the investment in infrastructure.

As seen here, the water law considers that the water tariff should pay for operation and maintenance costs and the amortization of the infrastructure. However, the real situation is quite different and some of these reasons are listed below:

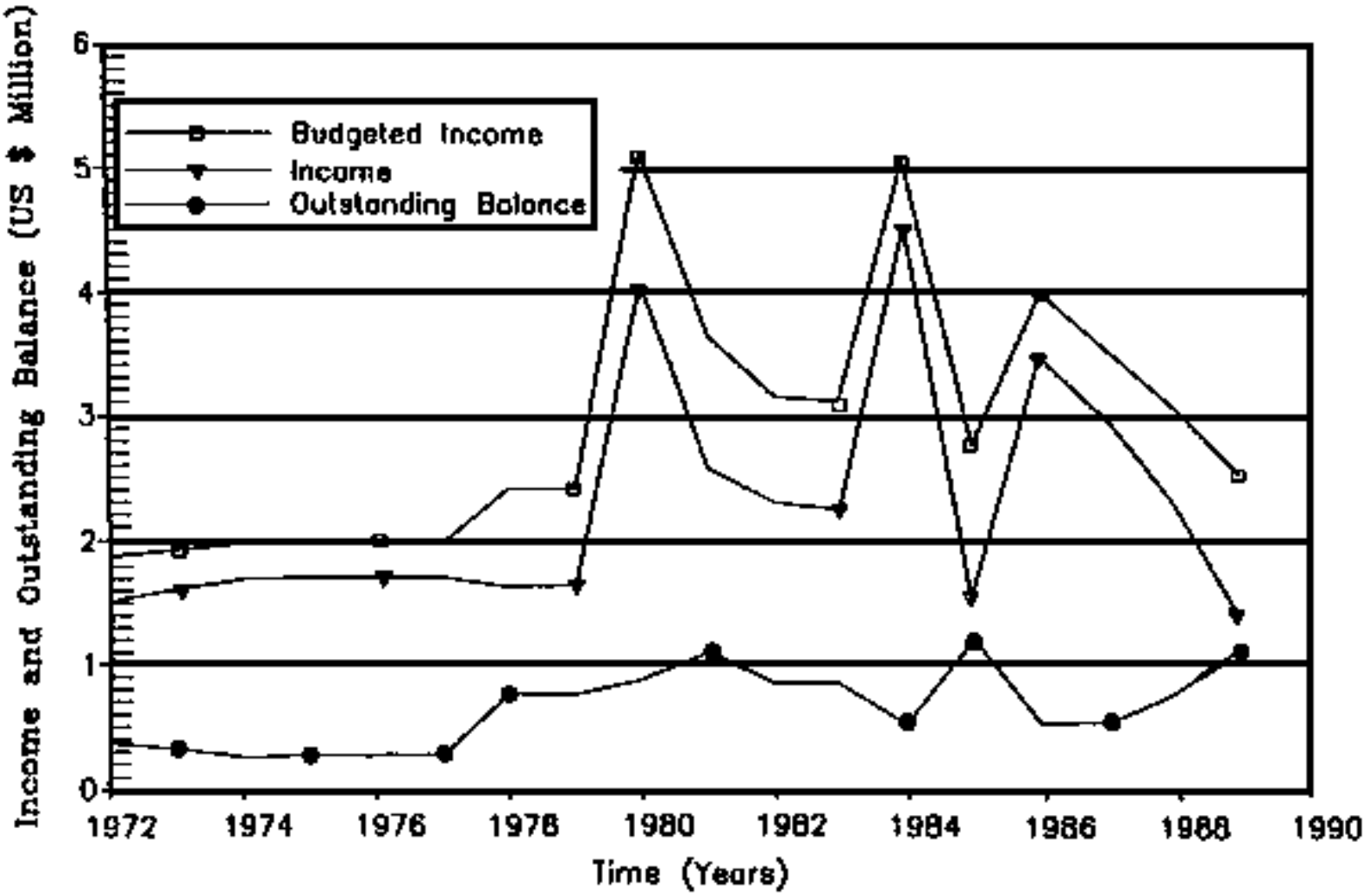
a. The water tariff never has represented the real value of the operation, maintenance and amortization costs of a water resource system.

b. The main water resources projects are considered as being allocated for irrigation purpose. Hence, the paternalism of the government supporting financially the activities in the agricultural sector and the economic crisis of the last 25 years has affected the efficiency of O&M activities.

c. The water user associations have not represented an efficient mean to make the payment of the water tariff effective. This lack of effectiveness is seen in the recovered amounts which have consistently been considerably below the estimated ones and time delayed.

d. The water tariff has always been considerably less than its marginal price. This situation generates low water use efficiencies; the water users are willing to use more water than they really need, causing for instance further problems like drainage problems in the lower basin levels. Table 3 shows some water tariffs in some peruvian valleys, and Figure 1 presents the variation of the recovered amounts from 1972 to 1989.

Figure 1: Income due to Water Tariffs.



Source: INADE (Perú)

Table 3: Water Tariffs in Peru (1991)

Project	Estimated Tariff $/m³	Payment Made $/m³
1. Chira-Piura	0.025	0.001
2. Tinajones	0.018	0.001
3. Jequetepeque	0.0034	0.001
4. Majes	0.003	0.001

Source: INADE (Perú)

2.2.2 Institutional Arrangements

The institutional arrangements are essential to assure the proper operation of a water resource system. These arrangements may come from establishing the right framework for operating and recovering costs to agree how the cost sharing has to be done.

In the case of developing countries, an important step in the planning and management process is usually skipped; this step is the commitment of water users and government to fairly share the financial responsibilities for having an adequate O&M of water supply facilities.

The priorities for the O&M of infrastructure follows more political reasons than technical ones. In developed countries, priorities are set up by the community with less intervention of the political system. Thus, issues like lack of appropriately trained personnel and communication equipment is evident in emergency conditions. Lack of adequate data hampers the decision making process in critical operational conditions, and if the data exists, it is usually not analyzed due to the absence of adequate personnel and equipment.

2.2.3 Cost Sharing

Cost sharing is the step through which operation, maintenance and amortization costs are financially planned. The institutions involved in the use of the water commit to afford the operation of the water system through the collection of the revenues.

In the case of most of Latin-American countries the cost sharing process is still a non-fully implemented one. Political intervention of the government and a lack of a defined responsibility from the water user associations delay the cost recovering process, postponing in several cases the application of proper O&M standards.

3. Proposal of a New Approach

This proposal intends to conjugate economic efficiency criteria and the rationale of the water resource, considering it as a public good susceptible to demand and the supply. Thus, this approach basically considers:

a. Implementation of the multipurpose feature of water in the hydraulic projects. This will allow to widen the spectrum of accrued benefits, and will give those projects a greater feasibility in the covering of their O&M costs.

b. Real cost sharing among the different water users

c. Tune up of the water law in accordance with economic efficiency criteria, giving more participation to the private sector into the water systems management.

d. Special treatment of the revenues by amortization. It will serve as an effective mean to implement further project stages and may give some financial flexibility to the government.

e. To avoid the decrease of the expected life of the infrastructure, water tariffs have to be paid according to their real value.

f. Allocate funds for preventive maintenance as it should eliminate a big portion of the corrective maintenance.

g. Improvement of communication mechanisms. This will allow, for the water users, governmental institutions, and private entities within the country, to have a better understanding of the importance of O&M activities and their financial needs. Among countries, it will allow the transfer of proper technology and experiences on O&M issues.

4. Conclusions and Recommendations

Because developing countries have invested huge amounts of money, which in some cases

represent an important percentage of their external debt, it is urgent to address financial sources to improve O&M of the existent water supply facilities.

The lack of institutional arrangements has caused the absence of a commitment between the users and the government to share the financial responsibility of O&M. This situation has created a discontinuity in the planning and management process and increased in most of the cases the O&M costs.

The water tariff is a mechanism that must be effective in order to obtain the revenues as they are calculated to cover O&M.

Communication between national institutions and also among countries should be improved to keep all kind of information updated in regard to O&M issues.

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Environmental Issues and Restrictions from the Perspective of the Borrowing Countries

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Introduction

When invited to participate in this Interamerican Dialogue on Water Management and to present a paper on “Environmental Issues and Environmentally related restrictions from the perspective of the borrowing countries” my first reaction was to limit myself to these topics, but then, our experience in Venezuela was different. We were not obtaining funds, not because of

environmental restrictions, but from macro-economical policies that the World Bank wanted implemented in the Country. These were and are the restrictions that have not permitted the water and sanitation sector of Venezuela to obtain funds for it's improvement.

It is my conviction that if we cannot separate one sector from the others, funds will not be available for some time, as social and political policies are harder to implement and must be tried out in each case, as each country reacts different to these policies.

Discussion

In the World Development Report 1992 done by the World Bank, chapter 5 starts with the following lines: “For many people in the developing countries the most important of the environmental problems are those related with water supply, sanitation and the disposal of solid wastes. If all the population had adequate water and sanitation services, more than two million deaths caused by diarrheic maladies could be avoided” (1). What this means is that for us, environment is probably something different than for developed countries, where this problems have been overcome.

That is why, when seeking foreign aid for our development, environmental considerations are always on our minds, one way or the other, because for us it is not just a matter of building something (a road, a dam), but the welfare that our population will derive from these projects (decent standard of living, some quantity and quality of water, etc.).Therefore, we could say that “environment” is a critical health problem for developing countries and not just a matter of improving the environment per se (cleaner air, preserving biodiversity, etc).

In trying to solve these issues our governments have sought foreign aid, specially from the World Bank or the Interamerican Development Bank, where better loaning conditions are to be had as the purpose of these banks was, and is, to provide funds for development (The World Bank really began as the International Bank for Reconstruction and Development). However these funds have always had some conditioning factors to guarantee the Bank that the money is put to good use. Some of them, unfortunately, are more on the political issues than on the environmental ones, thus giving the sector a secondary and conditioned position. This, at least has been the case of Venezuela.

VENEZUELA: an Attempt to Obtain Funds for the Water and Environment Sectors

When we began in 1989 to seek funds to reform and better our water supply and sanitation services, long deteriorated due to poor administration practice in the main agency that was in charge of these services, we naturally came to the World Bank, as the most probable source of funds for the rehabilitation of the sector. However, loaning conditions for the sector were set within the overall “ Bank's objective to help the government overcome it's present economic and financial crisis”(2). Therefore, unless the government complied with the economic recommendations that were suggested, the water and environment sector would not receive the necessary funds. There were, of course, some conditions within the sector i.e. elimination of the National Agency (INOS), creation of regional operating companies to handle water supply and sewage systems, raise in tariffs, etc.

To make a long story short, these sector conditions have been met almost to the last point (even tariffs have been raised, although not yet to the level of self-sustainability). This has not

happened in the macro-economical arena, where some of the measures recommended have caused rioting in our country. Specially in 1989 we had a serious one - gas prices were raised - and riots lasted three days with heavy losses in lives and assets. The government went back to new discussions with the Bank on overall strategies to implement the agreed policies. This has been going on since. To this day the water and environment sector has not been able to receive funds for their projects, although we have submitted for approval several proposals for environmental cleanup and rehabilitation of the water supply systems. IDB has been more responsive, and we have a couple of projects going on with their help.

Because of all these delays a move was made in the direction of bilateral financing, where, with some son of backup from the World Bank, funds could be had (at higher rates and restricted conditions). But, as a result, we now have several ongoing projects with financing from the U.S., Canada, England and Germany. This is helping us solve our most urgent problems.

In dealing with the Bank, one of the first things that should be mentioned is that we were always dealing with new people (new sectors, new chiefs of divisions, new delegations) and, of course, this meant renewed explanations and presentations of the same projects over and over again. Changes were made in the proposals, according to new points of view from the representative in turn, and lot's of time was lost this way.

We know that in some other countries in the region, like Peru and Bolivia, loans have been made and projects are on their way and it could be very helpful for all of us to hear about their experience in this dialogue conference.

My feeling is that environmental restrictions for loans from the international financing banks are commendable, as protection of the environment is a present and future necessity. But we must bear in mind that development and environment are linked by that new word “sustainable”, and that to carry this through, great investments are needed as the technology is foreign and expensive, and that our countries are in a poor financial condition to implement them. In fact in the document “Our Own Agenda” (3) it is stated that developed nations should be part of this “investing” as our common future needs it. The brake of commercial barriers and easier communications has made the World shrink and as economies are more and more heavily tied, problems belong more to humanity than to a determined sector or country.

That is why I think that the Bank or any lending institution has to revise it's borrowing conditions where environmental projects are concerned. All of us, as a sector that deals with human survival, should not be subject to certain economic conditions, however important they might be, but our projects should be analyzed on the context of what will happen if the loan is not given.(we could mention the bout with Cholera over a year ago, where cases were reported very far from the original point of detection).

Again our suggestion is that dealings with the water and environmental sectors should go apart from other political or economical considerations. In this way we could improve our quality of life, our health and as a result we could pursue our sustainable development faster (only healthy people can work and produce properly)

One final consideration should be given to the debt problem from Latin America, now at a figure around $ 459 billion. The service of this debt is enormous and ways must be sought to solve it so we can pay and develop at the same time. Borrowing countries should be aware that this isn't

helping anybody in the long run, and that their cooperation in solving this problem is essential.

Recommendations

More than “recommending” we might suggest that future loans for our sector should be worked out on the following premises:

A) The water and environmental projects should not be restricted by other considerations (economical, political) but by their own feasible limitations, as they form part of an effort for human welfare and survival.

B) Officials from the Banks should be maintained on their posts, long enough in a project to push it through. Perhaps the creation of a permanent delegate for the sector within the borrowing country would help pave the way.

C) Though not mentioned in this discussion, possibilities should be open for companies within the borrowing countries to tender in these projects. This would have a multiplying effect within the country as more money would circulate, benefiting indirectly part of the work force.

I would like to end by thanking the organizers for this opportunity and commend their efforts for making possible this dialogue and future ones.

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2. Letter to the Ministry from the World Bank, Nov 1989.

3. PNUD y BID. Comisión de Desarrollo y Medio Ambiente de America Latina y el Caribe. Nuestra Propia Agenda, 1990.

Regional Plan for Investment in the Environment and Health

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Editor's Note: At the time of publication of these proceedings, the english version of the presentation was not available. A report titled “Regional Plan for Investment in the Environment and Health - Background, Strategies, Fund of Preinvestment” is available upon request by writing to the author.

ABSTRACT

The economic stagnation that took place in Latin America and the Caribbean Region during the 1980's decreased public and private investment dramatically generating striking deficiencies in drinking water supply, sanitation, and in the replacement and maintenance of equipment and physical infrastructure. These deficiencies are evidenced by the violent outbreak of epidemics, such as cholera, as well as the high incidence of diarrheal disease in the Region, a major contributor to the approximately 130,000 deaths that occur annually among children under 5 years of age.

In order to cope with this situation there is a need for a strategy which includes short and long term interventions. With this objective, and as a response to the mandate given by the I Ibero-American Summit of Presidents and Heads of State, PAHO structured the document "Regional Plan for Investment in the Environment and Health". This plan identifies investments required in the Region to overcome the aforementioned deficit, and proposes some strategies for its implementation at the country and at the regional level. It also proposes the terms of reference to establish a Multilateral Fund for the development of pre-investment activities necessary for the implementation of the Regional Plan and suggests investing approximately US$ 216,000 million over a 12-year period. Seventy percent of these funds will be financed using national resources and 30% from external sources.

The Plan should be understood as a strategy, a frame of reference, and a process.

- As a strategy, it is intended to contribute to the achievement of indispensable reforms in the systems and services intended to ensure the protection and control of the environment and provide direct health care services for the population.

- As a frame of reference, it suggests priority areas for investment; proposes the need to define criteria of quality, productivity and efficiency; and presents alternatives for action that will be more effective than in the past. The countries - in accordance with their individual realities, potentialities, and limitations - will utilize this frame of reference to formulate their own national Plans of Investment and develop specific projects.

- As a process, it will operate basically at the country level. This is an initial step, and is intended to spur, promote, and facilitate future action.

An Investigation of the Barriers to Private Sector Participation in Water Resources and Sewerage Services in Latin America

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Editor's Note: At the time of publication of these proceedings, the english version of the presentation was not available. Further information on this presentation and topic may be available directly from the authors.

ABSTRACT

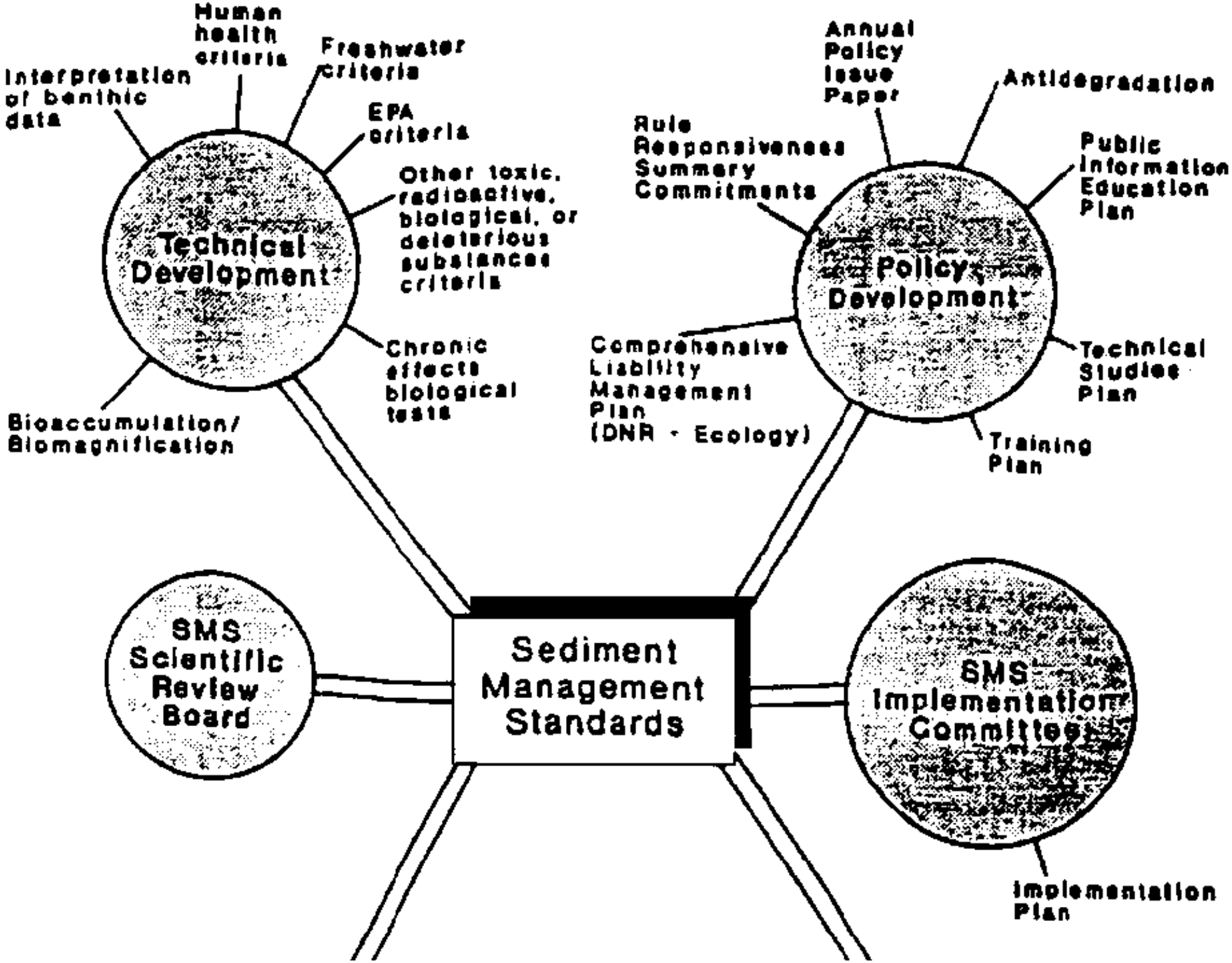
On behalf of the Infrastructure and Urban Development Department of the World Bank, Apogee Research, Inc. is undertaking a study of regulatory barriers to private sector involvement in water and sewerage services that exist in Latin America, with the explicit recognition that lowering such barriers is one small, but important, step in improving the efficiency of water sewerage service provision.

Regulation in the U.S.A., U.K., and France, while different in each country, shares some basic tenets. The institutional histories in many Latin American countries render some of these tenets

irrelevant and unimportant to successful privatization efforts - in short - the rules for successful ventures are different. This study attempts to pinpoint the critical issues from the private provider's point of view as well as a potential or actual concessionaire, in order to learn from the success or failure of previous efforts in the region.

Privatization of water and sanitation in Latin America has concentrated on long-term concessions of water supply systems, the recent privatization of the Buenos Aires water supply system and the Mexico City awards being the largest to date. The study looks closely at these two privatization efforts and compares them to each other, and to a failed attempt in Caracas.

Government representatives from host countries also will be interviewed, to compare their perception of the critical elements for successful privatization efforts to those articulated by private providers.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Freshwater criteria
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EPA criteria
Other toxic, radioactive, biological, or deleterious substances criteria
Technical Development
Chronic effects biological tests
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Antidegradation
Rule Responsiveness Summary Commitments
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Policy Development
Comprehensive Liability Management Plan (DNR - Ecology)
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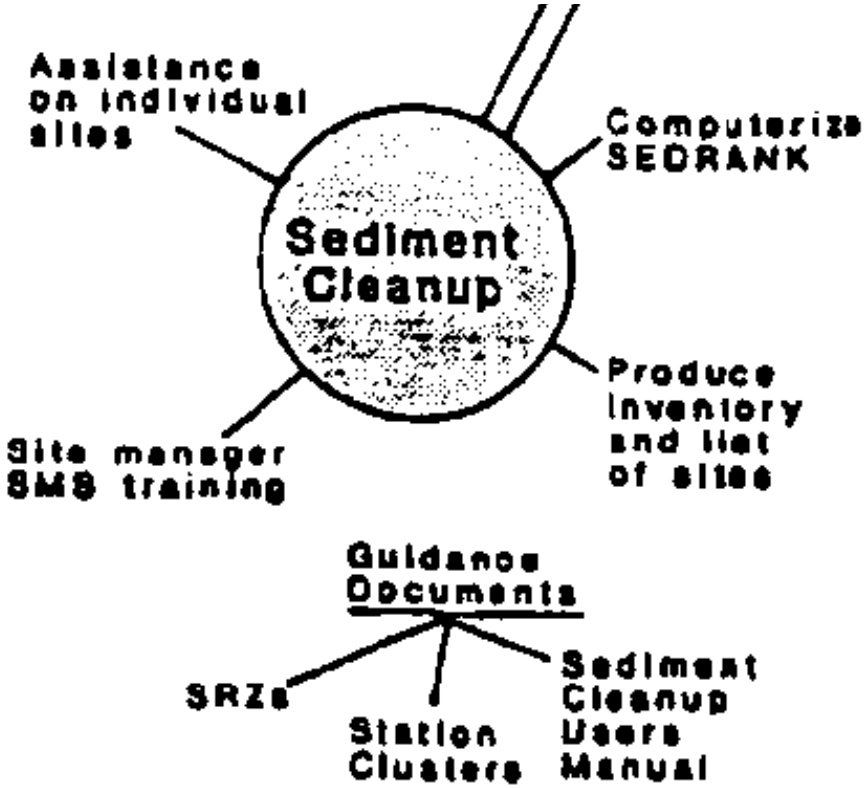
Training Plan
SMS Scientific Review Board
Sediment Management Standards
SMS Implementation Committee
Implementation Plan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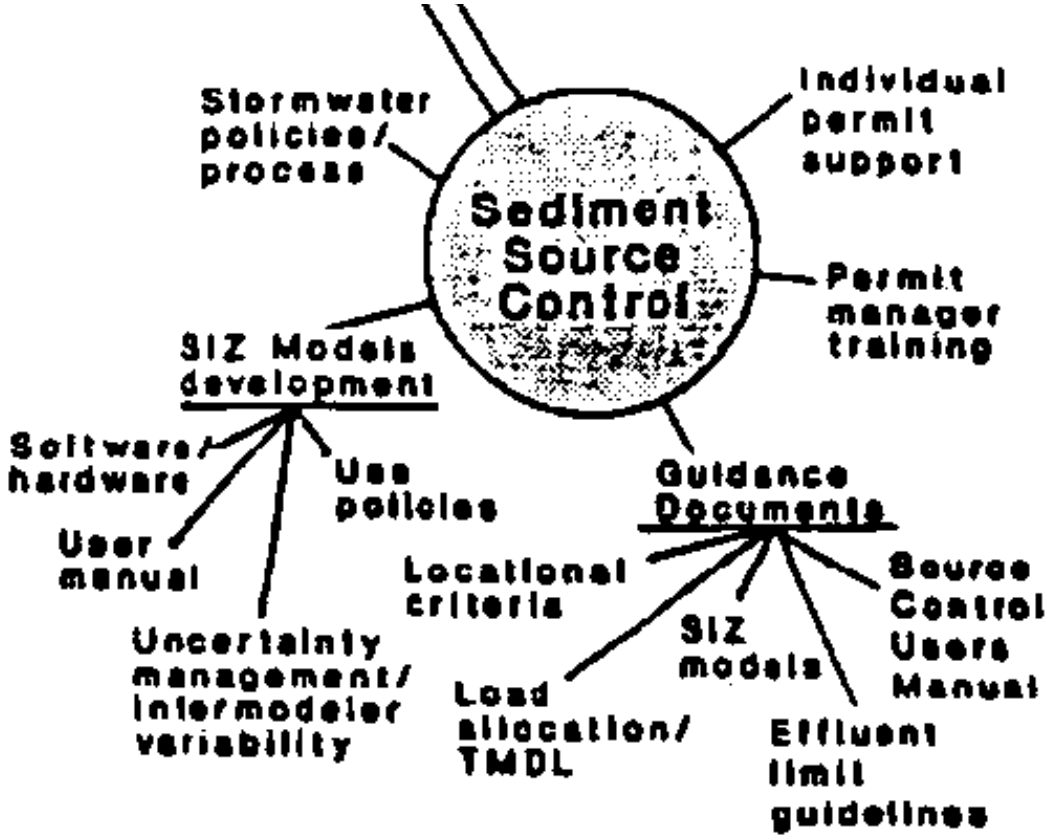
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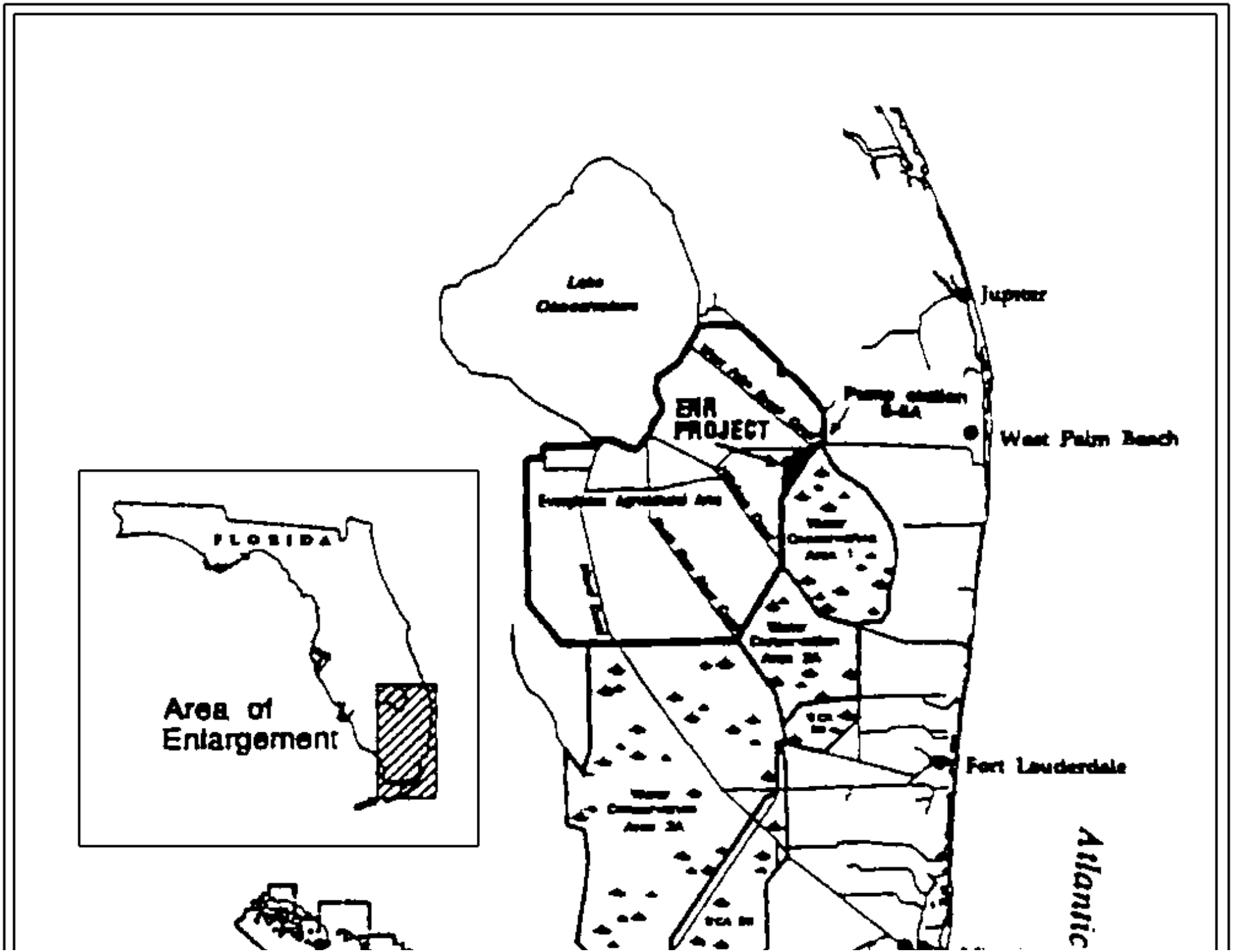
Effluent limit guidelines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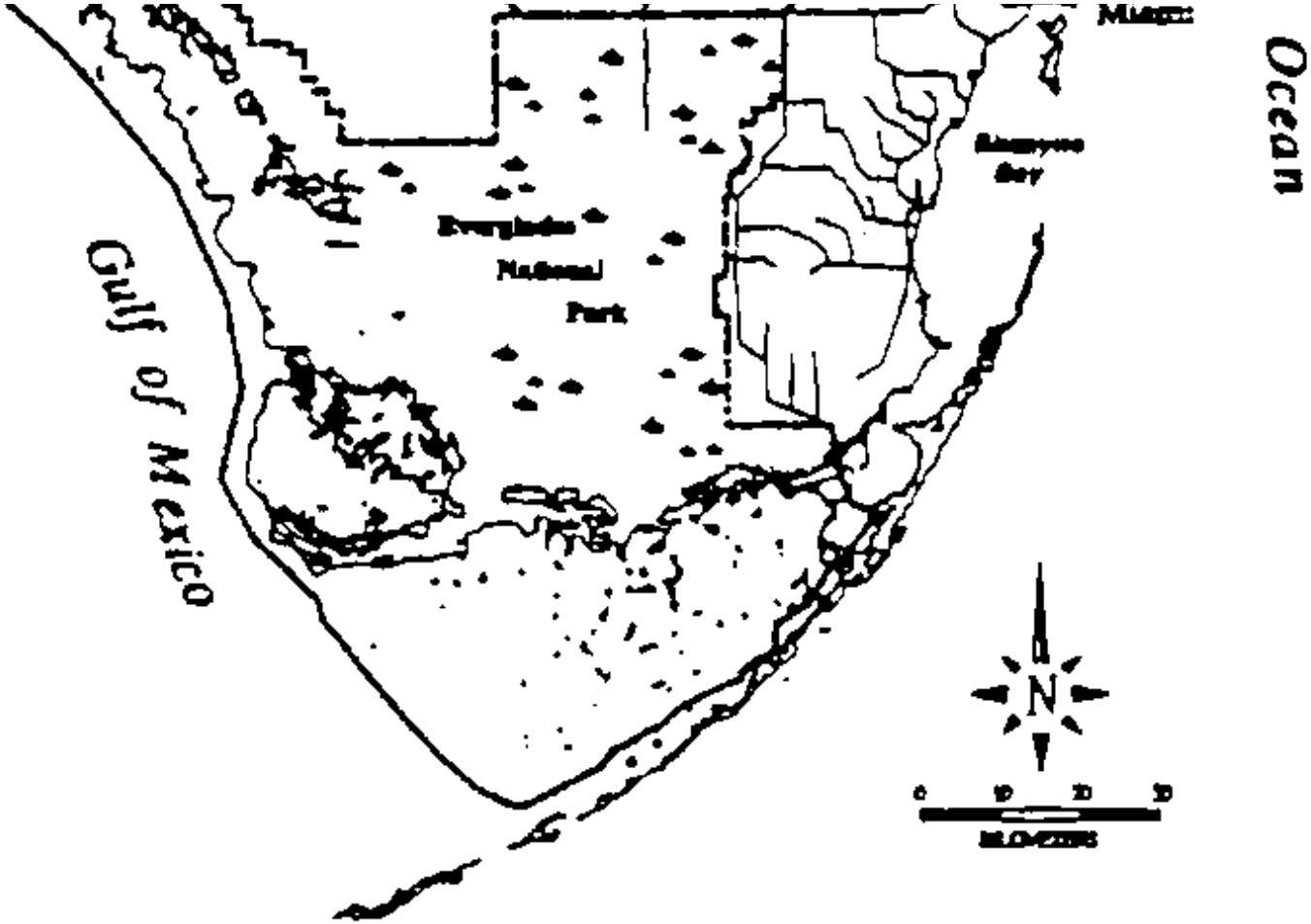
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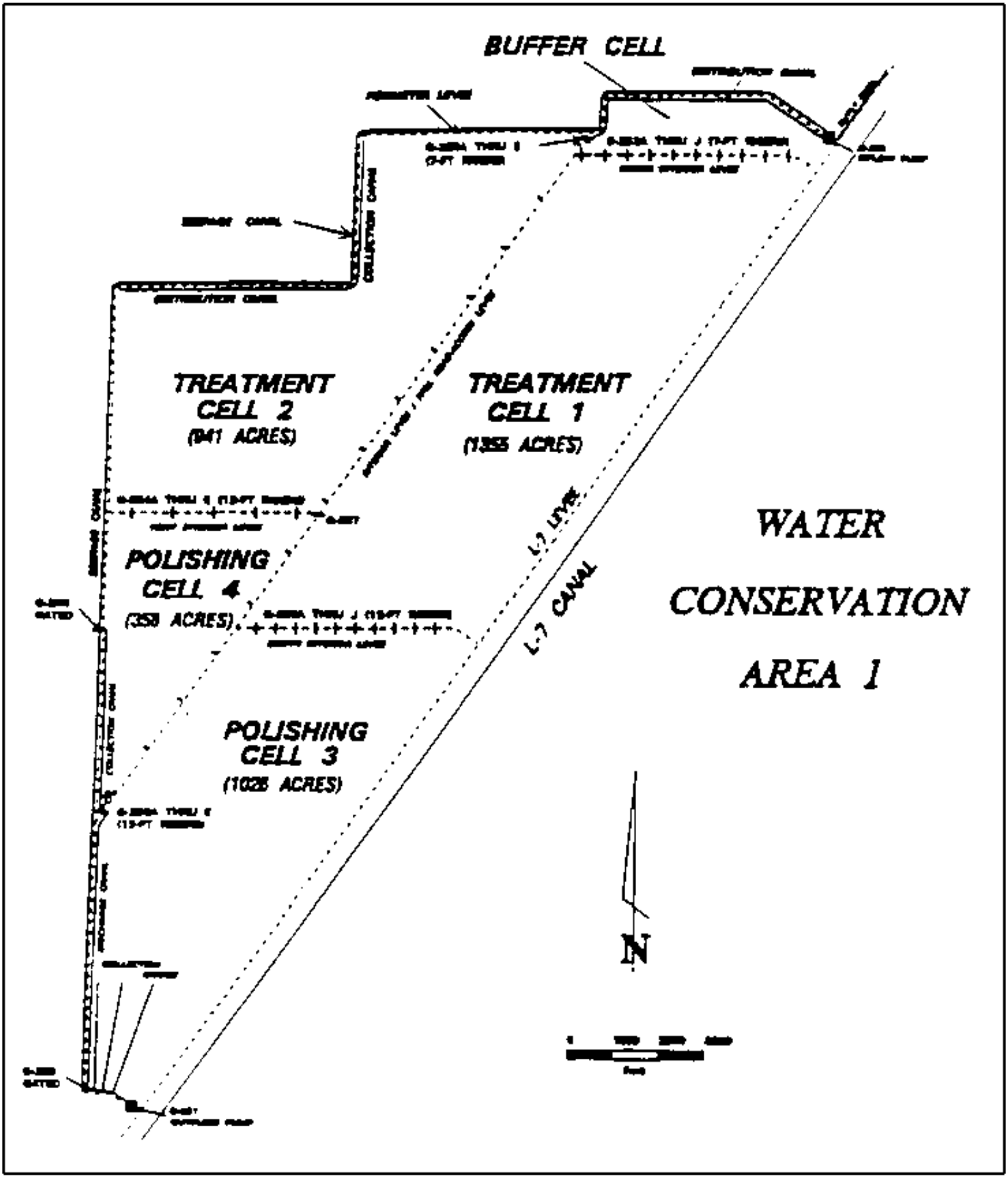
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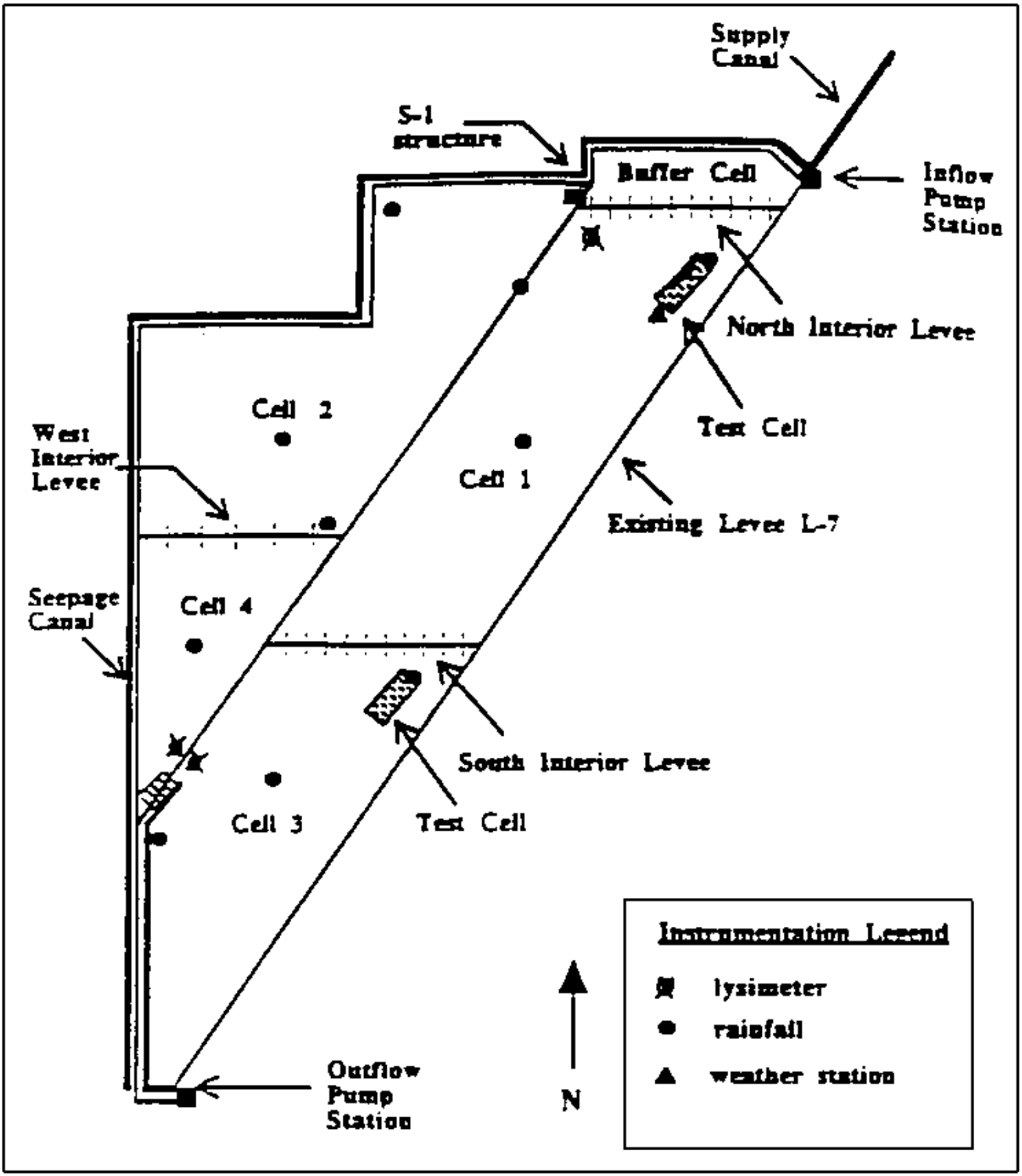
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Test Cell
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Cell 3
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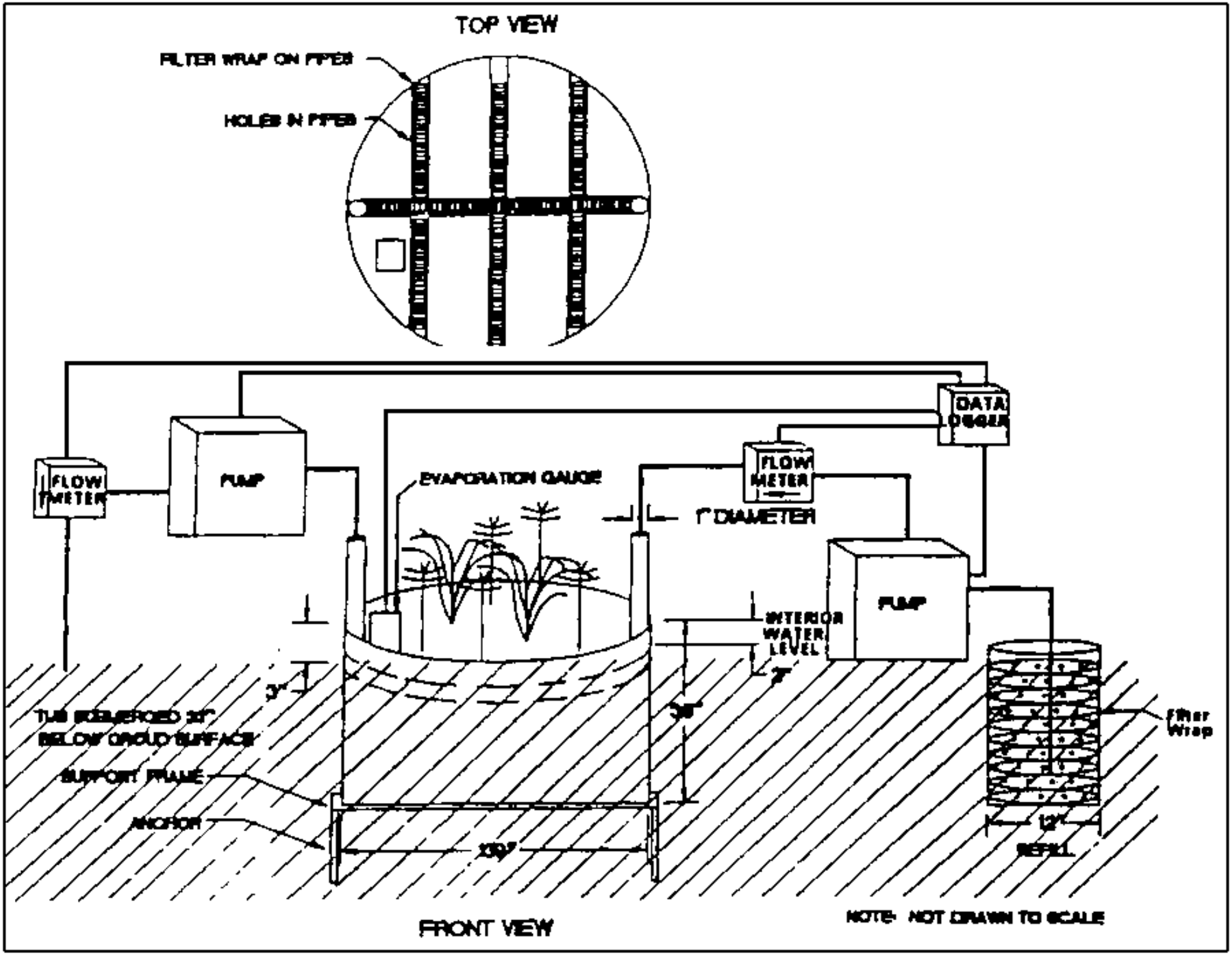
TOP VIEW
FILTER WRAP ON PIPES
HOLES IN PIPES
DATA LOGGER
FLOW METER
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EVAPORATION GAUGE
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1" DIAMETER
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INTERIOR WATER LEVEL
3"
7"
36"
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REFILL
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FRONT VIEW
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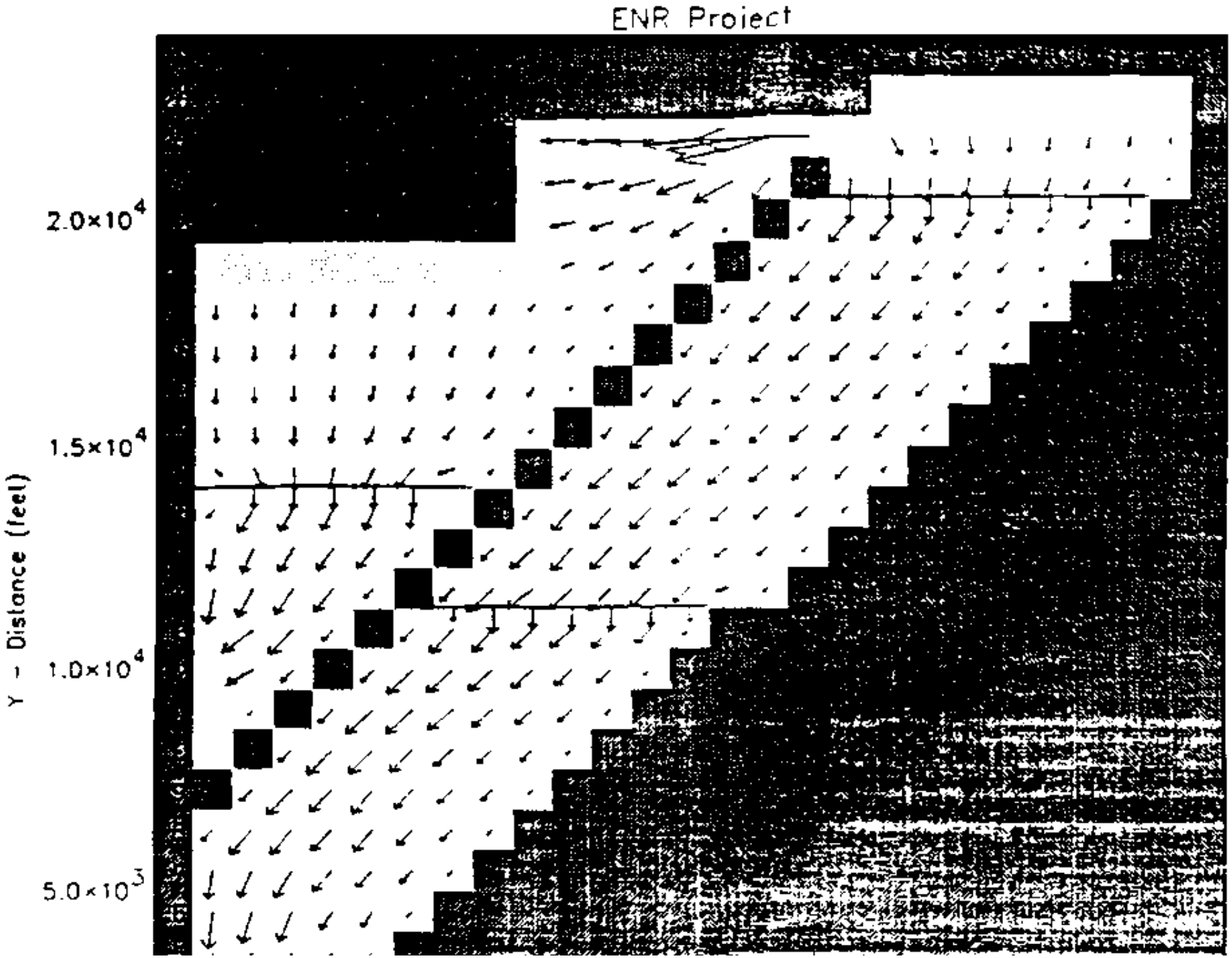
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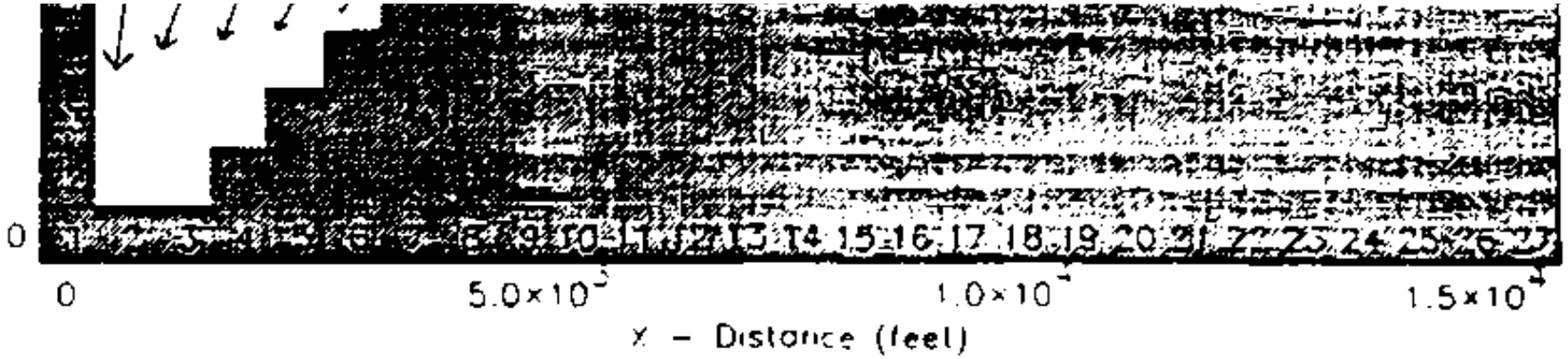
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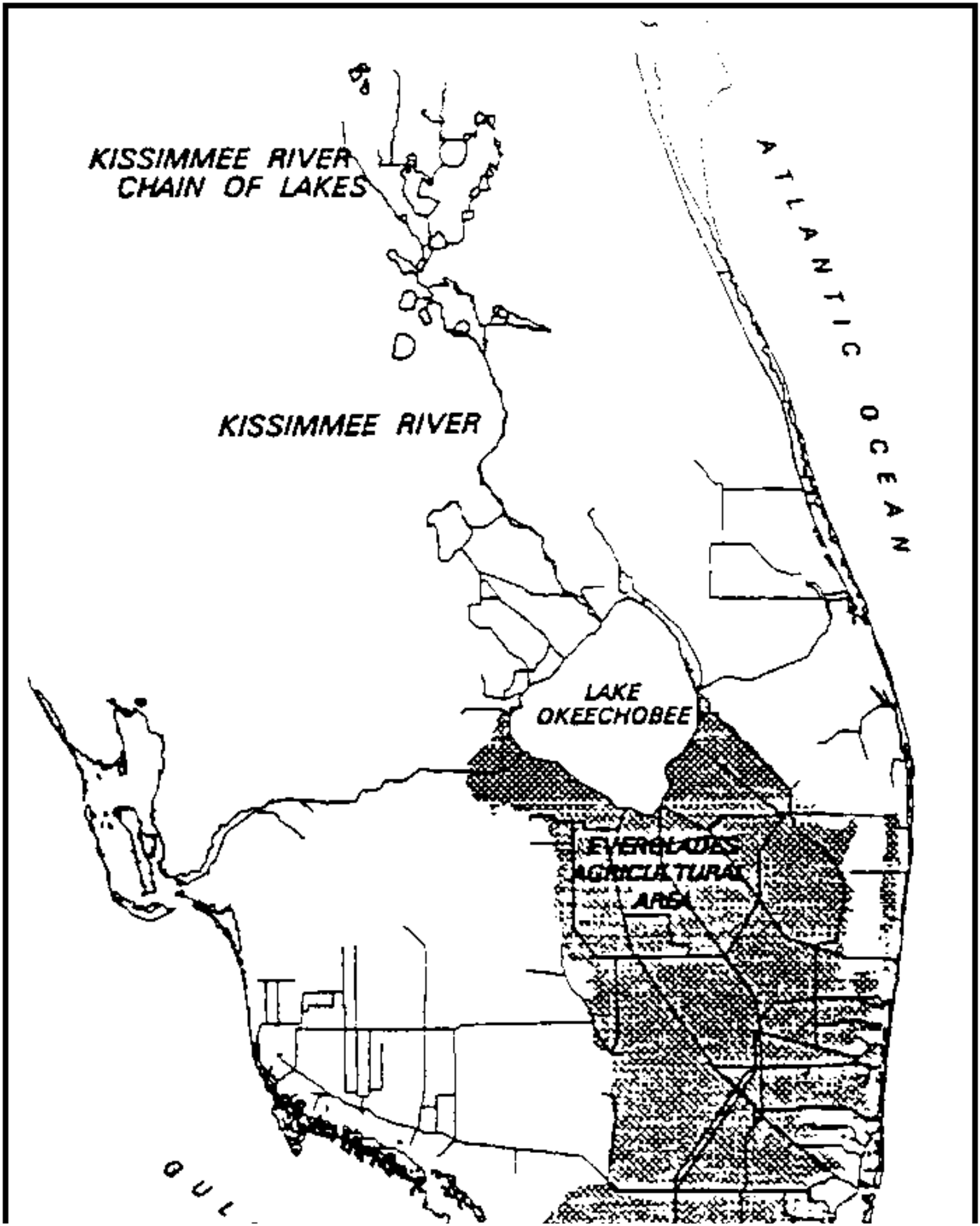
KISSIMMEE RIVER
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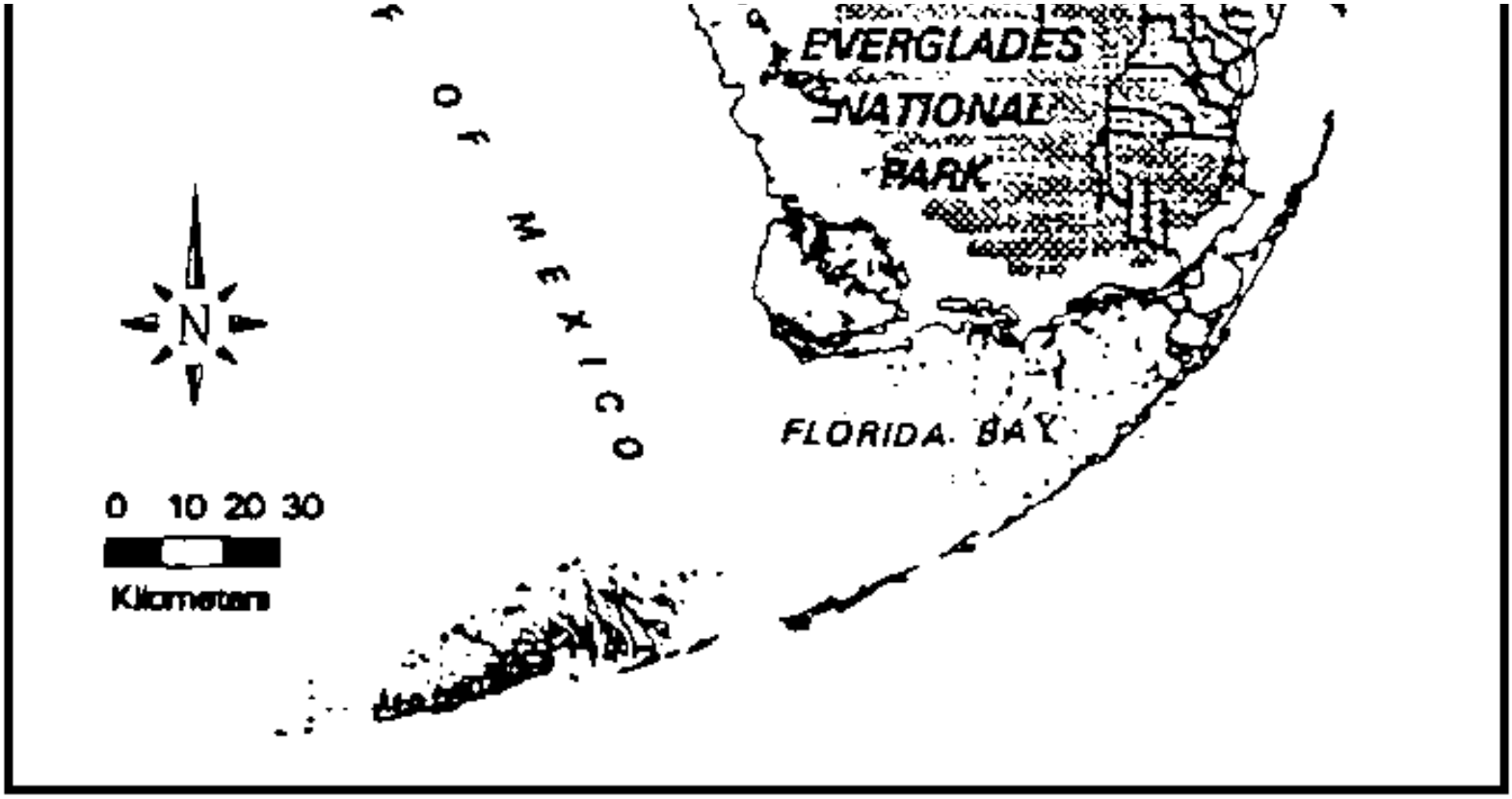
EVERGLADES
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Roundtable III - Water Governance and Policy

Co-Chairs

Evan Vlachos, Professor and Associate Director, Colorado State University, Fort Collins, Colorado, USA

Axel Dourojeanni, Director, Division of Natural Resources and Energy, United Nations Economic Commission for Latin America and the Caribbean (ECLAC), Santiago, Chile

Moderators

Sub-track: **Water Related Decision-Making Processes**

Richard Hamann, Associate in Law Research, University of Florida, Gainesville, Florida, USA

Marco A. Gonzalez, Secretary General, Nicaraguan Foundation for Sustainable Development, Nicaragua

Sub-track: **Water Law and Institutional Arrangements**

David Getches, Professor, University of Colorado, Boulder, Colorado, USA

Jose A. Urrutia, Consultant on Environmental Law and Professor, Universidad de Chile, Santiago, Chile

Coordinator

Steve S. Light, Policy Director, South Florida Water Management District, West Palm Beach, Florida, USA

Background Paper

Some Comments on the Challenge Facing Water Management in Latin America, by Axel Dourojeanni and Terence Lee, U.N. Economic Commission for Latin America and the Caribbean (UN/ECLAC), Santiago, Chile

Papers and Authors

Sub-track: **Water Related Decision-Making Processes**

1. *The Need to Integrate Environmental Ethics into Environmental Science, Law, and Economics in Water Resources Decision-Making,* by **Donald A. Brown,** Pennsylvania Department of Natural Resources, Harrisburg, Pennsylvania, USA.

2. *Negotiating Collaborative Solutions in Disputes Over Water Resources,* by **Barbara Gray,** Pennsylvania State University, University Park, Pennsylvania, USA.

3. *Rio San Juan Basin: A Case of Conflict in Management of a Bi-National,* by **Marco A. Gonzalez,** Nicaraguan Foundation for Sustainable Development, Managua, Nicaragua.

4. *Water Quality as a Top Priority for the U.N. Commission on Sustainable Development,* by **Steve Parcells,** National Audubon Society, Washington, DC, USA; and **Deborah Moore,** Environmental Defense Fund, Oakland, California, USA

5. *The World Bank - Water Resources Management Policy,* by **Francois-Marie Patorni,** The World Bank, Washington, DC, USA.

6. *The Issue of Equity in International Environmental Negotiations: The Perspective of a Developing Country,* by **Diana Ponce-Nava,** Universidad Nacional Autónoma de México (UNAM), Mexico.

7. *Integrated Conservation Planning in the Cuiabá River Basin, Mato Grosso, Brazil,* by **William J. Possiel,** The Nature Conservancy, Arlington, Virginia, USA.; **Adalberto Eberhardt** and **Angela Tresinari,** Fundação Ecotrópica, Cuiabá, Mato Grosso, Brazil

8. *Enhanced Decision-Making,* by **Warren Viessman, Jr.,** University of Florida, Gainesville, Florida, USA

Sub-track: **Water Law and Institutional Arrangements**

9. *The Impact of Multilateral Financing on Costa Rican Water Law Institutions,* by **Rodrigo G. Barahona.** Environmental and Natural Resources Law Center (CEDARENA), San Pedro, Costa Rica

10. *Legal and Institutional Aspects of Water Charges in Brazil,* by **Benedito P.F. Braga, Jr.,** Escola Politecnica da Universidad de Sao Paulo, Sao Paulo, Brazil.

11. *New Instruments to Improve Water Management in México,* by **Jaime Collado,** Mexican Institute of Water Technology (IMTA), Cuernavaca, Mexico

12. *Organizational Structures for Interstate and International Coordination of Water Management,* by **Julio C. Fossati,** Comité de Recursos Hídricos de la Cuenca del Plata, Buenos Aires, Argentina

13. *Sustainable Development and Management of Water Resources - A River Basin Approach,* by **Gerald M. Hansler,** Delaware River Basin Commission, West Trenton, NJ, USA

14. *Great Lakes Remedial Action Plans: Building the Institutional Capacity to Restore Beneficial*

Uses, by **John H. Hartig,** Wayne State University, Detroit, Michigan, USA

15. *Integrated Water Management in Chile: An Ongoing Process,* by **Gustavo Manriquez** and **Jaime Muñoz R.,** General Directorate of Water, Ministry of Public Works, Santiago, Chile (presented by **Carmen L. Gutierrez,** Regional Director of the Ministry of Public Works, Region V, Valparaiso, Chile).

Background Paper: Some Comments on the Challenges Facing Water Management in Latin America

Axel Dourojeanni and Terence Lee[1]

[1] Division of Natural Resources and Energy, United Nations Economic Commission for Latin America and the Caribbean, Casilla 179, Vitacura, Santiago, Chile

A Background Paper prepared for discussion in the Roundtable III: Water Governance and Policy

The Evolution Of Water Management In Latin America

Latin America enjoys a long tradition of controlled water use for specific social ends, and water management institutions have been important in the historical development of many Latin American societies. Contemporary water management in Latin America amalgamates these traditional models and more recent attempts to introduce management concepts based on the European and North American models.

Social control of water resources in Latin America considerably predates the arrival of European colonizers in the 15th century. The control of water use in pre-Colombian societies was a significant public activity which formed a fundamental part of the socio-institutional structure. Although much of the existing social structure was destroyed, the Spanish colonizers emphasized the social control of water use, replacing pre-Colombian water management norms with methods brought from Spain based on the Roman and Moorish traditions prevalent there.

The Spanish systems remained the norm until the countries of Latin America gained independence and drafted their own constitutions. These constitutions, in general, declared water to be a public good and laid the foundation for public intervention in the management of the resource. Water management was, however, largely a function of local government.

Beginning in the 1920's and continuing for almost half a century, national single-purpose institutions became the prevailing management form. This trend continued until the advent of other influences over the organization of water management and the nature of the emerging institutions changed in the 1970's. For example, in Argentina the consolidation of federal single purpose institutions was reversed as a strong decentralization policy was adopted, transferring responsibility back to the provinces.

In other countries, however, the process of forming single purpose national institutions continues, although in some cases it is accompanied by the introduction of other modalities of

water management. External influences over water management affected the evolution of policy with the reestablishment, on a much different scale, of the international and regional financial and development agencies following the second world war. The activities of these agencies reached a significant scale and level of influence by the early 1950's and accompanied a new stage of water management in Latin America.

The new, widespread adoption of organizational arrangements based on centralized single purpose institutions largely reflected the influence of the multilateral financial and technical assistance agencies, as did the use of water control projects as a means for achieving economic and social development. At the same time, the multilateral financial agencies exerted strong influences over water management through the conditions accompanying the provision of loans.

The international agencies, although they tend to be organized by sector, have strongly favored coordination and integrated river basin management. The actual practice in the region remains very different. There have been isolated applications of the concept in various countries, but with the exception of Colombia, few successful examples of integrated river basin management exist.

Even the application of the concept in water planning is not common. For example, the Mexican national water plan uses a regionalization at the highest level of aggregation which respects river basin boundaries, but the subregions used as the basic operational spatial units are defined by administrative boundaries. Moreover, even at the highest level of aggregation, some of the major basins are subdivided rather than treated as single units from source to mouth.

The Main Factors Influencing Contemporary Approaches to Water Management in the Region

Over the last decade, a series of changes have occurred in the countries of the region which have resulted in the reduction of the intervention of the state in the economy and to the increasing role of the private sector, including in some countries of the establishment of systems of private ownership of water rights.

The reform of the public sector has resulted in changes in both the management of individual uses (the management of demand) and in the management of all uses (management of supply).

a) Factors influencing the changes in the management of individual uses include:

- The need to improve the economic and financial efficiency of the management of water supply and sanitation companies, electricity companies and irrigation districts and other activities related to water use in accordance to a private enterprise.

- The increasing costs of obtaining, distributing and treating water in the constantly expanding large metropolitan areas as sources ever more distant have to be used and as the necessity to reduce pollution becomes ever more pressing.

- The conflicts that arise with the rural inhabitants and municipal governments, located in the river basins from which the water and hydroenergy is being transferred to large cities.

- The continual increase in the demand of water for irrigation and the increasing value of some agricultural products, largely for export, which need a level of technical

management beyond that traditionally applied. This requires the creation of agricultural water management institutions capable of managing complex systems of water regulation, distribution and drainage.

- The explosive increase in the number of the urban poor. The majority of this population live in marginal areas subject to floods and landslides and where the provision of basic services - water, sewers, drainage - is both costly and difficult.

- Related to the above, there is an urgent need to improve the quality of life in rural areas. The development and management of water resources in rural areas is the first constraint to be overcome to achieve this goal, specially in relation with water supply and sanitation, energy and agriculture.

- A noticeable increase in the economic and financial losses from water-related natural hazards, such as droughts and floods and increasing delays in the construction of regulation works. For example, Argentina, Colombia and Peru have suffered huge energy losses through drought in recent years. Flooding has led to increasing losses from the destruction of water control systems, irrigation systems etc.

- The concern and constraint imposed by environmental laws, at international, national and even municipal level, including agreements related to the management of river basins and water resources shared by more than one country (transboundary water).

- In addition, in some countries there is an increasingly evident deterioration in hydraulic structures due to age and the lack of maintenance. In many cities the maintenance and expansion of water supply and sanitation systems has not kept place with population growth and structural changes (the construction of high buildings).

These changes demand that the policies governing the administration of each individual water use should be directed towards increasing efficiency through the adoption of better business practices as well as more advanced techniques for water management. A key point is the need to improve information systems and the capacity of reacting quickly when a problem is detected.

b) In the area of multiple water use management (supply management), there are also a number of factors inducing change towards more integrated management.

- First, the increasing competition for water, in terms of both quantity and quality, which can only be resolved through conciliating the interests of different users by integrated management. There is an increase in the multiple uses of water as well as new interests such as improving navigation, aquaculture, recreation, and control of water quality.

- A further area of competition for water is provided by the irrational expansion of human occupation of areas some of them subject to landslide and flooding or suffering from serious water shortages. This has lead to the destruction of the natural vegetation in many watersheds, reduction of the base flow and the overexploitation of groundwater among other conflicts.

- Industrial growth has contributed more and new pollutants, the use of old and new fertilizers and pesticides, the expansion of mining, the clandestine production of cocaine and the resurgence of epidemics, such as that of cholera, have surpassed the capacity of any individual water use sector to confront the pollution problem. The public health authorities, who traditionally have had responsibility for these problems, are quite incapable of managing them due to the lack of authority, resources and operational capacity.

- A further important factor is that a wider variety of water users are getting political power. For example, peoples involved in fish fanning, whether in rivers, lakes or estuaries, has produced strong new pressure for better water quality. Similarly, pressure for watershed management, mainly for erosion control, has come from the construction of reservoirs for diverse purposes.

- Extreme events - droughts, floods and landslides - have also led to users joining forces to develop control measures for their common benefit and to distribute the cost of works according to the benefits received. Such developments are still incipient, however, due to the lack of organization and financial weakness of many users.

- Surprisingly perhaps, water management is more difficult when there is a single large water user, (e.g. a mining company) with no competition for water quality or quantity. Integrated water management is more easily achieved between strong organizations in conflict.

- Concern for integrated water management is non existent in regions dominated by the so called “informal sector: illegal gold mining, using mercury, or by the production of drugs, where a number of acids and other chemicals are used, or, even where, migrant farmers slash and burn forested slopes”. (by far the most difficult areas to work are located in the head waters of the Amazon Basin and in any tropical area with very difficult access)

In addition to these factors, which directly influence the interest in integrated water management in each country, we can add external factors. These “interventions” may be national or international and can influence either the public administration or the users without forming part of the one or the other. The more important include:

- The economic, financial and environmental demands of the multi-lateral banks and the information and organizations that they request to countries in their operations.

- The work of the innumerable international organizations which both directly and indirectly have an interest in good water management. The OAS, FAO, IIMI, WMO, UNESCO, UNDRO, PAHO, ECLAC and many others have made a significant contribution to knowledge in the countries as well as to the promotion of horizontal cooperation through the formation of expert groups, networks of institutions and other means.

- International agreements on environmental matters in general, and on water matters in particular, have also had their influence. For example the

recommendations of the United Nations Water Conference, the more recent Dublin Conference and UNCED as embodied in Agenda 21 as well as the “decades” related to water resources have been important steps that still supporting activities on water resources.

• Bilateral technical assistance has been very influential. Countries such as the Netherlands in drainage and land reclamation, France in groundwater and more recently in integrated river basin management, Germany in the promotion of training, Italy in watershed studies, and the United States in the training of professionals in its universities, to mention only a few examples, have assisted the diffusion of modern technology and cooperation among the professionals of the region.

• The Universities, NGO's, professional organizations, and other centers of education in both the public and private sectors have also played an important role in the promotion of the idea of integrated river basin management.

Opportunities and Constraints to Improve Water Management Practices

Recently, water management has once again attracted the attention of governments and water users after almost 10 to 15 years of serious neglect. The great majority of hydraulics works that have still being constructed were designed and financed in earlier periods. The state water administrations have been greatly reduced in personnel and resources where they have not been abolished. Policies has transferred many responsibilities on water management to private sectors and local governments without any support to assume such works.

In education and intellectual circles, water management has also been somewhat relegated to secondary importance with the emphasis on environmental quality. At the time of the first Conference on the Environment at Stockholm in 1972, only a few countries had an organized institutional system to administer water resources, forests or wildlife.

In 1972 the elaboration of national plans for water management had hardly begun and few of these have been implemented when the countries embraced the idea on environmental management. In these plans the problem of the management of water for multiple use was hardly considered.

There are few training programmes and institutions which specializes in water resources management. In contrast, there is an abundance of studies and training activities in specific areas of water resources development, mainly for the design and construction of hydraulics structures related to irrigation and drainage, water supply, hydroenergy and others. Such knowledge is easily transferred from one country to another, something that can not be said for management practices.

Without enough background in the organization for the management of individual natural resources the countries of Latin America and the Caribbean have tried to incorporate, in policies and laws, conditions for “global environmental management”. In some cases Ministries of the Environment have even been created. They have tried to manage the environment on a “holistic” approach, even covering such matters as global warming and the hole in the ozone layer without having yet the conditions to manage a single resource, such as water, on a large, integrated, scale.

Only recently has it begun to be realized that the sought after sustainable development can only be achieved starting through the management of some basic natural resources such as water. Water resource management is an excellent basis to begin to integrate actions aimed at achieving environmental sustainability. In fact integrated water resources management is probably the area where Latin America has more opportunities to do something important in a short term in relation with the goals of agenda 21.

These developments in the appreciation of the environment issue, have accompanied the profound economic crisis of the 1980's and the tremendous changes introduced in the direction of both macroeconomic and microeconomic policies, with the emphasis on the role of the private sector.

This is the background which has set the range of options and created the obstacles which face the countries of the region in trying to improve their systems for water management. It is necessary to develop a general change of opinion about the alternatives which are available and on how to overcome the many obstacles still in the way. Among the managerial issues to be discussed are:

- **Legislation** - one of the first actions of many governments has been the revision of water legislation, adapting them in some cases to new constitutions which enshrine the right to private property. The granting by the state of water rights with the character of real property which once granted may be freely traded is a result of this approach. Chile was the first country to adopt legislation embodying this concept and other countries are now following this example. The adoption of such an approach is certainly one of the issues most under discussion at the moment.

- **Privatization** - the privatization of many activities related to water, such as water supply, electricity generation etc., together with the transfer to farmers of the responsibility for irrigation schemes has caused profound changes in water management systems. Some of the questions presented by this transfer are to whom will large irrigation schemes be transferred, what form of organization should be used by farmers, what will be the future role of the state in management, and what will be the source of finance for farmer operated systems?. The situation varies among countries according to their histories, but it is a region wide trend.

- **Financing** - Related to the privatization there is a full spectrum of studies and proposals that needs to be made in relation with financial aspects. The role of the state and the private sector needs to be clarified in relation with subsidies for the low income sector of the population in urban and rural areas, sharing of the costs of main hydraulic structures as well as for the construction of flood control devices and other protective measures.

- **Organization for Multiple Use Management** - the main question remains how to organize for multiple use management in each country and in each river basin or water system? The available alternatives are all questionable. Some suggest the creation of basin authorities within the public sector with authority over all users. Others propose private systems with user participation in which the state would play a secondary role. Yet others propose only that the public sector should be better

coordinated in each actions.

- **Organization and legislation for the management on transboundary waters.** This is an aspect that still needs further consideration to.

Among the difficulties faced in the reorganization of water management has been the general political turmoil caused by the debt crisis and the consequent need for political, legal, institutional, technical, economic and even conceptual change.

In **water management policy** various initiatives have been stopped or modified by changes in government or have simply stagnated due to the lack of political agreement over major issues such as privatization. In many countries, the major decisions on the definition of the role of the public and private sectors are still to be taken. It is often the case that major decisions are taken in the absence of sufficient information on the part of the politicians. Decisions have been taken, in other cases, for policy reasons in ignorance of the reality of the water systems.

There are a number of draft **water laws** which are blocked by the need to conciliate them with the emerging environmental legislation. In some countries, e.g. Peru, the constitution itself is being reformulated so that any change in the laws relating to water have to await the outcome of the constitutional debate. Elsewhere, where water laws have been reformulated, as in Chile, the laws are under revision in the light of experience.

In respect of **institutional structure**, there are conflicts between the creation of river basin commissions and the regional authorities being created to decentralize government. This is especially the case when it is proposed to give the commissions more authority than the regions. There are also arguments about which Ministry should have the national water authority so that it can really have multi-sectorial jurisdiction. In addition, the debate over the role of the public and private sectors continues and there are arguments among ministries, municipalities and the private sector on who should have responsibility for a particular water body.

The **technical aspects** of the issues under consideration are frequently not considered in the discussions on water management. These discussions are commonly led by politicians, economists or lawyers without knowledge of the nature of hydrologic systems and in the absence of technical advisors.

There is, in general, a terrible lack of **information on water quantity and quality**, the flows are not frequently measured for which rights must be established. The majority of information on water users needs to be brought up to date in many countries. More complex tools, such as models permitting the joint management of surface and ground water do exist only for a few areas. The networks for the collection of hydrologic information are very weak compared with the needs, specially in mountain areas.

As we can see, there remains a tremendous task ahead in each country of Latin America and the Caribbean in the rationalization of water management. Most countries have excellent professionals working in water resources, as can be seen from the discussions in the meetings held in the region. They face, however, many challenges in their work which fall largely outside their direct competence. The work to be done has to be equal to the challenges which are coming from outside.

It is necessary to **begin by evaluating what is actually happening in water management** in

each country before proposing any significant changes in laws or institutional structures. It is obvious that the governing political and economic ideas do not take adequate consideration of the particular characteristics of water (externalities, chance, economies of scale, ecological aspects etc.).

Secondly, it is essential that **the economic and financial foundation of any proposed legal or institutional changes should be clearly identified.** Economic and financial analysis which should support the viable application of the new rules are too often poor or nonexistent. There is commonly confusion as to the meaning of prices, charges, costs, taxes and other financial instruments.

Third, it is urgently necessary to **give priority to the organization of good systems for integrated water management.** This is especially the case for the operation and maintenance and repair of existing multiple use works and for the management, rehabilitation and conservation of water supply basins. Water quality of both surface and groundwater must receive priority attention together with protection from extreme events.

Fourth, **training in multiple use water management is essential.** It is necessary to reinforce the work of institutions such as CIDIAT in Venezuela, the Fundación Getulio Vargas in Brazil, INCYTH in Argentina and ESAN in el Peru which have already entered into this activity with appropriate training material. As well as, promote the formation of centers elsewhere. To this end it is necessary to agree on criteria and concepts for management and financial systems as well as on the treatment to be given to environmental considerations. Documentation is need which provides positive suggestions for integrated water management and for the financing of multiple use within river basins.

Fifth, there is an urgent need to **improve cooperation among countries and institutions active in integrated water management.** The existing networks need to be reinforced. It is essential that the networks have stable financing to permit them to achieve their goals of the exchange of experience and knowledge. It should be possible to obtain greater contributions from the more profitable water uses, such as drinking water supply and electricity generation to support these activities. In the past, these institutions have shown little interest, however, in integrated water management. Perhaps, this is one are where privatization might bring real change.

Some international organizations, particularly the multilateral banks, have not contributed firmly to the development of integrated multiple purpose water management. They have tended to be very much project oriented and tended to “parcel-out” water use. Even the environmental studies they demand are usually limited to individual projects. **There is much room for improved collaboration by the banks in the achievement of integrated multiple use water management as well as watershed management.**

Sub-track: Water Related Decision-Making Processes

The Need to Integrate Environmental Ethics into Environmental Science, Law, and Economics in Water Resources Decision-Making

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Introduction-A Defining Moment in History?

Are we at a dangerous defining point in human history? According to a report entitled Our Common Future prepared for the United Nations by the World Commission On Environment and Development in 1987, rapid deterioration of the global environment is threatening life on earth. This report concluded that decisive political action is needed to ensure human survival. Our Common Future identified several environmental trends that threaten “to radically alter the planet, and many species upon it, including the human species.” Environmental deterioration identified in the report included: (1) rapid loss of productive dryland that was being transformed into desert; (2) rapid loss of forests; (3) global warming caused by increases in greenhouse gases; (4) loss of the atmosphere's protective ozone shield due to industrial gases; and (5) the pollution of surface and groundwater supplies caused by the release of toxic substances.

The scientific evidence of growing environmental degradation relied upon in Our Common Future is of even greater concern because the earth's environment is exhibiting stresses at a current population of approximately 5.5 billion people. These visible signs of deterioration become even more ominous when one considers the rapid growth in population expected for our planet in the 21st century. Because population may grow to 10 billion by 2050 and between 12 and 14 billion people by the end of the next century, Our Common Future concluded that urgent and decisive political action was necessary to prevent widespread environmental destruction.

Of equal historical significance as its environmental conclusions, Our Common Future also focused world attention on the futility of separating economic development problems from environmental issues. The report explained how some forms of development eroded the environmental resources upon which they must be based, and how environmental degradation

undermines economic development. For instance, development that can't afford to pay for treatment of sewage creates water pollution, and polluted water limits future development options. In addition, in many developing countries, in the absence of help from the developed world, rapid depletion of natural resources is the only hope of eradicating poverty. Thus, the report concluded that “poverty is a major cause and effect of global environmental problems.” That is, there is no hope of solving the global environmental problems unless the international community works rapidly to resolve problems of human development throughout the world.

To solve the twin problems of environmental degradation and unacceptable development, Our Common Future called for a world political transformation that supported “sustainable development” throughout the world. Sustainable development was defined as development which meets the needs of the present without compromising the ability of future generations to meet their needs. Our Common Future put sustainable development on the front burner throughout the world.

The United Nations Conference on Environment and Development in June of 1992, generally known as the Earth Summit, was the largest and most ambitious international conference of all time. 110 heads of state assembled at the Earth Summit, more than any other previous international conference.[2]

Five documents were signed in Rio. They were: (1) The Treaty on Climate Change; (2) The Treaty on Biodiversity; (3) The Convention on Forest Principles; (4) The Rio Declaration; and (5) Agenda 21.[3]

Although it did not receive as much publicity in the United Slates and some parts of the world as the Treaties on Climate Change and Biodiversity, Agenda 21 may prove to be the most significant of all the Earth Summit agreements. This document is an 800 page blueprint for international action in the 21st century. It contains 40 chapters focused on solving the twin problems of environmental protection and sustainable development.

Although much was agreed to in principle in Rio in signing Agenda 21, most of the details on environmental goals and standards and commitments of the developed world to the developing world will have to be worked out in more specific treaties, conventions, laws, and institutional changes in the years ahead. Great controversy lies ahead.

There are many thorny ethical questions that the world needs to face in implementing the Earth Summit agreements. What should governments do to control population? If the developed world has created much of the existing global pollution and the developing world needs to develop its natural resources to escape from poverty, what are the obligations of developed to developing countries? What should the people of the earth do about global environmental problems when there is some evidence about environmental damages, but where there is pervasive scientific uncertainty about the nature of the danger? These are just a few of the many ethical questions that will need to be faced in implementing the Untied Nations program on environment and development.

Nothing is the same after the Earth Summit. No longer can humans assume that resources are inexhaustible and that humans are above and separate from a nature that is exclusively available for human use. The problems that must be faced in implementing Agenda 21 call into question much of the world view that has been dominant during the period of world

industrialization.

Because humans are on a track that can lead to the destruction of much of life on earth, the world community is urgently challenged to develop an ethic that will not only recognize the duties that people have to care for other humans, but also to future generations and other forms of life with which we share this planet.

Some have argued that because of the urgency of the need for political and personal transformation to avert widespread environmental destruction in the next century, only a radical change in values can bring about the behavioral change needed to protect life on earth. As a result, calls for a new 'environmental or sustainable development ethic' have been growing. These calls have come recently from mainstream religious, political, and scientific organizations.

Some religious leaders have argued that only a truly religious transformation can bring about the needed shift in behavior; a cosmological paradigm shift which enables humans to see themselves as part of, rather than above, the web of life. They argue that such a change in vision, is necessary to allow the world and its plants and animals to become re-enchanted; to restore a sense of the sacred in nature that was lost during the industrialization period of human history.

In addition, many environmental organizations have called for a new environmental ethic. For instance, the World Conservation Union, has recently urged the adoption of a set of morally compelling principles to guide human action.[4] If the world is going to develop a sustainable development ethic, the world will need the leadership and collaboration of artists, poets, scientists, and men and women concerned about the global environmental crisis. Most importantly, the developed world needs to learn from the wisdom of those cultures that have never lost their deep and sacred respect for life on earth.

The Need to Examine Sustainable Development Ethical Questions Embedded In Day-to Day Practices

There are several reasons, however, to be concerned about putting the world's hopes exclusively in the call for creation of a new sustainable ethic that will guide the day-to-day practices of human life.

First, such calls for a new sustainable ethic sometimes seem to assume that an ethic can be created by simply calling for its creation, without understanding how ethical positions arise out of existing social practices and needs or within existing ethical belief systems.[5] For example, because any person struggling to survive is likely to be influenced in his or her view of 'right' or 'wrong' from the day-to-day forces against which he or she must struggle, no simple call for a sustainable living ethic is likely to be greatly influential until dire threats to survival are eliminated.

Second, Agenda 21 is expected to be largely implemented by national and local governments that translate the general principles of Agenda 21 into specific programs and laws. The most likely response of these governments is to assign these laws and programs to government agencies staffed largely by engineers, scientists, lawyers, economists, and other experts who are expected to implement laws and “manage” sustainability problems. Government experts will use the languages of science, economics, and law to frame the public policy questions that must be faced in implementing Agenda 21. Because a sustainable development ethic will surely

create considerable conflict between those persons who are deriving a living from unsustainable practices and laws which limit or prohibit the unsustainable behavior, there will be even greater pressure on national political leaders to look to scientists and other experts to define which human behaviors or activities are unsustainable. In fact, evidence of this increasing need to rely on complex scientific, legal, and economic procedures and analyses is apparent in many sections of Agenda 21. For example, Agenda 21 expressly calls for the use of such complex scientific procedures as toxicological risk assessment as the appropriate tool for determining which hazardous substances are harmful, and calls for the use of biotechnology to solve food scarcity problems.

If the policy languages of science, economics, and law are not ethically neutral or if important ethical positions are often hidden in scientific, economic, and legal languages, it is critically important that the ethical dimensions of science, economics, and law be understood in implementing Agenda 21.

Science and Sustainable Development Ethics

In the last few decades scientists have been making great contributions to our understanding of global environmental problems. For instance, it is inconceivable that the developed world would have made as much progress on controlling water pollution if scientists did not warn us about the dangers posed by certain pollutants and devise treatment schemes that remove some of those pollutants. The world clearly needs to increase scientific understanding of threats to water pollution problems. However, the ethical limitations and implications of our scientific tools must be understood.

In day-to-day environmental decision-making, environmental protection controversies are often thought of as technical-instrumental problems. To solve such problems scientists or other technically trained personnel use scientific procedures to develop the “facts” about a particular environmental danger and describe measures that can be taken to prevent or remediate environmental degradation. For example, if water pollution is viewed primarily as a technical-instrumental problem, science needs to determine what is the ecological significance of the contamination to human and environmental receptors (a question of scientific fact) and if so, what steps can be taken to mitigate against any adverse environmental effects (an instrumental question of means). Since these questions are about “facts” and “means”, according to prevailing conventional wisdom, they are best answered by experts who use value-neutral scientific procedures as analytical tools to find answers.[6]

Conversely, environmental protection issues can be understood as problems that most fundamentally raise ethical questions, questions about what is the “right” thing to do. For example, which environmental amenities “should” we protect or what “should” we do in respect to the environment when the technical “facts” about consequences are uncertain? Under an ethical lens, the most important questions about water pollution might be: (1) What “should” we do about certain types of water pollution before science can specify consequences with certainty?; or, (2) What is this generation's duty to the future generations or non-human species to prevent degradation of water resources?

Of course, environmental problems usually raise both complex technical-instrumental questions and thorny ethical questions. However, if we allow technical-instrumental discourse to dominate

our environmental and development decision-making discussions several consequences follow.

First, positions taken by decision-makers that are justified on scientific grounds but have actually been based on the values of the decision-makers appear to be compelled by “neutral” technical reasoning and therefore are not subject to public scrutiny. Thus, the values of those nations or institutions that command technical resources can determine the nature of action that needs to be taken and make it appear that this action is compelled by scientific reasoning. Because technical expertise is very expensive, only those that can afford to pay technical experts can participate in the public policy discourse. Therefore, if technical discourse is allowed to dominate public policy decisions, those who do not have large financial assets may be effectively disenfranchised from discussing matters that should be understood to be moral or political in nature.

Second, political action initiated to protect the environment before science can describe precise cause and effect relationships between a proposed action and its effect on the environment can be attacked as irrational because it is without a scientific basis that compels action. Because the Earth Summit has acknowledged that governments must be sensitive to the economic and developmental consequences of environmental decision-making, there is likely to be increased pressure on decision makers to withhold government environmental action that retards development in situations lacking a strong scientific factual basis. Therefore, if we let neutral scientific language dominate our discourses on sustainable living problems after the Earth Summit, we are likely to see less environmentally protective government action.

Although some environmental problems are well understood by scientists, many are not. Environmental decisions must often be made in situations of pervasive scientific uncertainty[7]. That is so because scientists must often rely on theoretical models of the way the world works to make environmental decisions. Because extreme degrees of complexity characterize ecological systems, attempts to quantitatively predict the consequences of many human activities on global, regional or local environmental systems or to model even the simplest of ecosystems have not met with success. Environmental models are fraught with uncertainty either because the mathematical relationship between “real-world” variables described in the model is not known or because the data needed to run or test the model is difficult or impossible to obtain. Environmental models therefore suffer from two kinds of uncertainty: (1) theoretical uncertainty, and (2) informational uncertainty. As a result environmental science, and in particular the field of ecology, is much, much softer than many people realize.

If the world waits until the scientific proof is in, the world is making an ethical judgement that favors the status quo. Because scientists are taught to be silent in absence of sound scientific proof, if there is urgent need to take action to prevent environmental destruction where scientific proof is not conclusive, scientific norms may be inconsistent with a ethical principles. Thus the scientific norm that a scientist refrain from speculation in the absence of proof may conflict with the public policy need to protect the environment for future generations.

Third, because scientific ways of looking at environmental issues are understood to describe the environment through “value-neutral” scientific methodology, scientific methods are understood to see the environment “objectively” without the distortion that comes from the biases of the analyst. Scientific discourse, therefore, being understood by many as value-free and objective, can unconsciously lead to the devaluation of environmental positions of those who don't share

the same metaphysical mechanistic assumptions of the scientist or those who value the environment for more subjective reasons. For example, because there are no “objective” criteria for beauty and ugliness, someone who believes that the flow of a water fall should be maintained at its existing rate because of its beauty may not be represented in a discussion which is limited to “objective” scientific language. Therefore, if government officials limit future discussions on sustainable living problems to discussions about scientific “facts,” then those decision-makers may devalue the position of those who believe that environmental entities should be protected for reasons not cognizable in scientific calculations.

For these reasons, the ethical implications of our scientific discourses must be understood and integrated into sustainable development decision making. If scientific discourse is allowed to dominate the public policy discussions about environmental problems after the Earth Summit, there will be expanded opportunities for obstructive behavior for those who oppose government action.

Because scientists have been taught to exclude values discourse from their scientific endeavors, the twin problems of environment and development recognized by Agenda 21 ironically create pressures for greater use and reliance on tools that are usually understood to be “value-neutral” tools that have a built in tendency to see the world and its creatures as sets of mathematically described interacting forces. Therefore, although many argue that a shift in consciousness that re-enchants the world is necessary to survival of life on earth, the human race has managed to create problems that will most likely be described by tools that depend upon even greater demystification of the world. For this reason alone, it is imperative that the ethical implications and limitations of the scientific tools that will be used by decision makers to implement Agenda 21 are understood.

Law and Sustainable Development Ethics

How does the law fit into day-to-day environmental problem solving scheme? According to the model followed in much of the developed world, government agencies staffed largely by technical experts breaks down environmental problems into an “objective” technical problem and a “subjective” policy component.[8] In developing the policy component the administrator looks at the guidance contained in the law and then applies the “objective” technical facts to the decision rule found in the law. In this way, government technicians apply scientifically derived “facts” to politically derived rules.

This analysis leads to the conclusion that the government must turn to the law to determine the applicable ethical rule to be applied to sustainability decision-making. A closer analysis of most environmental laws, however, reveals that the ethical rules contained in many environmental laws are notoriously vague. A relevant example in the United States is the National Environmental Policy Act or “NEPA.” NEPA clearly is law which articulates environmental policy goals which have a distinctly ethical character, because the goals of NEPA state that its purpose is to establish a harmonious relation between humans and the environment.[9] NEPA is thus understood to be a law which incorporates an ethically based environmental approach to federal decision-making.

However, the exact nature of the environmental ethical approach embedded in NEPA is ambiguous because the goals also include words or phrases which seem to recognize the need

to balance environmental concerns with the need to meet “social and economic requirements of present and future generations” and the requirement to use all “practical” means and measures to create and maintain conditions where man and nature can exist in productive harmony.

Because of this ambiguity, NEPA is capable of many interpretations. These include interpretations which assert that the NEPA requires that: (1) Environmental values take priority over economic values; (2) Environmental values should be considered and allocated efficiently with other values including economic considerations (that is, NEPA should be understood to correct market failures to include environmental values); and (3) NEPA forces technology and science to develop in appropriate ways so that there is no conflict between environmental protection and a high standard of living.[10]

It is therefore apparent that NEPA fails to answer some of the hard ethical questions that are posed by the potential conflict between human economic interests and environmental protection considerations and therefore does not create a clear prescriptive rule for the government to follow in applying the “facts” of any individual controversy and in making a decision. In addition, most environmental laws require a finding of environmental harm as a factual prerequisite before taking protective regulatory action.[11] When environmental science is uncertain about the environmental consequences of human action, insisting on high levels of scientific proof before government action may be taken is a prescriptive rule that puts the burden of proof on government decision-makers and privileges the status quo. Such a rule may prevent protective government action where there is a reasonable basis for concern but where science is uncertain about the consequences of certain human activities. The Water Pollution Control Act was passed in 1972 that required the states in the United States to develop effluent limitations developed from in stream water quality standards, if technology based standards are not sufficiently protective of in stream uses of the water. Now, 21 years later Pennsylvania and other states have yet to develop water quality based effluent limitations because the in stream models are in capable of withstanding legal attacks. The standard of proof that should be required of regulatory action is an ethical question, not a scientific question. If we let scientific standards dominate legal institutions we are making ethical choices that may be inconsistent with ethical choices legislators think they have established.

Economics and Sustainable Development Ethics

When government technical experts recognize that particular value questions have to be considered in environmental decision making, the values are usually discussed in terms of economic considerations, in terms of costs and benefits and efficient markets. Although economics, as social science, may be a valid attempt to describe and predict what will happen economically within a society if it chooses certain economic behaviors, many economists do not hesitate to make prescriptive statements about economic behavior. Many economists, for example, assert that the option that makes the most efficient use of resources ought to be the preferred option. Once an economist makes an “ought” statement, however, he or she is tacitly assuming some ethical position. When such recommendations are made, economists are choosing one ethical approach over others, and that approach is most often some form of utilitarianism. The underlying assumption of utilitarianism is that an option should be chosen that creates the greatest happiness for the greatest number of people. Since an efficient market maximizes happiness by satisfying the greatest number of individual preferences, the economist

usually asserts that the option which maximizes the efficiency of the market place is the “optimal” solution. This is a utilitarian formulation of the good.[12] It is a different formulation than other ethical formulations, and to the extent that the value assumption is not identified and remains hidden, the ethical basis for the final decision is never exposed, and other viable approaches are completely ignored.

The utilitarian approach raises additional ethical problems that cannot easily be answered from within a utilitarian system.[13] A utilitarian, for instance, must decide which alternatives will be entertained in the utilitarian calculus, which consequences of a given action will be considered, whose assessments of harms and benefits will be allowed, and what time scale will be used in assessing those consequences. The utilitarian framework, therefore, often rests upon imprecise judgments independent of, and prior to, the utility calculus itself.

Utilitarian methodology, moreover, cannot easily accommodate the rights individuals may have either to be protected from certain pollutants or to be spared from death-threatening situations. Most contemporary philosophers hold that utilitarian approaches must be supplemented by other ethical approaches, such as those that stress such concepts as rights, justice, and due process as fundamental. The utilitarian approach often assumes that various questions can be reduced to a quantifiable amount. Quantification of environmental or health benefits, however, is often difficult and sometimes impossible. For instance, what is the value of human life? Even if the problem of quantification can be solved, utilitarianism is still incapable of answering how benefits or costs should be distributed among potential losers and winners.[14] As a result, most commentators agree that a utilitarian analyses must be supplemented by concepts of distributive justice.

Moreover, utilitarian approaches also usually make human interests, as opposed to plants and animal interests, the center of value. Such an approach may be inconsistent with ethical systems which strive to value plants and animals without regard to their use to humans.

Although more sophisticated utilitarian approaches are capable of dealing with some of the problems mentioned above, all too frequently the value analysis one actually finds in the environmental public policy debates are oversimplified utilitarian calculations that more sophisticated utilitarians would likely reject.

Conclusion

Most of the nations at the Earth Summit appear to have agreed that international action is urgently needed to diminish the extraordinarily serious threats entailed by various global environmental problems including threats to water resources. Because the poverty of the developing world must be tackled to solve these global environmental problems, international action must include assistance to the developing world so that it may achieve environmentally sustainable development. The nations of the earth are now faced with developing laws, treaties, and programs that will reconcile the sometimes competing objectives of environmental protection and development. If the nations of the earth are going to solve these problems, we must learn to integrate ethical discourse into the policy languages of science, law and economics.

Reference Notes

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3. For a helpful summary of these documents see. Environmental Law, supra; also see, IOS Press, Environmental Law and Policy. August 1992.

4. The World Conservation Union, Caring for the Earth, (Gland. Switzerland, 1991)

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7. For a discussion of scientific uncertainty in environmental decision-making see, J. Dryzek, Rational Ecology, (New York, Basil Blackwell, 1987)

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11. Id.

12. For a discussion of economic theory and utilitarian ethics see Mark Sagoff, “At The Shrine of Our Lady of Fatima or Why Political Questions Are Not All Economic,” *Arizona Law Review* 23 (1981): 1283-98, and “Economic Theory and Environmental Law,” *Michigan Law Review* 79 (1981): 1393-419.

13. See Alasdair MacIntyre, “Utilitarianism and Cost/Benefit Analysis: An Essay on the Relevance of Moral Philosophy to Bureaucratic Theory,” in K. M. Sayre, et al., *Values in the Electric Power Industry* (Noire Dame: University of Notre Dame Press, 1977).

14. See David Harrison, Jr., and Paul R. Partner, “Who Loses From Reform of Environmental Regulation,” in Wesley A. Magat, ed., *Reform of Environmental Regulation* (Cambridge, Mass.: Ballinger Publishing, 1982).

Negotiating Collaborative Solutions to Disputes Over Water Resources

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All the talk about sustainable development creates a hopefulness about the possibility that as a planet we can reach agreements about balancing economic growth and environmental preservation. But talk is cheap. Many experiences with regional plans for sustainable development fall short of their forecasted results (Forman, 1989; Bosso, 1988; Gray & Hay, 1985). Yet the need for arriving at timely and widely-supported solutions to environmental

problems at regional and global levels only increases (WCED, 1987; UNEP, 1989). Should we pessimistic or optimistic?

Considerable evidence from the practice of alternative dispute resolution creates a basis for some realistic optimism.

Evidence of successful collaborative efforts to address sticky, adversarial, environmental issues of all kinds is mounting daily - clearly not fast enough to address all the problems-but nonetheless, convincingly. While much of the experience is from the U.S. (Bingham, 1986; Crowfoot & Wondolleck, 1988; Clark, Bingham & Orenstein, 1991), evidence of successful environmental dispute resolution addressing a wide range of environmental disputes, including those over water rights, water conservation, and water pollution, is mounting from all four quadrants of the earth (Trolldalen, 1992; Synergos, 1993).

Collaborative solutions involve all groups with a stake in the problem in the process of resolving the dispute. Gray (1989, p. 11) identified five features of collaboration. They include: (1) interdependent stakeholders, (2) constructive management of differences among the parties, (3) joint ownership of decisions, (4) collective responsibility for carrying out the agreements, and (5) emergent decisions. Thus, collaborating represents a process of identifying and solving problems collectively by the parties involved. This, however, may prove to be extremely problematic since disputes over water resources are often protracted and bitter, pitting long-standing adversaries against each other. Moreover, water disputes typically involve multiple stakeholders-ranging from farmers, ranchers, and fishing interests, to government agencies, to manufacturing and natural resource industries, to environmental interest groups and non-governmental organizations concerned about economic development. These groups often have wide-ranging agenda that, taken collectively, complexity decision making (dark et al., 1991). Additionally, they often involve significant technical challenges that rival the difficulties of bringing warring parties to the table. Thus, launching a collaborative process to generate integrative solutions to satisfy the needs of diverse stakeholders requires considerable finesse and skill.

Theoretically, collaborating occurs in three phases. The first of these has been called problem setting (McCann, 1983; Gray, 1989) because one of the principle tasks is to collectively define the problem to be solved and the scope at which it will be addressed. Table 1 identifies several issues that constitute this first phase of collaborating.

Organizing a forum within which stakeholders can seek a collaborative solution is a major task of the problem setting phase for those who initiate a collaboration. Parties who have a stake need to be identified and persuaded to participate in a collaborative process (as opposed to relying on litigation or protest or other political tactics) to solve the problem. These and other difficult issues arise and must be addressed before the parties can begin to negotiate about possible solutions to the problem. In international disputes, additional problem setting issues revolve around jurisdictional issues such as sovereignty and property rights for the global commons (Golich & Young, 1993; Soros, 1986; Sebenius, 1992).

Another critical issue in problem setting is who will serve as a convener for the collaboration (Gray, 1989). The convener may be, but need not be, a stakeholder in the problem. The task of the convener is to identity and bring all the legitimate stakeholders to the negotiating table. This

requires that the convener have some convening power, or clout - that is, the ability to induce the participation of others. Wood and Gray (1991, p. 152) identified four dominant modes of convening. These differ according to the convener's influence (whether it is formal or informal) and the type of intervention strategy they employ (responsive or proactive). Responsive conveners initiate the collaboration at the request of certain stakeholders. Proactive conveners attempt to organize the stakeholders on their own initiative. See Figure 1. Experiences with different forms of convening will be described further below under what we have learned.

Figure 1. **Dominant Mode and Central Attribute of Conveners**

		Convener Has What Type of Influence:	
		Formal	**Informal**
Source of Intervention into the Problem Domain	**Requested by Stakeholders (Responsive)**	**Legitimation**	**Facilitation**
		Convener is perceived as fair.	Convener is trusted.
	Initiated by Convener (Proactive)	**Mandate**	**Persuasion**
		Convener is powerful.	Convener is credible.

The second phase of collaborating is called *direction setting.* During the direction setting phase, negotiations over the substantive problem take place. This phase involves identification of all the parties interests, search for common interests, generation of alternative solutions, and reaching agreement on one. Table 2 outlines the critical issues that arise during direction setting. Typically, in environmental disputes, it becomes necessary to deal with highly technical, frequently controversial information (about expected levels of risk or projected mitigation effects). In these cases it may be necessary for participants to make joint site visits to ensure common understanding of the issues. Joint data collection efforts of this type have proven to be extremely useful in broadening the perspectives of each side and in building rapport among the parties (Gray, 1989; Gray, 1993). When technical issues are particularly sophisticated, it may be necessary to contract with a neutral expert or convene a panel of experts to help the collaborative partners interpret the scientific information.

The final phase, *implementation,* begins as soon as the agreement is reached. Often times, what appears to be a deal, needs to be modified or amended to satisfy the negotiator's constituents or because unexpected events occur after the deal has been struck. Additionally, amassing the necessary resources and personnel to carry out the agreements may take some time and require the creation of a new governance mechanism to implement or monitor the agreement. Table 3 indicates a range of issues that may need to be addressed during the implementation phase.

Collaboration in Action

The number of examples of successful collaborations to address water-related problems is growing. These can be classified by the nature of the conflict or problem:

Threats to the natural environment. Disputes of this type arise because some stakeholders expressed concern that others' actions are creating damage to the ecosystem. One example of a

collaborative that successful dealt with this problem is the Mono Lake Group. The collaboration was initiated after a group of environmentalists (the Mono Lake Committee) sued the Los Angeles Department of Water and Power because of environmental damage to a reservoir supplying water to the city of Los Angeles. A collaboration was convened to reach agreement on future issues affecting the lake. The stakeholders in this project included the L.A. Department of Water and Power, the Mono Lake Committee, the L.A. City Council and Mayor, the U.S. Forest Service, the county supervisors, and the California Department of Water Resources. Technical assistance was provided by the Environmental Defense Fund. Among the agreements reached by the group is the decision not to solve their problems by shifting ecosystem damage to other locations. Issues under consideration included recycling and reimbursement strategies for water conservation.

A major controversy over construction of a hydroelectric dam and highway through the Mexican rainforest, Chimalapas, in southern Mexico, was resolved through a collaborative initiative known as the Chimalapas Coalition. The coalition included the states of Oaxaca and Chiapas (where the rainforest is located), the federal legislature and several ministries, environmental NGO's, human rights groups, and international organizations. The convening role was performed by Synergos Institute, a U.S.-based partnership-building group, who enlisted participation of groups reluctant to join the coalition. Synergos also served as a bridge to organize and facilitate discussions among groups who had no formal relationships, secure outside funding to assist in organizing indigenous peoples (the Campesinos) to participate and creation of a structure for the Coalition.

The Coalition has assumed a variety of organizational forms over the past four years, ranging from a tightly organized formal partnership to a loosely-coupled affiliation of independent groups (Synergos, 1993, p. 8). The Coalition's efforts have produced several positive outcomes: (1) resolution of long-standing land tenure disputes, (2) community plans for use and conservation of the forest, (3) state government commitment to upgrade public works and improve services to communities, (4) agreement not to build the hydroelectric dam and highway, (5) creation of a loan fund for small projects, and (6) plans for a campesino-controlled biosphere reserve within the rain forest.

Water Allocation. A collaboration to deal with a dispute over redirecting the flow of river water to the dried up Umatilla River in Oregon was convened by one of the stakeholders, the Confederated Tribes of the Umatilla Indian Reservation. The CTUIR persuaded environmentalists and state officials to seek an informal solution to the water allocation issues rather than formally stall a $100 million water management project on the Columbia River. The environmentalists and fishing interests were challenging state and federal agencies for failure to enforce existing water laws. With the help of a mediator from Confluence Northwest and a water law expert an agreement was reached that “provides for more water in the Umatilla River by exchanging Columbia River water for irrigation water currently taken directly from the Umatilla or reservoirs in the basin” (Consensus, 1992, p. 4).

Local Control of Water Resources. Another example of collaboration resulted in the transfer of oversight and maintenance responsibility for the management of a large-scale irrigation system from central government authorities to local farmers in Sumatra, Indonesia. A collaborative partnership among NGO's, government agencies, water users' associations, universities and international donors made this local empowerment effort possible (Synergos Institute, 1993).

Generating Regulations. One form of collaboration that is embedded within traditional regulatory apparatus is regulatory negotiation or negotiated rulemaking. Negotiated rulemaking brings together parties with a direct interest in a specific rule about to be promulgated by a government agency. The agency serves as convener. The parties assay the relative merits of alternative rules until they reach agreement on a mutually acceptable version that is then published for review and comment. Parties are offered the opportunity to review and sign off on the final version which the agency then promulgates. Two such processes illustrate how negotiated rulemaking can be used to address water disputes.

In Idaho a water antidegradation policy was hopelessly stalemated after two legislative efforts had received vetoes from two different governors. After the second attempt the governor invited industry and environmentalist opponents to try mediation. Each group was asked to prepare draft regulation that the Governor put forward. Mediation was intended to produce a compromise agreement that would then be used as the basis for detailed regulations and legislation. This collaboration was effectively mandated by the governor as he threatened to adopt the opposing sides draft regulations if the other did not participate. With mediation assistance from the Northwest Renewable Resources Center, an agreement was reached among the participating parties including: the Idaho Mining Association, the Idaho Farm Bureau, Intermountain Forest Industry Association, Idaho Conservation League, Idaho Sportsman's Coalition, The Wilderness Society, and the Nez Perce Tribe.

An eight state effort to cleanup the Great Lakes is also using regulatory negotiation. Under the auspices of the U.S. Environmental Protection Agency, standards are being set for the regulation of 140 pollutants found in the lakes.

Conclusion

The above listing of cases is certainly not exhaustive, but it serves to illustrate the range of water issues that lend themselves to solution through collaborative methods. Key to the process is selection of a convener who can organize the participants and bound the scope of the problem so that successful resolution is within reach. In the cases above, the projects differed in the type of convening mechanism. These are mapped in Figure 2. In international disputes that role may often best be played by a neutral nation state or by the United Nations or by a consortium of international organizations. For example, Trolldalen (1992) has suggested that the Global Environment Facility (GEF), a tripartite agreement between the United Nations Development Programme (UNDP), the United Nations Environment Program (UNEP), and the World Bank, may be an appropriate agency for conflict resolution.

Figure 2. **Dominant Mode and Central Attribute of Conveners**

		Convener Has What Type of Influence:	
		Formal	**Informal**
Source of Intervention into the Problem Domain	**Requested by Stakeholders**	**Legitimation**	**Facilitation**
		Mono Lake Group	Chimalapas Coalition Indonesian Irrigation
		Mandate	**Persuasion**

	Initiated by Convener	Idaho Water Degradation Policy	Umatilla River Dispute

Additionally, all but one of the processes described above relied on the assistance of a neutral mediator or bridging agency who ensured that a constructive process of dispute resolution was employed. Often this role is played by both a “process” and a “technical” expert to ensure that both the feasibility of the technical solutions and the dynamics of the negotiations are carefully attended to.

Collaboration is clearly not a panacea for dealing with the complex issues involved in water management, particularly in international settings. However, it does offer an alternative and implementable vision for addressing environmental resource disputes that otherwise will likely result in protracted adversarial squabbles and failure to evolve solutions that promote a sustainable planetary future. If we don't try collaboration, do we have another alternative?

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Table 1

Phase 1: Problem-Setting

Goal: Stakeholders Agree to Talk about the Issues

ISSUE	QUESTION	DESCRIPTION
Common Definition of the Problem	“What is the problem?”	Need agreement that a community issue causes problems important enough to collaborate. The problem must be common to several stakeholders.
Commitment to Collaborate	“What's in it for me?”	Stakeholders fed that collaborating will solve their own problems. Need to be dissatisfied with current conditions. Shared values are key.
Identification of Stakeholders	“Who should participate?”	An inclusive process that includes multiple stakeholders so the problems can be understood.
Legitimacy of Stakeholders	“Who has the right and capability to participate?”	Not only expertise but also power relationships important.
Leader's Characteristics	“Do I trust and respect the leader - the organization and the person?”	Collaborative leadership is key to success. Stakeholders need to perceive the leader as unbiased.
Identification of Resources	“How can we fund the planning process?”	Funds from government or foundations may be needed for less well-off organizations.

Inskip (1993). Adapted from Gray (1989)

Table 2

Phase 2: Direction-setting

Goal: Negotiating

STEPS	QUESTION	ISSUES
Establishing Ground Rules	“What is acceptable and unacceptable behaviour?”	Gives stakeholders a sense of fair process and equity of power.
Agenda-setting	“What are the substantive issues we need to examine and decide?”	Stakeholders' different motivations for joining mean that establishing a common agenda may be difficult.
Organizing Subgroups	“Do we need to break into smaller groups to carry out our work?”	Large plenary committees need to be broken into smaller working groups.
Joint Information Search	“Do we really understand the other side of this negotiation?”	Different sets of information and/or not enough information to make a judgement. Joint search can help find common basis and sort out which are common, opposing or different.
Exploring Options	“What are all the possible options to solving our problems?”	Multiple interests mean that multiple options need to be considered before closure. Stakeholders' own interests are important.
Reaching Agreement and Closing the Deal	“Are we committed to going ahead on one option or a package of options?”	Stakeholders can agree on recommendations for a formal organization or a joint voluntary course of action.

Inskip (1993). Adapted from Gray (1989).

Table 3

Phase 3: Implementation

Goal: Systematic Management of Interorganizational Relations

STEPS	QUESTIONS	ISSUES
Dealing with Constituencies	“How do we persuade our constituencies that this was the best deal we could negotiate?”	Stakeholders need time to make sure that their constituents understand the tradeoffs and support the agreement.

Building External Support	"How do we insure that organizations that will implement are onside?"	A concern that senior officials in Government or business have not been briefed fully.
Structuring	"Do we need a formal organization to fulfill our agreement?"	Voluntary efforts can work. A formal organization may be needed to coordinate long-term collaboration.
Monitoring the Agreement and Ensuring Compliance	"How do we figure out assets, legal obligations and compliance with contracts?"	Time for lawyers and possibly more legal/financial negotiations.

Inskip (1993). Adapted from Gray (1989).

Rio San Juan River Basin: A Case of Conflict in Management of a Bi-National Basin

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Note of the Editor: At the time of the publication of these proceedings, only the abstract in english of the presentation was available. Further details or the complete paper may be available by contacting the author at the specified address. Also, refer to the special paper titled Binational Management of the San Juan River Basin: From War to Cooperation, in Part VI.

ABSTRACT

The presentation will report on the progress of talks relating to the dispute on the Rio San Juan Basin. Prior to the Dialogue, a special meeting will be held at the North-South Center at the University of Miami where parties from Nicaragua and Costa Rica will meet to discuss the water quality degradation within the Rio San Juan River Basin.

The goal of these talks is to present a bi-lateral or bi-national view of the San Juan River Basin management and protection. It is very important since historically the political, institutional and legal development of Costa Rica and Nicaragua have been quite different. The results of those developments are different levels of exploitation of the river basin and different legal rules regulating the use and protection of the basin.

Though many efforts have been made during the past decade to protect the border areas in the bi-national coordinating effort, the San Juan River Basin which practically covers all of those protected areas has not been the object of significant bi-national regulation. The talks include representatives of both governments and scholars and the efforts that have been made to find a way to control the water quality in the Rio San Juan Basin. Particular emphasis will be given to the role of the Central American Commission on the Environment and the Bi-National Commission on International Systems for Protecting Areas for Peace.

Water Quality as a Top Priority for the U.N. Commission on Sustainable Development

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As the U.N. Commission on Sustainable Development (CSD) begins its work in earnest, there are many questions surrounding what the CSD can and should do to tackle the problems and solutions identified in Agenda 21, signed at the Earth Summit in June 1992. There are many broad procedural and oversight functions the CSD can satisfy, as well as some areas to break new ground, including developing standards and guidelines for development assistance to ensure investments are made in truly Sustainable development, creating an information clearinghouse for environmental data and environmentally-sound technologies, and providing a forum or mechanism for dependent auditing of international Sustainable development programs.

In addition to such general procedures, the CSD should make strategic and concrete progress towards solving a few key sectoral problems in the short-term as a hallmark of Sustainable development. By facilitating such progress the CSD will gain credibility among the international community. What follows are brief points for why water quality should be one of the CSD's priorities, what some of the problems are, and how to solve the problems, and what the CSD can do to help.

1. Make water quality a top short-term priority for CSD

Compared to other urgent international environmental issues where diplomacy, avoiding the appearance of environmental imperialism, and differing priorities among developing and industrialized countries makes for turbulent and tricky negotiations, water quality is something that everybody can agree on. And in many areas of the world, it's a relatively easy problem to fix.

- Safe drinking water and proper sanitation (e.g. primary sewage treatment) are basic human needs. Both developing and industrialized countries share concerns over human health, disease, and children's welfare. Contamination of water is an immediate, life-threatening, industry-limiting, mainly localized problem.

- Many U.N. agencies, like UNICEF, PROWESS, and HABITAT, have already shown that simple, low-cost technologies can make an enormous difference in treating waste and waste water, particularly in rural areas. There are many new technologies available for conserving water (thereby reducing the volume of waste needing treatment) and treating wastewater. Funding has been a limiting factor.

- Significant gains could be made in the near term, thereby illustrating that the CSD has a useful purpose.

2. Some facts about water problems

- More than 1 billion people lack access to adequate and safe water supplies, while

1.7 billion (almost one-third of the world's population!) lack adequate sanitation services.

• Large amounts of sewage are untreated; in Latin America 98% of sewage is not treated. As a result contaminated water supplies cause approximately 80% of diseases in the developing world. Diarrhea kills 4-5 million children per year.

• Fisheries, which provide 23% of the world's protein sources, are declining worldwide (both freshwater and ocean) due to water pollution, as well as from the loss of rivers and wetlands from damming, diking, draining, and deforesting activities.

• The economic and productivity costs are substantial. Cholera epidemics reduce agricultural exports and tourism (estimated $1 billion loss in 10 weeks of cholera scare in Peru). In Jakarta, Indonesia, $50 million is spent by households to boil water, in turn using large amounts of energy as well. For poor people in Bangladesh and Peru, the cost of boiling water is between 11 % and 29% of family income.

• Despite large expenditures on water-related projects by institutions like the World Bank, which has spent a cumulative total of about $35 billion, these problems continue to persist. Investments in water supply and sanitation were extremely inadequate throughout the 1980s; public investment was about 0.5% of developing countries' GDP for the decade.

3. What are the solutions to water quality problems?

• More financial resources, in “smaller bundles” are needed to invest in sewage collection and treatment. “Smaller bundles” means that huge World Bank loans and credits are not the only answer to this problem. In fact, UNICEF has estimated that 80% of the world's unserved could be provided services for one-third the cost of conventional approaches using low-tech, low-cost technologies.

• Mechanisms to mobilize private and community investment in water supply, sewerage, and sanitation should be promoted, as well as financial accountability of water utilities and disincentives for pollution like the “polluter pays” principle.

• There are numerous new, low-cost, clean technologies for waste water treatment and water conservation that are emerging that need to be transferred to developing countries. Governments should develop national policies, building codes, and appliance, fixture, and manufacturing regulations to promote low-water-using, clean technologies.

• There are innovative sanitation, hygiene, and public health programs being used to provide community-based health care at low-cost with high returns, such as de-centralized, local community health agents that provide education in nutrition, hygiene, health, and sanitation.

• Water conservation, particularly in urban areas, has the dual benefit of reducing per capita water use, reducing energy needs to produce hot water, and reducing the volume of wastewater needing treatment. Greater investments in municipal, domestic, industrial, and irrigation water conservation and efficiency improvements

are required from local, national, and international funding sources.

• Multi-lateral development banks, bi-lateral agencies, and U.N. Agencies need to make water supply and sanitation a high priority in their budgets. Yet, they should invest far more in low-cost, de-centralized, community-based sanitation programs than in capital- and resource-intensive, high-tech tertiary treatment plants are large dams.

• NGOs, private voluntary organizations, local governments, and for-profit and non-profit businesses should be the primary providers and disseminators of these investments, projects, and educational programs.

4. What can the CSD do to improve the world's water quality?

• Convene a Working Group on Global Water Issues, which would include the major players such as the World Bank, the regional development banks, UNDP, UNEP, UNICEF, WHO, WMO, GEF, NGOs, and other knowledgeable people.

• Develop, in conjunction with other international agencies, governments, NGOs, etc., water quality goals, such as tripling the coverage of primary sewage treatment by 2000.

• Develop guidelines for development assistance to achieve water supply and water quality goals so that the investments of the MDBs, UNDP, GEF and UNICEF, bi-lateral aid agencies, etc. are efficient, socially acceptable and environmentally sound. Guidelines should include a focus on water conservation and re-use before development of new supplies, extending services to the un-served first, preventing pollution through source reduction, determining the community's desired level of service, and making pollution data available to the public.

• Make water quality improvements a strategic issue that deserves top budget priority in UN agencies, multi-lateral and bi-lateral aid institutions, and national programs. Only 1/5 of World Bank lending for water and sewerage projects is spent on sewerage and sanitation components. Governments should be encouraged to shift new loans, credits, and grants away from large-scale infrastructure projects like dams towards water conservation and re-use, rural water supply and sanitation, and wastewater treatment.

• Implement Chapter 18 of Agenda 21, relying on national reports (as required by Agenda 21), Country Environmental Action Plans (as required by the World Bank), Regional Strategy papers of UN agencies and MDBs, and other relevant sources, to develop a coherent framework and list of priorities in the water sector, such as:

- the World Bank's forthcoming Water Resources Management Policy, which emphasizes water conservation and demand management;

- the World Bank/UNDP partnership to develop a guide on capacity building in the water sector;

- UNICEF's community-based water supply programs;

- the Organization of American States' InterAmerican Dialogue on Water Management to build a network of experts, data, and policies;

- local government and community-based programs for public health, like Viva Crianca in the state of Ceara, Brazil (winner of the 1993 UNICEF Maurice Pate Award); and

- NGO projects to provide low-cost, small-scale drinking water supplies in rural areas, such as the village ponds built by Utthan Mahiti in India's arid Gujarat state.

The World Bank - Water Resources Management Policy

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Note of the Editor: Documents related to the World Bank's Water Resources Policy can be obtained directly from the author at the specified address. At the time of the publication of these proceedings only abstracts of this presentation were available.

ABSTRACT

The World Bank, from its early days, has had a very active assistance program for water resources management. By the end of 1991, the Bank had lent over US$ 34 billion for water operations. Projections for the next five years indicate that about US$ 19 billion will be lent for water resources investments, in close to 200 projects. While this is a significant portion of Bank operations, it is only a small fraction of developing countries' projected investment needs in the sector, which may total US$ 700-800 billion for the next decade.

Countries are now faced with increasing difficulties in meeting the demand for cheap, clean and reliable water supplies, because of fragmented management, overreliance on government agencies, and neglect of pricing, participation, and the environment. A new approach is called for, one that recognizes that water is both a basic need and a scarce economic resource.

This approach is set out in the Bank's Water Resources Management Policy Paper, which was approved by the Bank's Board of Directors in May 1993. The paper seeks to balance, in particular, two fundamental considerations:

- the need for a holistic management approach that gives due weight to longer term factors and to protecting the ecosystem, and

- the advantages of relying more on markets, pricing, and decentralized management to improve the allocation of water among competing uses.

The key to achieving compatibility between these considerations is the establishment of proper legislative, regulatory and institutional arrangements capable of maintaining coordination and coherence in policies and investments, as well as facilitating the utilization of market forces.

In the process of developing its policy, the Bank engaged in a wide ranging consultation with

borrowing countries, international agencies, and NGOs. Through this process, the Bank benefitted from many insights provided by knowledgeable sources.

The main features of the policy are:

- development of a comprehensive analytical framework for water resources management;
- greater emphasis on incentives, pricing, demand management, and cost recovery;
- establishment of strong legal and regulatory frameworks;
- decentralization of water services delivery while at the same time establishing coordination mechanisms;
- promotion of wider participation by stakeholders;
- greater attention to the protection, enhancement, and restoration of water quality and water dependent eco-systems;
- priority to the provision of adequate water and sanitation services for the poor.

This is an ambitious agenda. In most countries, its implementation will be gradual, dealing first with priority issues which differ from country to country.

ECONOMIC DEVELOPMENT INSTITUTE OF THE WORLD BANK (EDI) TRAINING STRATEGY IN THE WATER SECTOR (FY 94-96)

Water is essential to all human activities. However, in the years to come, water shortages and pollution are likely to cause extreme hardship in the poorer countries, national and international conflicts, and practically irreversible damage to the environment. In many parts of the world, this has already occurred.

There is a widespread consensus that, to address the complex and multi-disciplinary issues associated with the water sector, (a) water management should be approached in a comprehensive inter-sectoral manner, integrating the whole set of policy, institutional, economic, financial, technical, environmental and social dimensions, so as to plan, develop and operate water systems in a sustainable manner, (b) capacity building activities should be undertaken to increase the capacity of policy makers, decision makers and managers to design and implement sustainable policies and programs of action for efficient and comprehensive management of the water sector, and (c) human resources development, including making people aware of issues and of approaches to resolve them, and developing a cadre of trained professionals, is a cornerstone for capacity building.

The basic objective of EDI's strategy in the water sector is to increase the capacity of people who make or influence policies, to help them design and implement sustainable policies and programs of action to manage the water sector in their countries. EDI pursues this objective by (a) designing and implementing national and regional programs, including seminars covering the whole range of water sector issues, and assisting national institutions to establish continuing training programs, (b) helping to create and operate international networks amongst training and related institutions to stimulate contacts among members, and (c) launching regional programs

to strengthen water training institutions.

The above capacity building activities are designed and carried out in partnership with the concerned institutions and individuals in the Bank's member countries, and with external multilateral and bilateral agencies. In order to achieve lasting effects, activities should continue during several years, and be progressively taken over by the concerned countries.

Elements of a typical national program include: (a) a series of seminars, prepared and implemented in collaboration with a national partner institution and a cross-section of stakeholders. The seminars would use as guiding themes the main concepts included in the World Bank's Water Resources Management Policy Paper and in Regional Strategy Papers, and themes identified by the participants during the preparation of each of the seminars; and (b) a program of assistance to the partner institution.

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The Issue of Equity in International Environmental Negotiations: The Perspective of Developing Countries

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From the time of the Stockholm Conference on Human Environment, the activity in the field of international environmental law has increased. There are now about 140 multilateral treaties and hundreds of bilateral treaties on environmental issues. Most of them apply to environmental issues in a rather limited manner, either from a geographical perspective, meaning that they apply to specific pieces of geographic regions of the world, or from a subject-matter point of view, meaning that they apply to a specific species or to a specific natural resource.

Probably the most important result of the efforts of the past twenty years is understanding that the earth is not an infinite place or source of goods, but rather a very limited place, and that the resources stored in the planet may be exhausted. This understanding has taken on a feeling of a threat: if we do not find solutions, something bad is going to happen in the future or maybe even in the present. The concepts of the extent to which the global ecosystem components are linked, and the understanding that the global ecosystem is adjusted, together we have changed our approach to solutions.

This is one of the first times that the international community has understood that certain problems need a global solution. Few cases in the past have brought countries together politically, to try to solve a problem they agreed global. For example, in the nuclear arms race case, the feeling of global threat was never stronger than the feeling of national security held by the few countries that owned all the nuclear arms; so, a global solution was not achieved. Another case was the Law of the Sea Convention negotiations, in which one component of

earth's ecosystem was certainly viewed from a global perspective. A global understanding of the management of the seas was attempted, but, after ten years, this convention still has not entered into force, for various reasons, indicating that the global understanding of the oceans' role within earth's ecosystem did not prevail.

Addressing environmental problems may be the first time industrialized countries have wanted something really bad. They realize that they all need to do something about the environment. For developing and middle-income countries, too, this is the first recognition of potential harm if they follow the same development patters the industrialized countries have followed for the past 150 years. The realization of the need to find a global solution has taken place in the latest three or four years. There are about fifteen international meetings per month on various international global issues. International environmental law is being developed as we speak.

An issue the international community has understood is the grave extent of global deterioration of the environment and the need to repair it. We are not talking about deterioration that may happen in the future. Environmental deterioration is already harming communities and ecosystems. Something must be done.

To agree on what has to be done by whom, we call upon the principle of equity. In the last four years, participating in international negotiations, I have heard six different conceptions of the equity principle. It is a difficult concept, how you define it?. I have taken the task of writing down every time a country offers a different definition of equity, and I want to share the results with you. Although I will put forward questions and not solutions, the underlying purpose in this definition of equity is finding the criteria for distributing the costs of global environmental protection, whether for purposes of mitigation, adaptation, or compensation.

One concept of equity frequently utilized is that we must understand the historical responsibility of countries in the present situation of global deterioration. This concept immediately puts the burden on developed countries. For the last 150 years, their industrializing processes have irrationally, maybe even irresponsibly, used natural resources. This has made possible their present standards of living, twenty times higher that the average standard of living in developing countries. Therefore, an equitable response dictates that these rich countries who have run upon the bill, pay the costs of repairing the global environmental deterioration.

There has been also mention of “present responsibility”. Some delegates in negotiations say that we do not have to talk about historical responsibility, but simply by speaking of present responsibility we have a hint of who is causing the problem. Today, in 1993, any ordinary citizen of a developed country consumes twenty times more of everything than an ordinary citizen of a developing country. So, those who have the better standards of living at present should pay for them. This input could be used to protect the environment.

Another idea related to responsibility emerges with the concept of liability. In Spanish, responsibility means both responsibility and liability. But in the English language, there is quite a distinction between responsibility and liability. This is why liability has to be mentioned. Liability in Anglo-Saxon law brings in the element of intention or negligence, an element of the torts system of law. So, in this case an equitable response is that whenever environmental damage is proved, those who are liable should pay for it. We now have listed three different concepts to support the definition of equity.

Another criterion for defining equity states that resources of the world should be distributed in an equal manner. These global resources are defined as “global commons”, or a common heritage of mankind. Many developing countries, who possess most of the earth's natural resources, react to this concept. This is true with Mexico. In recent negotiations regarding biological diversity protection, the concept of common heritage was brought up. The response was in effect: “This is not a common heritage of mankind; it is a heritage of the Mexicans, both present and future generations. We are not ready to give away these resources, which, according to the principle of sovereignty over natural resources, belong to the Mexican nation”. A similar response was given by the Brazilians when it was said that the Amazonian forest was a common heritage of mankind. Furthermore, a similar response came from such countries as Malaysia, India and China.

The concept of equal distribution of the global commons gives rise to discussion of the intergeneration equity concept, which states that present generations are not absolutely free to do anything they want with present natural resources. They must, in justice, protect those resources for future generations. Therefore, equity is defined as an equitable distribution of resources between present and future generations. Again, the political response is why should a Brazilian or Indian Community stop cutting trees for fields to allow future generations of Canadians or Norwegians to live better? The Brazilians of Indians want to live better today, and they have basic needs.

When debating about present and future elements of intergenerational equity, another element is encompassed: what about what past generations did? We see again the historical element brought onto the table. Past generations undertook certain patterns of development that allowed present generations, in some areas of the world, to have excellent standards of living. The question follows: Why do not share what past generations did, among present generations? This concept is also called intragenerational equity. It takes the stance that we cannot talk only about equal distribution between present and future generations; we must also talk about equal distribution among present generations.

A proposal has been put forth in several negotiations that we should achieve a convergence at a common per capita level of consumption through a treaty, establishing international legal standards. To achieve this common per capita level of consumption of a given resource, we must take into account basic needs. What are the basic needs that any human being must satisfy to be considered living decently? Here, many sociological arguments come into play, because the basic needs for a warm country are rather different from basic needs for a cold country. The basic needs for a fishery community are very different from the basic needs of a forest dwelling community.

Another criterion for defining equity is “preserving the status quo”. In Anglo-Saxon law, this is known as “adverse rights” “squatters rights”, or “appropriation rights”. It is a principle known in Roman law as “first in time, first in right”, or “first come, first served”. In this sense, it is questionable whether such rights can be applied to pollution rights. Should a country that has achieved certain pollution levels have the right to maintain those pollution levels? There is a precedent in that respect in international law. Some specialists consider this principle to be the basis for the Montreal Protocol on Ozone Depleting Substances. In this protocol, a baseline for consumption of chlorofluorocarbons (CFC's) the substances generating the increasing hole in the stratospheric ozone layer, was established: a certain baseline for developed countries and a

certain baseline for developing countries. From that baseline onwards, countries have different obligations. The obligations for developed countries are stricter than those for the developing countries. But the idea of establishing a baseline already exists.

Another criterion for defining equity is brought to the table when people mention a political will to pay. We are talking about a global problem that must be solved. Forget about everything except this criterion: those who have resources should show the political will and interest to do something about it, just because they have the resources to pay for it. Again, the burden falls on developed countries, at least at the international level. However, this idea will immediately prevail in internal or domestic law when finding ways and means to protect the environment at the domestic level.

One criterion more calls for “distributive justice”. It aspires to a new international economic order with the idea of “starting from scratch”.

Together all the described concepts of equity make the issue of finding a solution to global environmental problems, become very complicated. Many of these concepts are recriminatory, finger pointing toward certain groups of countries. Negotiations experience illustrates that one has to be very pragmatic, and the goal must be to find a formula that works. A combination of all the criteria mentioned previously might build a consensus for defining equity, that could provide the basis for further understandings from which to find solutions to global problems. The result in a concrete agreement would be that the north developed, countries, and South developing countries, would take similar measures regarding certain environmental problems. But the equity perspectives of the two groups of countries are different.

In the end, the perspectives of the two groups of countries do not matter. Rather, the important point is to reach concrete measures. This has to be used in a positive way for humanity. Equity cannot be defined in a unilateral or simplistic manner. It is very critical to a global solution to agree upon a definition of equity.

Finally, I want to touch on the aspect of governance, a current development in international negotiations. By understanding Principle 21 of the Stockholm Declaration, countries are realizing that sovereignty cannot be claimed in the traditional sense any more. It is clearer to all countries that they must at least share information regarding internal activities that cause transboundary impacts. This is very poorly understood, yet has reached global levels. There is no mechanism at the international level that truly accomplishes the goal of setting a framework for countries to share information and later enable them to agree on measures.

To speak of governance means to speak of I a system of review of the action of countries, regarding environmental problems, no such system in place allows exchange of views in an impartial, neutral and positive manner. It is to be hoped that within the next twenty years, we will see the development of new governance rules it the international level.

Integrated Conservation Planning in the Cuiabá River Basin, Mato Grosso, Brazil

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ABSTRACT

The Pantanal is the world's largest freshwater wetland, and one of its most productive wetland wildlife habitats. It covers over 140,000 km^2 in Brazil alone.

Over the past 250 years traditional development, especially cattle ranching, had been compatible with conservation of the Pantanal, but current trends threaten the dynamic processes that sustain the wetland system.

The Nature Conservancy in partnership with Ecotrópica Foundation has launched a major initiative to protect the biological diversity of the Cuiabá River basin, one of the Pantanal's main tributaries.

The three most significant activities affecting the water basin are: a) agroindustrial development in the water basin, b) intense gold and diamond mining, and c) urban and regional development. In addition, the proposal to create a transportation link between various countries in Brazil, Paraguay, Bolivia, Argentina and Uruguay, represents a major threat to the stability of the complex hydrologic regime.

Efforts will begin with the development of an integrated conservation plan for the northern Pantanal, which will include an in-depth study of the region from the ecological, social, and economic points of view. Threats and their causes will be identified, conservation priorities will be established, and solutions will be proposed which take into account the needs and aspirations of the local inhabitants. The expansion and protection of a core area in and around the Pantanal National Park will be considered.

The product of this study will be an Integrated Conservation Plan for the Cuiabá River Basin, describing the dynamics and problems of the region and containing specific recommendations for conservation and compatible development action.

When the Plan is completed, the Ecotrópica Foundation with support from The Nature Conservancy will work to secure the cooperation of the public and private sector in order to implement its recommended actions.

KEYWORDS

Pantanal, wetland, river basin, biodiversity, threats, bioreserve

THE PANTANAL ECOSYSTEM

The Pantanal is the largest freshwater wetland in the World, covering over 140,000 km^2 in Brazil alone (EMBRAPA, 1993). In the Pantanal three distinct floristic stocks - cerrados, Amazon forest and Chaco - come together in a complex mosaic of terrestrial diversity (Prance, 1982). The cycle of heavy tropical rains in the wet season causes the Pantanal's rivers to overflow, flooding an area the size of Nebraska.

The geomorphology of the Pantanal consists of an alluvial plain, which varies between 100-200 m in altitude and is surrounded by a crystalline plateau - *planalto* -, approximately 600-700 in altitude, covered with cerrado vegetation.

During the dry season the waters recede, exposing rich grasslands and forests, dotted with countless lagoons and marshes. The temperature is hot and rainy in the summer and mild and dry in the winter with average temperatures of 32°C and 21°C respectively. Average precipitation is between 1,000 and 1,400 mm per year, concentrated between December and March. It is estimated that 92% of the plains are composed of hydromorphic origin and more than 70% of the soils are considered to be low fertility (EMBRAPA, 1993).

This cycle makes the Pantanal one of the world's most productive wetland wildlife habitats. Millions of waterfowl breed and feed along its rivers and lagoons, and dense populations of jaguars *(Pantera onca)*, capybaras *(Hydrochaeris hydrochaeris)*, marsh deer *(Blastocerus dichotomus)*, giant anteaters *(Myrmecophaga tridactyla)*, hyacinth macaws *(Anodorhynchus hyacinthinus)*, rhea *(Rhea americana)* and others thrive in its forests and grasslands. The waters themselves are home to vast numbers of caimans *(Caiman crocodilus yacare)*, giant otters *(Pteronura brasiliensis)*, and a great diversity of fish species. There have been 80 species of mammals, 650 species of birds, 50 reptiles and amphibians, and 260 fish recorded from the Pantanal region. The abundance of aquatic and terrestrial life forms in the Pantanal is nothing short of spectacular. The geomorphology and evolution have conspired to produce a complex ecosystem of international patrimony (Mittermeier et al., 1980).

The Pantanal clearly warrants a major conservation effort. Over the past 250 years traditional development by the *Pantaneiros* had been compatible with conservation of the Pantanal, but current land use trends threaten the dynamic processes that sustain the wetland system. In particular, the plan to create a transportation link between the countries of the *Mercosur* - the proposed regional economic integration program, or “common market” between Brazil, Paraguay, Bolivia, Argentina and Uruguay - represents a major threat to the stability of the complex hydrologic regime. The focus of this paper is on international collaboration to protect a sub-basin within the Brazilian Pantanal, the Cuiabá River basin.

Cuiabá River Basin

The origins of the Cuiabá River lie in the Serra Azul in the sub-basins of the Manso River and its tributary, the Casca River. These headwater basins of the system cover an area of about 4,650 km^2. The Cuiabá River is the principal tributary of the Paraguay River, and consequently of the Pantanal of Mato Grosso. It extends 1,000 km from its origin to its confluence with the Paraguay River. Draining an area of approximately 100,000 km^2, it reaches its mouth with an average discharge of 480 m^3/sec.

The complexity of the hydrological regime reflects that of the greater Pantanal. While hydrological studies have documented, at least superficially, the dynamics of the water basin (UNDP, 1973), they also indicate the presence of a network of underground streams and subsurface water movement. A more in-depth assessment of the hydropatterns of the basin is necessary to better understand the effects of specific human activities on the system, and to develop plans to counteract those effects.

The Cuiabá River basin was one of the first colonized areas in western Brazil, where *Bandeirantes* arrived in the sixteenth century using the Paraguay river to gain access to the region. Over the centuries development pressures have been steady, but have had relatively low impact. The tradition of cattle ranching in the low lying areas of the region has been a major

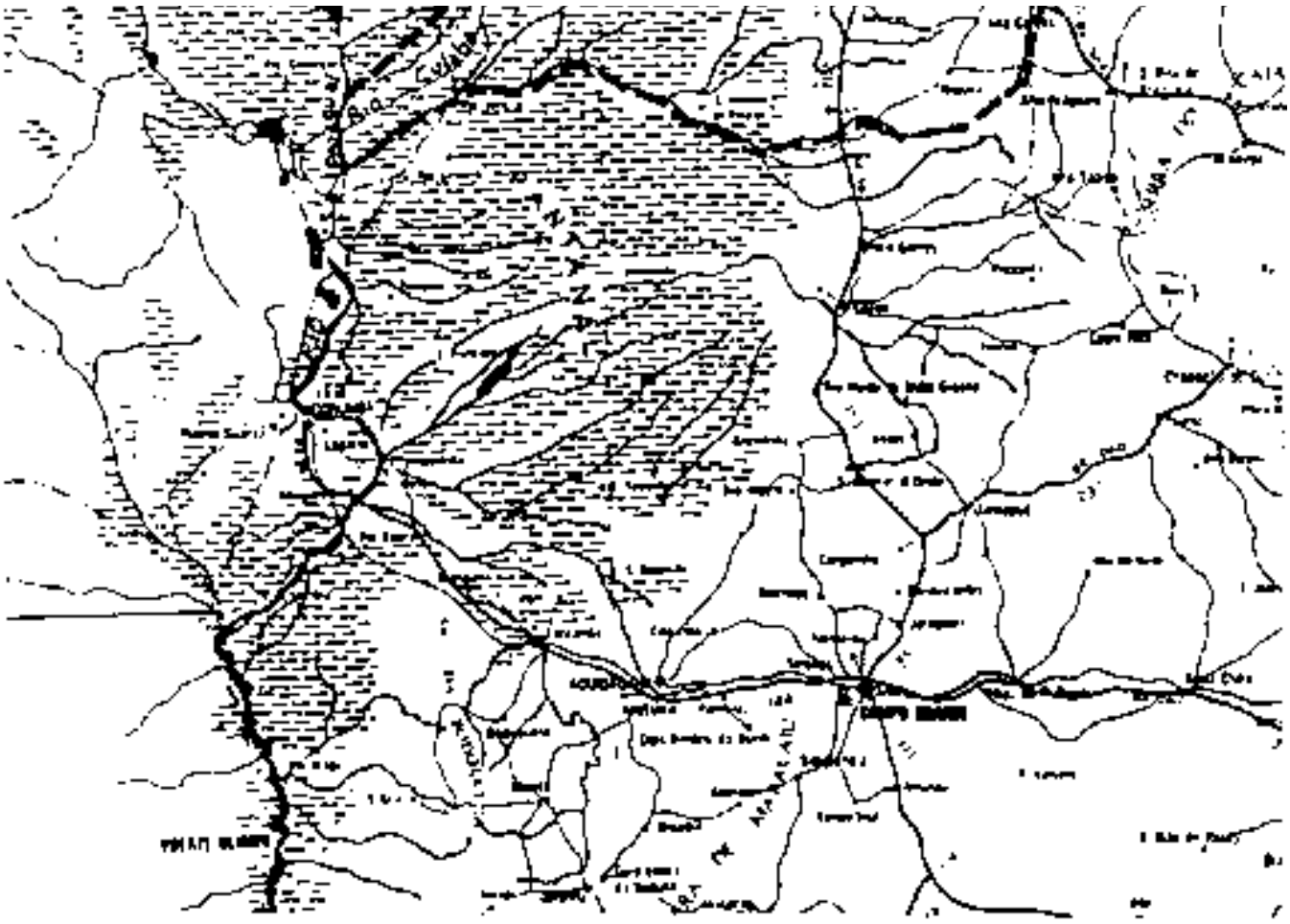
contributor to the current, relatively healthy, state of the basin.

The three most significant activities affecting the water basin are: a) agroindustrial development in the upper water basin, especially soybean; b) intense gold and diamond mining resulting in increased sediment load and mercury contamination; and c) urban and regional integration development efforts and their impact on the environment.

Agriculture

For the past 200 years, the principal economic activity has been cattle grazing in the lower basin. There are an estimated 3.8 million head of cattle which produce approximately US$60 million per year (EMBRAPA, 1993). The development of cattle ranches in the Pantanal has been compatible with maintenance of the hydrological patterns and, while localized impacts can be noted, this traditional activity has provided an economic base for local landowners, the *Fazendeiros.*

LOCATION OF THE PANTANAL REGION



In the late 1960's there was a boom in development activities in the *planalto* of the Pantanal region, caused in part by stale efforts of regional integration and by natural expansion pressures. The development of two agricultural technologies have had a major effect on the water quality of the Pantanal: the production of large-scale cash crops and biomass fuel production. The expansion of mechanized soy production is of particular concern because of the system-wide effects of non-point water pollution (Alho, et al. 1988).

The most important crop in the upper basin region is soybean, grown in extensive monoculture, followed by rice, corn, beans, cotton, sugar cane, and wheat. These crops are grown mainly in upland areas; agriculture in the Pantanal plain comprises a very small proportion of the total economic activity (EMBRAPA).

With the possible expansion of agriculture in the Pantanal as a result of the improved transportation networks being proposed by the development of the Hidrovia project, one of the possible negative aspects would be the transportation of toxic cargo by boat, with the risk of accidents and serious environmental consequences.

Socio-Economic Considerations

The grasslands of the Pantanal have been used for grazing cattle for hundreds of years. Traditional families own huge ranches, worked by men whose ancestors have lived in the Pantanal for generations. The herds share native grasses with capybaras and deer, and a rotating pasture system ensures that there is plenty for cattle and wildlife. Especially-bred *Pantaneiro* horses, whose gait allows them to cross marshlands without miring, are used to drive

the cattle to market.

A rich cultural tradition has developed in the ranches of the Pantanal, expressed in music, dress, food, lifestyle, and philosophy of life. This *Pantaneiro* culture embodies a deep respect for nature. The *Pantaneiros* are very protective of “their” wildlife, with both land owners and local inhabitants showing a high level of concern for the environment. However, poverty brought on by a lack of education and opportunity often overwhelms environmental concerns among the rural inhabitants, and ranchers faced with changing economic conditions are increasingly yielding to development pressures. Still, few cultures are more willing to find solutions to such conflicts.

There is little information on the distribution of wealth in the Pantanal, but it reflects that of Brazil as a whole. While multi-billion dollar development schemes are often provided incentives by the federal government, and in the case of Hidrovia multiple governments, in many instances local peoples do not welcome projects which would change the entire socio-economic landscape of the region. In the Cuiabá River Basin, a consortium of the basin's municipalities has been created to “save the river and protect their environment.” The consortium has as its goal to “encourage practical action in the preservation, recuperation and conservation of the Cuiabá River” (*Diário de Cuiabá,* 1992).

“It is hard to demand of political leaders, especially those who rely on the voles of the living to achieve and remain in high office, that they ask those alive today to bear the costs for the sake of those not yet born, and not yet voting. It is equally hard to ask anyone in business, providing goods and services to the living, to change their ways for the sake of those not yet born, and not yet in the marketplace. However, sustainable development will ultimately be achieved only through cooperation among people and all their various organizations, including business and governments.” (Schmidheiny, 1992).

Integrated Regional Development Planning in Cuiabá

The Nature Conservancy is well known for identifying biologically significant areas, designing and managing preserves, and acquiring land to meet the conservation objectives established through preserve design. Several years ago the Conservancy resolved to broaden its vision of conservation of biological diversity through its “Bioreserve” initiative. The Bioreserve methodology is based on the Biosphere Reserve concept of the Man and the Biosphere Program (UNESCO-MAB). Using the biological inventories conducted by the Natural Heritage Programs in the United States, and the Conservation Data Centers in Latin America, The Nature Conservancy has identified focal areas based on our mission of helping to protect biological diversity. While some of the threats to the critical biological areas in Latin America are being addressed through the *Parks in Peril* program, buffer area programs are being developed in broad collaborative efforts, and integrated regional development planning provides the framework for the cooperation required for both of these efforts.

Integrated regional development planning is a response to a regional environment in which, instead of confronting environmental complexity by subdividing issues into sectoral components, the region is divided into spatial units with the aim of examining the sectoral interactions (OAS, 1984). Interactions of this kind are often conflictive for two reasons: (a) competition for the same goods or services by two or more interest groups; or, (b) a change in the mix of available goods

and services as a result of the activities of one sector which are detrimental to another sector. In integrated regional planning efforts, the interaction with neighboring areas is also analyzed. Consequently, regionalization is necessary, and once such regional and subregional environments are defined, as has been done by the Ecotrópica Foundation in collaboration with The Nature Conservancy, connections between neighboring units can be analyzed.

There are two important distinctions between The Nature Conservancy's Bioreserve planning methodology and other integrated regional planning efforts. The first is the emphasis in the early stages of the planning process on threat analysis, at the ecosystem and species levels. The second is inviting broad participation in the planning process. People within the region who will be most affected by development decisions are encouraged to define and take control of their own environments by making their needs and desires known in the planning process. This is fundamental to the network approach espoused by Michael Carley and Ian Christie (1993), where they discuss the “Top-down or bottom-up” approaches to sustainable development planning. Many of the recent environmental and development disasters have been driven by short-sighted, short-term, top-down development decision-making.

Bioreserve planning utilizes methods of systems analysis and conflict resolution to attempt appropriate distribution of the costs and benefits of development activities throughout the affected populations or sectors. Thus, conflict identification and resolution strategies are fundamental requirements if a development plan is to be “integrated” and implemented. Sectoral integration is necessary because individual sector activities may help, but often hinder the activities of other sectors in their efforts to appropriate goods and services from the same and allied systems. The decision as to which activities are the correct ones or how each can be adjusted to reduce conflict can only be made through negotiation by the parties involved and not by an individual sector - be it conservation, forestry, mining, agriculture or livestock production - trying to dictate to other sectors.

Threats

The most ominous threats to the Pantanal are the land use practices leading to the degradation of its water basins and resulting decline in water quality. The waters of the northern Pantanal come from the upper Paraguay and Cuiabá rivers, which originate in northwestern and central Mato Grosso state, a scrub forest region being convened to agricultural uses such as soybeans, sugar cane, rice and corn. Causes of degradation include:

Deforestation for agriculture, which causes soil erosion and silting of rivers.

Mining and the sediment and chemical contamination associated with this activity.

Non-Point Source water pollution from agricultural runoff, including pesticides and fertilizers.

Point Source water pollution originating from growing urban centers such as Cuiabá, Caceres and Várzea Grande.

Artificial drainage to create new pastures and fields. Dikes and canals built in upstream farms alter water flow patterns and intensify floods downstream, affecting the natural balance between wet and dry.

Threats specific to the Pantanal's wildlife include:

Overfishing for edible and ornamental fish. Regulations such as closed seasons and size and catch limits are inadequate and not observed by commercial fishermen due to lack of enforcement.

Poaching. Targets include hyacinth macaws, parrots and toucans for the illegal pet trade, and caimans, jaguars, and otters for their skins. Due to lack of patrolling, and isolation from traditional farms, poaching is heavy inside the Pantanal National Park.

Uncontrolled tourism. Tourism without proper planning and infrastructure is rapidly growing in the northern Pantanal. Detrimental effects include illegal sport fishing, disturbance of wildlife, excessive noise in bird nesting areas, and demand for pollution-causing urban conveniences.

Insufficient protected habitat. Much of the Pantanal's fauna requires forested habitat, which is scarce within the national park's boundaries, and is thus inadequately protected.

THE PANTANAL PROGRAM

The density of wildlife populations in the Pantanal creates an excellent opportunity to preserve one of the most endangered components of the western hemisphere's biodiversity. A properly delimited protected area system in the Pantanal would protect an impressive array of mammals, parrots, waterfowl, caimans, and fish. Yet in this vast wetland there are only two conservation units, Taiama Ecological Station (14,325 ha/35,383 acres) and Pantanal National Park (135,000 ha./333,450 acres). In addition, the dynamics of the Pantanal ecosystem are themselves unique in the world. Recognizing the importance of this extraordinary ecosystem, The Nature Conservancy in partnership with the Ecotrópica Foundation has launched a major initiative to protect the biological diversity of the Cuiabá River basin in the Pantanal. The goal of the Pantanal Program is to preserve critical habitat and natural processes while promoting compatible development in the Pantanal as a whole. While compatible development in the buffer areas is essential, we will also focus on providing an infrastructure for expansion and protection of a core area in and around the Pantanal National Park.

The Core Area

The 135,000 ha (333,450-acre) Pantanal National Park, located at the confluence of the Cuiabá and Paraguay rivers, was created in 1976 out of a single cattle ranch, Caracará. This is the only national park in the Pantanal. The former Caracará farm has since been identified by the conservation community as an important area to protect. In the initial recommendation for the park's establishment, however, biologists recognized that what is now the Pantanal National Park, by itself, would not provide significant variety of seasonally inundated and “dry” forest cover to maintain viable wildlife populations. The initial study of this site recommended that the reserve be increased in size to include neighboring areas with representative forests and dry lands (Couto, et al., 1975).

Clearly, then, the park's borders as they currently stand do not take these conservation needs into consideration. As a result, two deficiencies in the park's design are readily apparent: the protected area contains vast grasslands and marshes but only small samples of forest habitat (12%), and 95% of the park is submerged during the floods, with a large proportion of its

mammal fauna being forced to migrate to unprotected areas. Biological research indicates that in order for animals to follow resources from place to place during regular yearly cycles, a well-chosen reserve should include habitats in which the temporal behavior of vegetation is synchronous. If only one habitat is home to a complex of species, adjacent, different habitats may provide the resources at a short but critical time of year to maintain species' populations (Foster, 1980). While at present the Pantanal National Park is surrounded by low-density cattle ranches which are compatible with wildlife, development schemes and changing land use patterns threaten the long-term viability of the conservation unit.

The Pantanal National Park, which has been identified as the core area for regional planning efforts, lacks adequate infrastructure and has only one government ranger on site. The ranger's patrol boat often lacks fuel, and the headquarters building where he lives with his family is in dire need of repairs. Financial support for building infrastructure through the National Program for the Environment (PNMA) has been available to resolve immediate infrastructure needs, but according to the Brazilian Institute for the Environment (IBAMA) staff in Cuiabá, the regional office is unable to take advantage of this program because of inadequate administrative capabilities.

With the addition of a private reserve adjacent to the Pantanal National Park, private sector experimentation with stewardship activities can be conducted without entering into cumbersome bureaucratic channels. The principal stewardship challenges are: 1) maintenance of successional stages, 2) removal or mitigation of the effects of alien plants and animals; 3) the repair and prevention of poaching, overuse, and other human impacts; 4) meeting the effects of climatic and hydrologic changes; 5) intercepting or diminishing the effects of incompatible external influences such as water pollution; 6) facing legal challenges such as reserved mineral extraction or water rights; 7) coping with the effects of past alterations and the absence of key species such as predators; 8) resisting further extinctions (Pyle, 1980). And one of the most important factors is scientific research. Ehrenfield (1970) notes that “before a natural community can be managed, its principal elements and their principal interactions must be known.”

1. Protected Area Expansion

The Pantanal National Park was chosen to be the program's cornerstone protected area due to its federally protected status, lack of land tenure problems, large size, and rich aquatic and grassland habitats. The *Rapid Ecological Assessment* of the Pantanal National Park and its surroundings (The Nature Conservancy et al., 1992) clearly demonstrated the need to expand this protected area. While the Pantanal National Park protects adequate extensions of the Pantanal's lagoon, marsh, and grassland habitats, it does not contain viable samples of the wetland and forest habitats typical of the northern Pantanal. These habitats are essential for the survival of a significant proportion of the Pantanal's wildlife. Twenty-seven percent of the region's bird species live exclusively in forests, for instance. Currently, 16,200 ha (40,014 acres) of forest are protected within the national park, most of it broken up into small fragments. In order to preserve a representative sample of the Pantanal ecosystem, additional forest habitat must be protected.

The REA identified several heavily forested areas adjacent to the park which are ideally suited for this purpose. High concentrations of forest fauna were found there, including many species not observed within the park. In addition, the areas appear to contain significant amounts of drier

land, and are thus valuable as a refuge for the park's large mammals during the flood season.

It is the intent of this collaborative effort to acquire land to establish a reserve, to be owned and administered by an in-country non-governmental organization. Together with the national park, this reserve will preserve viable samples of the major lowland habitats of the northern Pantanal. Thirty three thousand two hundred hectares (82,000 acres) of land has been proposed for acquisition. Over 49,400 ha (122,000 acres) of forest, combining forest cover in the park and the private reserve, would thus be preserved. As opportunities arise, additional forest acreage could be protected through further purchases or by obtaining conservation easements from the land owners.

2. Protected Area Management

Once agreement of the government is obtained and the expansion is accomplished, the Ecotrópica Foundation, together with IBAMA and The Nature Conservancy, will prepare a management plan for the combined protected area. Through its *Parks in Peril* Program, the Conservancy proposes to strengthen the park's patrolling capabilities while providing adequate facilities for park staff and for hosting researchers, supporters, and other visitors. The adjacent forest reserve will be similarly protected under this plan.

> *Patrolling* - Rangers for both protected areas will be hired, trained, and equipped with uniforms, radios, and field equipment. Boats and horses for patrolling will be provided.
>
> *Infrastructure* - The park's headquarters will be repaired and remodeled. Housing for new staff and facilities for visitors will be provided. Patrol bases will be established in key areas of the park. A base will be built at the private reserve as well, to serve as its headquarters and shelter its guards. Signs will be posted announcing the park's and reserve's protected status.
>
> *Community Relations* - Orientation sessions for the area's residents to familiarize them with the work of the park rangers are proposed.

While the park and the reserve will have separate infrastructure and personnel, the proximity of the two areas and the agreements with IBAMA will permit extensive cooperation between the two reserves, which will be managed in an integrated manner.

3. Bioreserve Management

Efforts to protect nature reserves within the Pantanal can only succeed if external factors influencing the protected areas are taken into consideration. The Everglades National Park is a tragic example of a wetlands preserve doomed by the lack of watershed protection and declining water quality. Ninety percent of its bird fauna has disappeared, and the damage to its natural balance may be irreversible (Ogden 1978, Robertson and Kushlan 1984, and Kushlan and Frohring 1986). In order to avoid a similar fate for the Pantanal, the Conservancy will engage in a bold and innovative effort to ensure the survival of the entire northern Pantanal ecosystem.

The effort will begin with the development of an integrated conservation plan for the northern Pantanal. In cooperation with its in-country partners, the Conservancy will provide technical and financial assistance to carry out an in-depth study of the region from the ecological, social, and economic points of view. Threats and their causes will be identified, conservation priorities will be

established, and solutions will be proposed which take into account the needs and aspirations of the local inhabitants. The product of this study will be an Integrated Conservation Plan for the Cuiabá River Basin, describing the dynamics and problems of the region and containing specific recommendations for conservation and compatible development action.

When the plan is complete, the Ecotrópica Foundation with support from The Nature Conservancy will work to secure the cooperation of the public and private sector in order to implement its recommended actions.

Institution Building - Brazilian conservation groups such as Ecotrópica will be supported and strengthened through training, technical assistance, and equipment donations, thus increasing the effectiveness of local conservation initiatives.

Developing Strategic Alliances - Collaborative relationships will be developed with federal and state government, non-governmental organizations and communities. Mechanisms will be developed to encourage the constant exchange of information, maintaining an open dialogue.

Establishment of a Private Reserve - Brazilian law provides several incentives, such as tax deductions, to land owners who set aside part of their properties for permanent preservation through the program for *Reservas Particulares do Patrimonio Natural* (RPPN - Decree # 98914 of 1/31/90). Once registered, these private reserves are protected by law in perpetuity. The Conservancy will work with land owners and the government to promote and facilitate the establishment of such reserves in ecologically sensitive lands identified in the Integrated Conservation Plan. Management guidance and assistance will be provided for these reserves in order to enforce the intent of the law. Unique biological communities, key watersheds, and wildlife corridors will be protected in this manner.

Water Basin Protection - Strategies will be developed and implemented to reduce water pollution and siltation, preserve natural vegetation along the rivers and at their headwaters, and reduce activities such as dike and canal building, which affect natural water cycles.

Promotion of Compatible Development - Through environmental education, awareness raising, demonstration projects, and technical assistance, the Conservancy will promote the adoption of sustainable, nondestructive economic activities in the Pantanal Bioreserve. Examples of this include: agricultural practices not dependent on heavy chemical inputs; well-planned ecotourism; well-managed commercial fisheries; and low impact cattle ranching. In addition, the program will work with government agencies and private interest groups, such as land owners' associations, in order to create a constituency for conservation and promote the adoption of environmentally sound development policies.

Long Term Monitoring and Research - Continuous monitoring of water quality, hydrological cycles, wildlife populations, and ecological systems will yield an understanding of the broad dynamics of the Cuiabá River Basin ecosystem and allow detection of long-term threats and measures of evaluating the success of the defined strategies.

Economic Assessment - Fundamental to the success of the planning effort is the study of the economic structure and dynamics of the municipalities located within the water basin and the establishment of a series of development alternatives for the region. Profiles of the principal economic activities will be developed as an input to help assess development alternatives. Local

retention of revenue is considered to be of critical importance in prioritizing the assessment.

The Pantanal is a region particularly receptive to community outreach and landowner cooperation strategies. The *Pantaneiro* culture, with its deep love for nature, appreciates the value of conservation. Guided by the Integrated Conservation Plan, the Ecotrópica Foundation, with the technical and financial support of The Nature Conservancy, will act as a catalyst to consensus and take action towards achieving the objectives of the Cuiabá River Conservation and Compatible Development Plan. By translating local attitudes into actions, the Pantanal Program's goal is to ensure the preservation of the natural bio-hydrologic characteristics and ecological processes essential to the survival of this important component of the Pantanal ecosystem. In doing so, this international partnership will lead to better technical information about this complex ecosystem, which can be applied to broader regional conservation and development considerations.

4. Long Term Protection Fund

The conservation processes initiated by the actions outlined above must be maintained over the long term. The Nature Conservancy through its *Brasil Verde Conservation Campaign,* and Ecotrópica through its partnership with the Conservancy, will seek private and multilateral agency support to carry out the Pantanal Program. Looking at medium-term funding needs, the program hopes to establish an endowment fund for this purpose through a debt-for-nature transaction. Brazilian foreign debt purchased at a discount will be exchanged for twenty-year government conservation bonds, the annual yields of which will be used to:

a. pay the salaries of rangers, environmental educators, and community outreach personnel;

b. repair and maintain infrastructure and equipment in the national park and in the private reserve;

c. support patrolling, research, and monitoring activities;

d. support demonstration projects and provide technical assistance for environmentally sound development;

e. provide financial support necessary for the Ecotrópica Foundation to administer the program.

The Nature Conservancy has successfully completed debt-for-nature transactions in many countries, including Brazil, and has broad experience in the creation of conservation funds.

CONCLUSION

Past experience in developing countries has time and again demonstrated that only by taking human needs and economic realities into account can a conservation initiative succeed. Practical alternatives to environmentally unsound practices must be provided to local populations, and development policies must be changed to take conservation needs and values into account. This is best accomplished by working closely with governments, economic interest groups, and local people. The Nature Conservancy's Pantanal Program will be managed in accordance with this philosophy.

The Pantanal is one of the most precious natural treasures on Earth. Its vast watery wilderness, teeming with wildlife, makes it as fascinating as it is irreplaceable. Yet for all its majesty, the Pantanal is a fragile land. Being a wetland, it is vulnerable to heavy-handed human activities, and being so diverse, it has much to lose. Events in other great wetlands of our planet, such as the Everglades, have shown us how quickly and irretrievably our carelessness can destroy our natural heritage.

There is an alternative future for the Pantanal. By taking bold action now, we can prevent history from repeating itself and save this delicate ecosystem. By preserving critical habitat, strengthening protected areas, protecting watersheds, and promoting environmentally sound economic activities, we can ensure that future generations will know the majesty of the Pantanal as we did.

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Enhanced Decision Making

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INTRODUCTION

Water management is everyone's business. Everyone has a stake in seeing that future decisions regarding the way in which water is managed are more holistic in nature and more in tune with the views of the many publics involved. Communications networks linking agencies proposing how to manage the nation's waters and those caring about the nature of the management styles proposed have often been weak or disrupted. A melding of views must be achieved, the challenge is to bring this about.

COMMIT TOTALLY

Every stakeholder should be involved in planning and decision making processes. Total involvement is required. All of us are stakeholders and we must learn to accept a forum view rather than a parochial one.

Planning and management agencies should seek invitations by other agencies, interest groups, and organizations to enter into cooperative partnerships. Cultivating relationships among stakeholder groups facilitates resolution of disagreements. Establishing networks facilitates the development of programs that can meet the interests of those at the table.

ACCEPT THE INSTITUTIONAL CHALLENGE

Entrenched traditions of agencies, rules of law, and social customs resist modification and often constrain good water management. But by exploring alternative ways of solving problems, identifying the pros and cons of implementing various options, and by articulating payoffs that could result from change, reforms can be brought about. The roles of the federal and state water agencies need re-defining. Changes in program emphasis announced by the Bureau of Reclamation in 1987 are an example. But it is not enough to say that changes will be made, they

must be real, and not just ploys to ensure continued funding for old ventures.

Planners and managers should be sensitive to the impacts their proposals may have on other governments and/or agencies. What is considered best at one vantage point is not necessarily the best at another, and plans for action should be developed in recognition of such differences.

Since the demise of the Water Resources Council (WRC) in 1982, there has been a vacuum at the federal level in providing a water policy and management overview. This missing link needs filling. The WRC provided a forum that no longer exists. It was designing a format for cataloging the nation's water problems and identifying options for dealing with them. It was recognizing the special problems associated with the protection of natural systems and it was creating an ethic of more reasoned and more conservative water use. It was providing a forum for a state-federal partnership. Furthermore, the Council was taking a look at the “big picture” a look that more parochial agencies could not, or would not, take. The value of having some type of council or water board is widely recognized. But the “turf-protection” attitude that exists in Congress and the Administration impedes its development.

Regional, international, and global water management institutions must also be designed and implemented. Cities, counties, slates, and even nations, are often too limited in jurisdiction to deal appropriately with water issues that transcend their boundaries. A broad understanding of the functioning of entire ecosystems must become the basis for unified action.

Finally, we must find a way to overcome the “not in my backyard” (NIMBY), syndrome. Problems associated with water management are often compounded by blocking actions of those who may be in agreement with the need to solve a problem but do not want it solved in their locality. This encourages continued malpractices, and delays even incremental improvements.

DEFINE THE COSTS AND BENEFITS

Too many believe that water should be provided free, and that they should be able to use it in any way they see fit. But questions must be raised relative to the costs to be incurred by various water management options and the benefits to be gained, and by whom, of implementing them. With federal funding cutbacks, state and local governments will have to bear an increasingly larger share of costs.

We are going to have to take a hard look at our national priorities and reconsider how water management fits in. A reshaping of priorities for allocating the nation's assets is in order. We can't fund additional water management initiatives out of new money when there is none. What must be done is to shift resources from areas of excess indulgence, to those in need, the water environment being a case in point. Untouchables will have to be touched, but there are few other viable options.

ESTABLISH PARTNERSHIPS

Planning and management agencies should aggressively move to strengthen and/or establish partnerships with relevant publics (Environmental Advisory Board, 1991). But this partnering must be based on an understanding that the missions, legislative mandates, and administrative policies among partners may be very different. It requires that differences in view be identified and accepted, and that commonalities in interest be sought as the building blocks for consensus.

The goal should be to ensure that there are no real losers, that all receive some spoils in pursuing a common target. Partners must recognize that tradeoffs must be made to improve the collective whole. A necessary condition for establishing mutual trust is that partnering arrangements be open, frank and honest. Unless that condition is met, there will be little incentive for meaningful cooperation.

EDUCATE AND COMMUNICATE

Education and communication are fundamental elements in shaping the direction of water policy. Every citizen should be taught to accept a moral obligation to protect the earth from abuses by governments and individuals and to strive to bring about a more environmentally conscious electorate. And progress along these lines is being made.

For example, in 1983, the Texas Society of Professional Engineers became convinced that an informed citizenry was a prerequisite to solving the state's water problems (Smerdon, 1985). Farsighted leaders saw the value of incorporating information on water resources in the curricula of elementary and secondary schools. It was believed that benefits would extend from students to their parents through a student-parent network.

CAPTURE SOCIETY'S VIEWS

Planning is for people, and it is their vision of the future that must be captured. They, not the planners should set the specifications. Furthermore, the public should be used as a sounding board for suggesting reformulations of existing water projects and programs. Planners must learn to identify and embrace public views and perceptions at the outset.

ARTICULATE RISK

A troublesome issue is that of dealing with risk. There are problems surrounding the quantification of risk, the perception of risk, and the level of risk to be accepted by society (Keith, 1986). Unfortunately, there are not many good models for risk communication to the public. There is a great need for education on the part of both those who understand the likelihood of danger and those who only perceive that danger. Scientists are often not able to converse adequately with the public or to deal with emotion rather than reason. The policy maker, on the other hand, must be able to operate in an arena of uncertainty and public fear, and at the same time bring some rationality into judgments about levels of risk to accept. There is a need for targeted risk assessments and risk benefit analyses. And the public view must be included, up-front, in policy designs where risk and uncertainty are issues. The costs and benefits of reducing risk must be more clearly articulated.

FOSTER TECHNOLOGIC AWARENESS

The technologic capability for addressing water management problems is staggering. But exploitation of its potential is constrained by our inability to apply it within the realities of political and social systems. Scientific and technical understanding should be united with the goals of society. Optimal technical approaches may be, and often are, socially unacceptable, and compromises usually have to be struck. And these settlements must be based on a blending of technical understanding and public perception. It is incumbent upon technicians to exercise every measure available to them to ensure that the public view is understood and incorporated in

their designs.

PROVIDE THE FORUM

Formulating water policies which effectively address public views requires providing the right forums for the circumstances. Two types of forums are needed, those related to resolving conflicts (consent building), and those related to solving problems that transcend normal political and/or agency boundaries (system-encompassing). To deal with conflicting interests, the principal stakeholders (publics), mast be brought together in an atmosphere mat encourages cooperative exchanges of views (Babbitt, 1986). The key is to make negotiation rather than litigation the vehicle for settlement.

Workable strategies are needed to enhance die ability of agencies to deal with the various publics as they address water resources problems. Agencies should work to provide forums in which all of the involved publics can explore mutually acceptable courses of action.

BE PROACTIVE

Water management plans must be proactive. They must be pace-setters in affecting water management decisions. This is important because water management decisions frequently default to regulators and the courts which rarely have the expertise to prescribe appropriate courses of action.

Water management plans should be designed to guide water resources policy making. Adjustments in philosophy and plan definition by planners will be required, and support of a more positive planning role by legislative bodies and implementing agencies will be needed. There will have to be a more interactive interface between planners and the public. Identification of potential sources of conflict will have to be made an integral part of the planning endeavor so that these conflicts can be dealt with up-front, and options for resolving them sought before combative situations emerge. Because water management is heavily influenced by regulatory requirements, it is crucial that these measures be the result of carefully devised plans and the policies that flow from them. Water management guided by regulatory measures and court actions is destined to be parochial and sub-optimal.

Unfortunately, the adoption of effective planning models has been hampered by the separation of planning and implementing authorities, turf protection attitudes, inadequate and poorly paid planning staffs, short sighted focusing of efforts, lack of objectivity, poor understanding of the planning role, and limited funds. The states, in particular, have been deficient in their ability to sustain comprehensive water resources planning functions. Thinking imaginatively about better ways to plan and manage has not been a strong point in our government.

TAKE A HOLISTIC VIEW

Water policies should be ecosystem-oriented. Agencies must begin to adopt broader problem-solving approaches (Sheer, 1989). Regional system-encompassing planning and management strategies should be devised and institutions to accommodate them must be designed. And the public must be acquainted with efficiencies that could be gained by taking a more holistic view. By creating such an awareness, the public can become an identifier of options rather than a reactor to them.

CONCLUSIONS

Water management policies of the 1990s must be more be holistic in nature. Institutional reforms consistent with this view must be sought and implemented. A variety of options are available, but the best approach is to tailor the changes to fit the circumstances presented. A uniform modification of institutions is not recommended. The challenge is to find the key to what works where and to move forward with imaginative a contemporary agendas.

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Sub-track: Water Law and Institutional Arrangements

Impact of Multilateral Financing for the Arenal-Tempisque Irrigation Project in the Legal and Institutional Framework of Water Law in Costa Rica

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Note of the Editor: At the time of the publication of these proceedings, only the abstract in english of the presentation was available. Further details or the complete paper in Spanish may be available by contacting the author at the specified address.

ABSTRACT

During the period 1979-1983, the Inter-American Development Bank approved a loan for the First Phase of the Tempisque-Arenal irrigation project in Costa Rica.

In 1983, Costa Rica created the Groundwater, Drainage, and Irrigation National Service (SENARA), which consolidated the administrative entities dedicated to irrigation existing at the time. With the new law and operating guidelines, the Irrigation Districts were created under an special jurisdiction for water management.

In 1988, the loan agreements with the Inter-American Development Bank and the Venezuelan Investment Fund for the implementation of the Second Phase were ratified. In this phase, the SENARA needed to identify institutional cooperation with other entities, create the Coordinating Board of Irrigation Districts, and regulate land titles under district jurisdiction.

The Costa Rican Water Law of 1942 requires modifications to include the operation of irrigation projects, and to fit its measures for other water uses having their own legal and administrative ruling. The modification of this law must be conceived under the concept of integrated watershed management. Currently, there exist a number of law proposals.

Legal and Institutional Aspects of Water Charges in Brazil

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Water resources management in the Brazilian context is a very complex issue for two main reasons: the vast territorial extension of the country (8.5 million km^2) with its natural variability in terms of ecosystems, hydrology and sociopolitical organization and the existing federative system of administration that conflicts, to a certain extent, with the concept of using the watershed as the water resources planning unit. Considering that, from a political point of view, it is virtually impossible to change the administrative system of a federation of States, the proper management of water resources will require the articulation among the federal, state and municipal levels of decision. Moreover, nongovernmental organizations and the public in general should be effectively involved into the decision process.

From a technical point of view, the effective implementation of integrated water resources management in Brazil will depend on the adequate handling of three management instruments: a procedure for concession of the right of use, cost sharing mechanisms for multiple use projects and user charging schemes. These mechanisms should consider the socio-environmental diversity of the country which can be grouped into three main regions: a) Amazonia, northeast and central-west Brazil which need economic development to offset regional disparities; b) the ecological sensitive areas of Amazonia, Pantanal and southern coastline and c) the degraded urban and rural watersheds of the south and southeast in view of their need of conservation, restoration and environmental control.

Water charging is one of the above instruments that has received great attention, mainly from state governments, due to its possibility of generating resources to finance hydraulic works and other environmental measures at the watershed level. The process of charging has two main characters: to rationalize water use and conservation (user pays principle) and to internalize pollution costs (polluter pays principle). A pioneer federal law in Brazil regulating this matter is the Water Act, enacted in 1934 which suggests the polluter pays principle. According to its articles 111 and 112, if the interests of agriculture or industry so determined, and with previous administrative permission, waters could be polluted, but to compensate the consented favor, the farmers or industrial undertakers should indemnify the public and private sectors damaged.

Until 1979, the only legal instrument available was the Water Act. Federal Law 6662/79 is the first law after this long interregnum determining that the use of water for irrigation would be subject to charges (art. 21), Federal Law 6938/81, instituting the National Environmental Policy, predicts (art. 4, VII), the obligation of the polluter or predator to restore and/or indemnify from the damages of using environmental resources with economical purposes. To date there is no indication of application of these laws in practice.

The Federal Commission of 1988 (art. 20) assures to states and municipalities participation in revenues from the exploitation of hydropower in their territories. The matter was disciplined by Federal laws 7790/89 and 8001/90, constituting in the first case of effective and systematic application of the user pays principle in Brazil. Presently, the executive has submitted a project to the Congress (project of law 2249/91), defining water charging for different water uses as an instrument of the National Water Resources Policy (art. 4, 11). This will be implemented via tariff to be determined by the executive. Regarding the financial resources collected, the project does not stipulate to whom they will accrue or even the object of their application.

An important feature of the Brazilian case is the fact that states took the lead in the process of implementing water charges in the rivers of their domain. State of Sao Paulo, for example, the most developed state in the union has promulgated State law 7663/91 which in its article 14 allows the charge for water use including; derived waters, for public or industrial water supply systems, irrigation and other urban and rural users; used waters, for hydropower generation, navigation and recreation and dilution, for transport and assimilation of effluents from wastewater systems and other liquids of different nature. Other states, such as Ceara, Bahia, Santa Catarina, Rio Grande do Sul, Minas Gerais, Goias e Mato Grosso and Pernambuco, are indifferent stages of implementing their state laws.

Presently, there is a great debate regarding the implementation of the federal project of law 2249/91 and its relation to the state initiatives underway. Apparently, the project has the merit of

presenting a very comprehensive treatment of all the important aspects of water management but it centralizes the collection of charges in a federal agency which in turn will redistribute them among the participating states.

New Instruments to Improve Water Management in México

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Note of the Editor: At the time of the publication of these proceedings, only the abstract of the presentation was available. Further details or the complete paper may be available by contacting the author at the specified address.

ABSTRACT

The improvement of water management in Mexico required recently a combination of legal and institutional arrangements in order to overcome old inconveniences. The political process culminated in 1989 with the establishment of the National Water Commission (NWC), as the only authority in charge of water management.

The NWC is empowered to:

- regulate water allocations and concessions
- coordinate investments in the water sector
- ensure the conservation of water quality and the restoration of natural aquatic systems
- resolve conflicts among users in the transmission of water rights
- define priorities in each of the country's river basins

The NWC's governing body, chaired by the Minister of Agriculture and Water Resources, assures inter-sectoral coordination since its members are officials from all ministries involved in water management.

The main instruments for improving water management are the following five.

Watershed Councils: These are mechanisms through which federal, state, and municipal governments, users, and other interested groups share the responsibility of planning and managing the watershed's water resources. The council considers the river basin as the basic unit for water planning and management, and integrates both quantity and quality, as well as surface and ground water. Social participation is encouraged so that decisions are made taking into account all interested and affected parties. The main purpose of the council is to promote water pollution control and efficient water use.

Financial Water System: The core of this system is that those who benefit from water use or those polluting the environment have to contribute to the management of the resource i) in an equitable manner and in proportion to the benefits they derive or the degree of pollutants they generate, and ii) to the restoration and improvement of water quality in rivers and aquifers. The system is designed to gather a mixture of

resources: federal and state subsidies, loans from national and international financial institutions, internal revenues generated from the payment of water rights and waste water permits, and private participation.

Public Registry and Water Rights: The objective of the registry is to keep track of all water rights transactions within users, and to provide them with legal certainty of their water rights. The allocation of water rights is granted through licenses or concessions in order to use the Nation's waters. With the registry the NWC can regulate the transmission of water rights in such a manner that proper consideration of third party effects and other externalities are taken into account.

Waste Water Permits: These permits, associated with water rights, are based on the principle that those who pollute should pay the cost of water treatment. However, to promote contamination abatement, it is less costly for a user to treat its waste water than to pay discharge rights. The regulations are simple and enforceable, according to an established set of quality standards and to the systematic monitoring and evaluation of water quality.

Water Utilities: One of the goals of the NWC is to provide the technical, administrative, and financial assistance to support the evolution of existing users systems and utilities, into autonomous, self-financing units. The main water utilities are irrigation users' associations, which manage subsystems of 10 to 15 thousand hectares, and drinking water and sewerage utilities, which provide services to all sizes of cities and towns. Today there are 186 irrigation users' associations in 78 large irrigation districts transferred to the users, which cover 3.2 million hectares representing 50% of the total irrigated land. As for potable water utilities there are 135 of them in cities with more than 50 thousand inhabitants.

The water rights and the permit systems coupled to the financial systems and complemented by standards and regulations are instruments that allow market mechanisms to improve water management, especially those issues related to allocation decisions and water use efficiency. These policy instruments are formally incorporated in the National Water Law, which was passed on December, 1992. Implementation strategies are presently under way, and the instruments are expected to be fully operational by the end of 1994.

Organizational Structures for Interstate and International Coordination of Water Management in La Plata Basin

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Note of the Editor: At the time of the publication of these proceedings, only the abstract in english of the presentation was available. Further details or the complete paper in spanish or portuguese is available by contacting the author at the specified address.

ABSTRACT

A quick review on the influence and impact of the water resources on the global economy,

outlines the need of an appropriate coordination on water use and preservation, indicating the jurisdiction and constitutional faculties of the national and provincial states. Due to the fact that over 70% of the Argentine Republic territory is on arid or semi-arid areas, the water resources administration is a life-weight matter for the country development.

Showing and analyzing the differences between two institutional coordination organs: in the national field, the hydric basins committees (Comites de Cuencas Hidricas), and in the international field, the Hydric Committee on the La Plata Basin (Comite Hidrico de la Cuenca del Plata), which deals on a basin geographically shared among Argentina, Bolivia, Brazil, Paraguay and Uruguay.

A frame on water policies and a global project for the organs under study is formulated, in accordance with the institutional characteristics of the argentine political regime.

Sustainable Development and Management of Water Resources - A River Basin Approach

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The *water policy and governance* track of this Interamerican Dialogue on Water Management is perhaps the most important facet in considering the relationships between sustainable development and water resources management. Will government completely stifle environmentally sound development, or let development run roughshod over natural resources, or provide a balance when considering both ends of the spectrum.

To me, sustainable development is characterized by the use of water for its many purposes:

- municipal and industrial water supply
- irrigation - agricultural and other
- waste assimilation capacity
- navigation
- recreation, including fish & wildlife habitat, and
- flood control

Whereas, water management deals with the regulation of those uses - and whether or not they should be sustained as is, abandoned, altered, or expanded.

In democratic societies, it is the legislative branch which establishes the policies for governance or regulation of water resources management. The executive branch is left to interpret their mandates, in varying degrees, based upon the legislative authority so bestowed. Administrative bodies in the executive sometimes exceed their authority, or fall short of performance, based upon the intent of the legislative mandates.

One sure-fire arrangement to assure unnecessary grid-lock in managing the water resources for sound sustainable development is to allow the splintering of water resource considerations into many different legislative committees. Policies declared through law enactments concerning energy production, agricultural irrigation, flood protection, navigation, water supply for municipal

and industrial uses, fish and wildlife protection (including endangered species and wetland considerations), recreation, and waste assimilation capacity often are at cross, competing or conflicting purposes in the U.S.A. These laws enacted at the national level are generated by special interests with narrow viewpoints through myriad legislative committees.

Often, the executive departments and agencies implementing such specific and often narrow policies have their “hands tied” in making any decision - good or bad - because of the apparent veto power established in any single law relating to a specific water resource use or protection goal.

One important element when considering policy development dealing with water resources uses and protection is to avoid the possibility of absolute veto - no room for compromise, mitigation, or the use of common sense. Some flexibility is needed in the laws and policies which they enunciate to assure that local or regional decisions are made which do not give, in effect, any absolute veto power which supports an NGO's views of either “no development” or “development at any environmental cost.”

The “Clean Water Act” is an example of a reasonable law dealing with water quality protection. The states establish water quality standards based upon criteria developed by a national agency (U.S. E.P.A.). The states establish such standards through an open public process based upon a profile of each stream segment, a profile which includes:

- existing uses;
- existing water quality;
- ability to improve the water quality if it exceeds the national minimum standards of “fishable and swimmable” and is economically achievable;
- ability to protect and preserve high quality water if it now meets all legitimate uses; and
- the ability to determine if national “fishable and swimmable” standards cannot be met, and so establish a lesser standard, if a higher level of a proof can be shown to the satisfaction of the overview agency - the U.S. E. P. A.

This is a flexible approach in addressing one function of water resources regulation which impacts on sustainable development. Two important elements are enunciated in this policy - flexibility and the fact that decisions are made at the regional or local level (states), and not by a national czar.

A hybrid of this approach which has been very successful in providing flexibility and regional decision-making regarding water resources use and protection is the creation of a river basin or watershed based agency - such as the Delaware River Basin Commission (DRBC). When formed in 1961 by laws enacted by Congress and four state legislatures, the five governments agreed to share their sovereignty in water resources management through a single agency which focused on a hydrologic unit, the Delaware River, Estuary, Bay and all their tributaries. It included both surface and groundwaters, as well as land uses related thereto.

The DRBC was mandated in the legislation to consider not just instream and ground water quality, but many other aspects of water resource protection and utilization (including

development, both existing and new, sustainable or otherwise). Its powers also include regulation concerning:

- surface and ground water quantity through allocation
- waste discharges
- flood control
- fish, wildlife, and wetlands protection
- recreation (including parks)
- hydroelectric uses
- navigation uses
- water conservation
- instream flow considerations

In its thirty-two years of existence, the DRBC has exercised its powers in all of these areas, and has made its decisions for project approval based upon plans, policies, rules and regulations - adopted by a simple majority vote of the five members to the DRBC. Those members or commissioners are the governors of the four states of Delaware, New Jersey, New York and Pennsylvania, plus the Secretary of the U.S. Department of the Interior. They have alternate commissioners who act in their stead, and are usually heads of the environmental/water agencies.

Is development sustained in the Delaware River Basin? Regarding the impact or influence of water resources regulation on development, it has been sustained. One of the primary purposes of establishing the DRBC, as stated in its Compact, was to:

> *"...make secure and protect present developments within the slates...."*

Again, four state legislatures and Congress approved that purpose.

All existing public projects such as water treatment plants, wastewater treatment plants, significant parks, and reservoirs are included in our dynamic (ever-changing) comprehensive plan. Major investor-owned water related projects are also included.

Our comprehensive plan also includes plans, policies, rules, and regulations concerning the many different aspects of water regulation. These plans, policies, rules, and regulations comprise the yardstick by which we review and act upon any new development.

So, any new development cannot:

- conflict with an existing one, and
- it must be constructed and operated in accordance with our comprehensive plan and basin water code.

Are our policies, rules, and regulations overly restrictive so as to thwart even environmentally sound development? We think not. That is because their formulation has been developed with the advice of the basin water users in the first instance.

Our formal advisory committees are formed with a spectrum of the public interest (users) being represented - not just no-growth advocates on the one hand, or bull-dozing developers at any cost to the environment on the other. Based upon any specific regulatory issue being considered, such as water quality standards, effluent standards, ground-water management,

water conservation, etc., the appropriate advisory committee first agrees to a common set of facts. This separates irrelevant or false information which any segment of the “public interest” may propound from the pool of true information upon which some decision would be made. Next, the advisory committee considers alternate forms for resolving the apparent gap in water resources management - alternate regulations, best management practice recommendations, or at what level should program elements be acted upon. Then, a final recommendation is made to the DRBC for official rule-making, which again is a wide-open process including briefings, public notice, and public hearing before a vote of the five commissioners.

Waste treatment plants, surface and ground water withdrawals, pipeline river crossings, reservoirs, and any construction of a certain size which impacts on the basin's water resources must be reviewed and approved by the DRBC. We consider flood impacts, wetlands, water quality, ground water levels, streamflows, depletive water use, and infringement on existing development in one docket decision. The applicant for a new project need not jump through a multiple of “flaming hoops” within the DRBC.

A state or federal agency, on their own, can require a more restrictive condition relative to a project, but not less than those incorporated in DRBC's comprehensive plan and water code. And often, DRBC's requirements are more stringent than national standards - because the decision to do so was made on the regional profile, by regional officials, based on advice of people living in the region.

In summary, flexibility has been allowed in making decisions concerning development because of the power and authorities given in the Delaware River Basin Compact. The decisions are made at the regional macro or micro level, instead of inside the beltway in Washington, D.C. And finally, someone can develop a new project in an environmentally sound fashion without the threat of DRBC disapproval because of some minuscule environmental “veto” requirement. This is because, the Delaware River Basin Compact, that policy document governing our actions, clearly states that:

> *“The commission shall approve a project whenever it finds and determines that such project would not substantially impair or conflict with the comprehensive plan....”*

Thank you.

Great Lakes Remedial Action Plans: Building the Institutional Capacity to Restore Beneficial Uses

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Introduction

The Great Lakes are an unparalleled resource shared between the United States and Canada which represent one-fifth the total standing freshwater on the Earth's surface. Over 37.5 million people live in the Great Lakes Basin Ecosystem with more than half dependent on the lakes for drinking water supplies. The Great Lakes are also used for transportation, commerce, energy production, and recreational activities, among other beneficial uses. Resource limitations of the

Great Lakes and an increasing demand for greater and more diverse use of them has led to an urgent need for more cooperative and coordinated approaches to Great Lakes' management.

Use of an ecosystem approach, as called for in the United States-Canada Great Lakes Water Quality Agreement, has changed traditional approaches to water management. The ecosystem approach holistically accounts for the interrelationships among land, air, water, and all living things, including humans; and involves all user groups in comprehensive management. Currently, there are 43 degraded Areas of Concern in the Great Lakes Basin where locally-designed, ecosystem approaches are being used to develop and implement remedial action plans (RAPs) to restore beneficial uses (Figure 1). Thirty-nine of the 43 Areas of Concern have either a stakeholder group, coordinating committee, public advisory council, or comparable institutional structure broadly representative of societal, economic, and environmental interests in an Area of Concern. These RAP institutional structures have been established to coordinate and facilitate RAP development and build the institutional capacity to restore beneficial uses. The purpose of this paper is to present an overview of the Great Lakes RAP program to the Interamerican Dialogue on Water Management and evaluate the experiences with institutional capacity building through RAP institutional structures for potential application in other regions in the Western Hemisphere.

Figure 1. Areas of Concern and Remedial Action Plans (RAPs) considered under the U.S.-Canada Great Lakes Water Quality Agreement (GLWQA)

BACKGROUND ON THE GREAT LAKES RAP PROGRAM

The Great Lakes RAP Program originated from a 1985 recommendation from the International Joint Commission's Great Lakes Water Quality Board and was formalized in the 1987 amendments to the Great Lakes Water Quality Agreement. The Agreement calls for federal governments, in cooperation with state and provincial governments, to ensure that RAPs incorporate a systematic and comprehensive ecosystem approach to use restoration, and to ensure that the public is consulted in all actions undertaken pursuant to RAPs (United States and Canada 1987).

Areas of Concern are defined as geographic areas that fail to meet the objectives of the Agreement where such failure has caused or is likely to cause impairment of beneficial use or the area's ability to support aquatic life. Impairment of beneficial use means a change in the physical, chemical, or biological integrity sufficient to cause any of the following 14 use impairments:

- restrictions on fish or wildlife consumption;
- tainting of fish and wildlife flavor;
- degradation of fish and wildlife populations;
- fish tumors or other deformities;
- bird or animal deformities or reproductive problems;
- degradation of benthos;
- restrictions on dredging activities;
- eutrophication or undesirable algae;
- restrictions on drinking water consumption, or taste and odor problems;
- beach closings;

- degradation of aesthetics;
- added costs to agriculture or industry;
- degradation of phytoplankton and zooplankton populations; or
- loss of fish and wildlife habitat.

RAPs are an iterative, action-planning process used to identify the responsibility and timeframe for implementing remedial and preventive actions necessary to restore impaired uses.

Specifically, each RAP must:

- define the environmental problems, including geographic extent of the area affected, using detailed maps and surveillance information;
- identify beneficial uses impaired;
- describe the causes of the problems and identify all known sources of pollutants;
- identify remedial actions proposed to restore beneficial uses;
- identify a schedule for implementing remedial actions;
- identify jurisdictions and agencies responsible for implementing and regulating remedial actions;
- describe the process for evaluating remedial program implementation and regulating remedial measures; and
- describe the surveillance and monitoring activities that will be used to track program effectiveness and eventual confirmation that uses have been restored.

RAPs are submitted to the International Joint Commission for review and comment at three stages. Stage I defines problems and use impairments in Areas of Concern and identifies causes. Stage II presents remedial and preventive measures, while Stage III confirms restoration of uses. RAPs use a multi-stakeholder, multi-sectoral approach within the local community to restore beneficial uses.

CAPACITY BUILDING

To address the GLWQA charges to use an ecosystem approach and ensure public participation, state/provincial/federal governments have provided leadership in establishing RAP institutional structures broadly representative of societal, economic, and environmental interests. These RAP institutional structures are changing the way governments, communities, and other stakeholders make environmental decisions. No longer are environmental decisions being made in distant board rooms of capitol cities. Decision-making power is being shared with stakeholders at the local level (i.e. Areas of Concern). As a result, governments are building the capacity to restore beneficial uses.

Incorporating the ecosystem approach into RAPs has meant viewing different organizations, agencies, and stakeholders as equal members of a team in a partnership to identify and solve environmental problems (Hartig and Vallentyne 1989). There has been a shift from command-and-control to collaboration-and-consensus-building. This shift has, in many Areas of Concern, resulted in a reformation of governmentally mandated planning processes. In essence,

RAPs are attempting to overcome environmental decision-making gridlock by developing a coordinated, multi-stakehholder response to restoring impaired beneficial uses in Areas of Concern (Hartig and Zarull 1992).

Implementing the ecosystem approach is more about process than product. Although there is no single best approach to developing and implementing RAPs, it is clear that a successful process will: be inclusive; share decision-making power; be integrative; work to achieve a planned, agreed-upon, and flexible road map to restoration; and provide evidence of commitment and continuing accountability (International Joint Commission 1991). A major outcome of this is the creation of accountability on the part of those responsible for the wide range of remedial and preventive actions needed. Most governments have opted for a RAP process without elaborate rules, regulations, or guidance, and a focus on results. Sustaining the RAP process will, among other things, require: continued public involvement, achieving effective communication and cooperation, creatively acquiring resource commitments, and building a record of success (Hartig and Zarull 1992). Both short-term and long-term milestones and benchmarks must be celebrated. Examples of milestones and benchmarks include: government management actions, remedial and preventive actions by sources, changes in discharge quality, reductions in contaminant loadings, changes in ambient air/water/sediment concentrations, reductions in bioaccumulation rates, biological recovery, use restoration, and increased human use of resources.

The environmental problems in Great Lakes Areas of Concern are societal problems that will require societal solutions. Governments can play a critical role in helping solve collectively society's environmental problems. Governments have the ability and resources to facilitate a coordinated societal response to such environmental problems. Governments alone do not have sufficient financial resources to rehabilitate Areas of Concern, but governments do have substantial scientific and technical expertise. Indeed, much can be accomplished by pooling resources, increasing coordination, cutting red-tape, and using common sense. The traditional command-and-control regulatory approach of government has often led to institutional gridlock. Through the RAP process, governments in the Great Lakes Basin are now employing a management/facilitation approach, which permits distribution of responsibilities and shares decision-making power.

Stakeholders in Areas of Concern have been instrumental in helping governments be more responsive to and responsible for restoring degraded areas of the Great Lakes. In essence, RAPs are reinventing the role of government in management of Great Lakes Areas of Concern. Through new institutional frameworks, RAPs are fostering cooperative learning, consensus building, and better-informed decision-making. Osborne and Gaebler (1992) have effectively described this process of reinventing government and identified 10 principles for entrepreneurial public organizations which demonstrate more effective governmental roles in solving societal problems. Table 1 presents these principles as developed by Osborne and Gaebler (1992) and selected RAP examples of how federal, state, and provincial governments in the Great Lakes Basin are helping creatively solve environmental problems. These RAP examples are intended to provide some specific examples of successful, entrepreneurial roles of government in rehabilitating Great Lakes Areas of Concern (Hartig et al. 1993).

Based on a review of the Great Lakes RAP program, comprehensive water resource management is most effective if it is mission-driven and not rule driven. Successful RAP

institutional structures are empowered to pursue their mission of restoring impaired uses. Empowerment of RAP institutional structures is demonstrated by: a focus on watersheds or other naturally-defined boundaries to address upstream causes and sources, and obtain commitment from within the watershed for implementation; an inclusive and shared decision-making process; clear responsibility and sufficient authority to pursue the mission; an ability to secure and pool resources according to priorities for action using nonprofit organizations or other creative mechanisms; flexibility and continuity in order to achieve an agreed-upon road map to use restoration; commitment to broad-based education and public outreach; and an open and iterative RAP process that strives for continuous improvement (Hartig and Law 1993).

RAP institutional structures represent a forum for cooperative learning to generate a common understanding of problems and build consensus for action throughout the watershed. To ensure linkages of RAPs to other related planning initiatives, governments must adopt and reward cooperative (rather than competitive) approach to working with other stakeholders, agencies, and organizations. Further, open communication and information networks must be developed across and within public agencies and organizations, and RAP institutional structures should be used as mechanisms for coordinating planning and program functions at the local level. This locally-led approach to coordination through RAP institutional structures should be complemented with governmental efforts to ensure intra- and interagency initiatives are complementary and reinforcing by: explicitly recognizing the need for coordination and integration of interrelated programs in agency mission statements; and incorporating institutional arrangements necessary for the desired coordination into agency work plans.

Government agencies will undoubtedly have to embrace/endorse new RAP institutional structures to ensure a smooth transition from RAP development to implementation. Therefore, it is important that governments adopt long-term, visionary goals for Areas of Concern and commit to a customer-driven and value-added process of continuous improvement that shares decision-making power.

Table 1. Selected Remedial Action Plan examples of applying principles for entrepreneurial public organizations as developed by Osborne and Gaebler (1992).

PRINCIPLES FOR ENTREPRENEURIAL PUBLIC ORGANIZATIONS	REMEDIAL ACTION PLAN EXAMPLES
Steer more than row	New York State Dept. of Environmental Conservation (NYSDEC), the agency responsible for RAP development, contracted with Monroe County to work through its Water Quality Management Advisory Committee to develop the Rochester Embayment RAP. NYSDEC acts as a catalyst and facilitator through an interagency technical working group to oversee RAP development and implementation.

Empower communities rather than simply deliver services	Ontario Ministry of the Environment and Environment Canada have encouraged local ownership of the Hamilton Harbour RAP. They have removed barriers and provided seed-money and technical assistance. The Hamilton Harbour Stakeholder Group developed goals and principles to guide RAP development. The RAP is not a government document, but a community-based plan developed and owned by stakeholders.
Encourage competition rather than monopoly	There are 168 combined sewer overflows (CSOs) in the Rouge River Basin (Michigan). Considerable effort has been placed on development of a comprehensive strategy to abate CSO problems and the Rouge River RAP is in the implementation phase. If a community has an approved National Pollutant Discharge Elimination System permit that has an enforceable schedule and is consistent with the RAP, then it receives a higher priority for funding under Michigan's State Revolving Loan Fund (SRLF) Program. This SRLF Program provides low interest loan assistance for water pollution control projects. Such competition for low interest loans encourages innovation and excellence.
Driven by missions, not rules	RAPs are unique in that they focus on restoring 14 use impairments identified in the Great Lakes Water Quality Agreement. The International Joint Commission helped facilitate agreement on a set of listing/delisting guidelines to be able to make a determination on when these uses are impaired and when they could be considered restored. Each Stage I RAP is intended to reach broad-based agreement on use impairments in an Area of Concern. These use impairments are intended to drive the RAP process, help stakeholders and organizations pursue their mission of restoring uses, and achieve greater accountability.

Fund outcomes rather than inputs	In Thunder Bay (Ontario), a six-staged, four-year habitat rehabilitation project began in 1990. Contributions from the Great Lakes Cleanup Fund and various agencies totalled $2,305,000 and $3,006,000, respectively. The project will create/restore degraded and lost nearshore aquatic habitat in four tributaries, rehabilitate the littoral zone, stabilize wetlands, restore riverine diversity, and increase abundance of fish and wildlife populations in Thunder Bay. Emphasis was intentionally placed on accountability, performance, and results.
Meet the needs of the customer, not the bureaucracy	In Green Bay, Wisconsin, a Citizens' Advisory Committee (CAC) and four technical committees advised Wisconsin DNR on development of their RAP. Initially, the CAC identified the ten most pressing problems and a “Desired Future State” for the lower river and bay. The “Desired Future State” includes: a healthy bay; a balanced, edible fishery; water-based, recreational opportunities; good water quality; balanced shoreline use; productive wildlife and plant communities; and an economical, transportation network. Wisconsin DNR and stakeholders are implementing the RAP to achieve this citizen-developed “Desired Future State.”
Concentrate on earning, not just spending	For Ontario's 17 Areas of Concern, the Canada-Ontario Agreement RAP Steering Committee commissioned a RAP benefits study which would help move the Canadian RAP Program from plan development to implementation. Assuming implementation of all 17 RAPs and achievement of water quality objectives, it was estimated that annual economic benefits would be $ 270 million (1989 Canadian dollars). This substantial economic benefit of Canadian RAPs helps all stakeholders recognize that they are investing for a return.

Invest in prevention rather than cure	In the St. Clair River Area of Concern, Dow Canada has voluntarily separated its waste streams at its Sarnia, Ontario facility, which allows Dow to recover, reuse, and recycle process wastes, thereby virtually eliminating the potential for spills and harmful discharges. Such unforced and unsolicited actions toward pollution prevention and waste reduction have been described as “invisible miracles” of RAPs.
Decentralize authority	In an effort to decentralize authority for cleaning up the Grand Calumet River and Indiana Harbor Canal, the Indiana Department of Environmental Management established, for the first time in its history, a regional office outside Indianapolis. This office, located in Gary, IN, houses the RAP Coordinator and other environmental staff. Their purpose is to coordinate programs at the local level and facilitate the work of the Citizens' Advisory for the Remediation of the Environment (CARE) Committee in development and implementation of the RAP. The CARE Committee is made up of the Mayors of Gary, East Chicago, and Hammond, representatives of industry, education, small business, and environmentalists.
Solve problems by leveraging the marketplace, rather than simply creating public programs	The Cuyahoga River RAP Coordinating Committee (CCC) is a broad-based, 35 member institutional structure established by Ohio Environmental Protection Agency (EPA) to develop their RAP in Cleveland, Ohio, With the encouragement of Ohio EPA, the CCC created a nonprofit organization under Ohio law named the Cuyahoga River Community Planning Organization. The purpose of this nonprofit organization is to support the goals of the RAP with additional resources for planning, and to develop and support programs on public involvement, education, and research. Funding support has come from foundations and other institutions. This nonprofit organization plays an important entrepreneurial role which cannot be performed by traditional, command-and-control

	bureaucracies.

CONCLUDING REMARKS

There is no doubt that environment, economy, and society are inextricably linked and mutually dependent. Therefore, human activities can no longer be managed in a piecemeal fashion and new institutional arrangements will be necessary to account for interrelationships and mutual dependencies. As the United Nations World Commission on Environment and Development (1987) noted in its book, Our Common Future:

> *Most of the institutions facing those challenges tend to be independent, fragmented, and working to relatively narrow mandates with closed decision processes. Those responsible for managing natural resources and protecting the environment are institutionally separated from those responsible for managing the economy. The real world of interlocked economic and ecological systems will not change; the policies and institutions must.*

Considerable progress is being made in re-orienting Great Lakes decision-makers to a more inclusive remedial action planning process that shares decision-making power with all stakeholders and achieves local ownership. RAP institutional structures have been instrumental in implementing locally-designed ecosystem approaches and building the capacity to restore beneficial uses. Such RAP processes have been described as a step toward grassroots ecological democracy in the Great Lakes Basin. In the spirit of cooperative learning, continued emphasis should be placed on international sharing of experiences with institutional structures for comprehensive water resource management in order to learn from each others' experiences.

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Integrated Water Management in Chile: An Ongoing Process

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Note of the Editor: At the time of the publication of these proceedings, only the abstract in english of the presentation was available. Further details or the complete paper in spanish may be available by contacting the authors and presenter at the specified address.

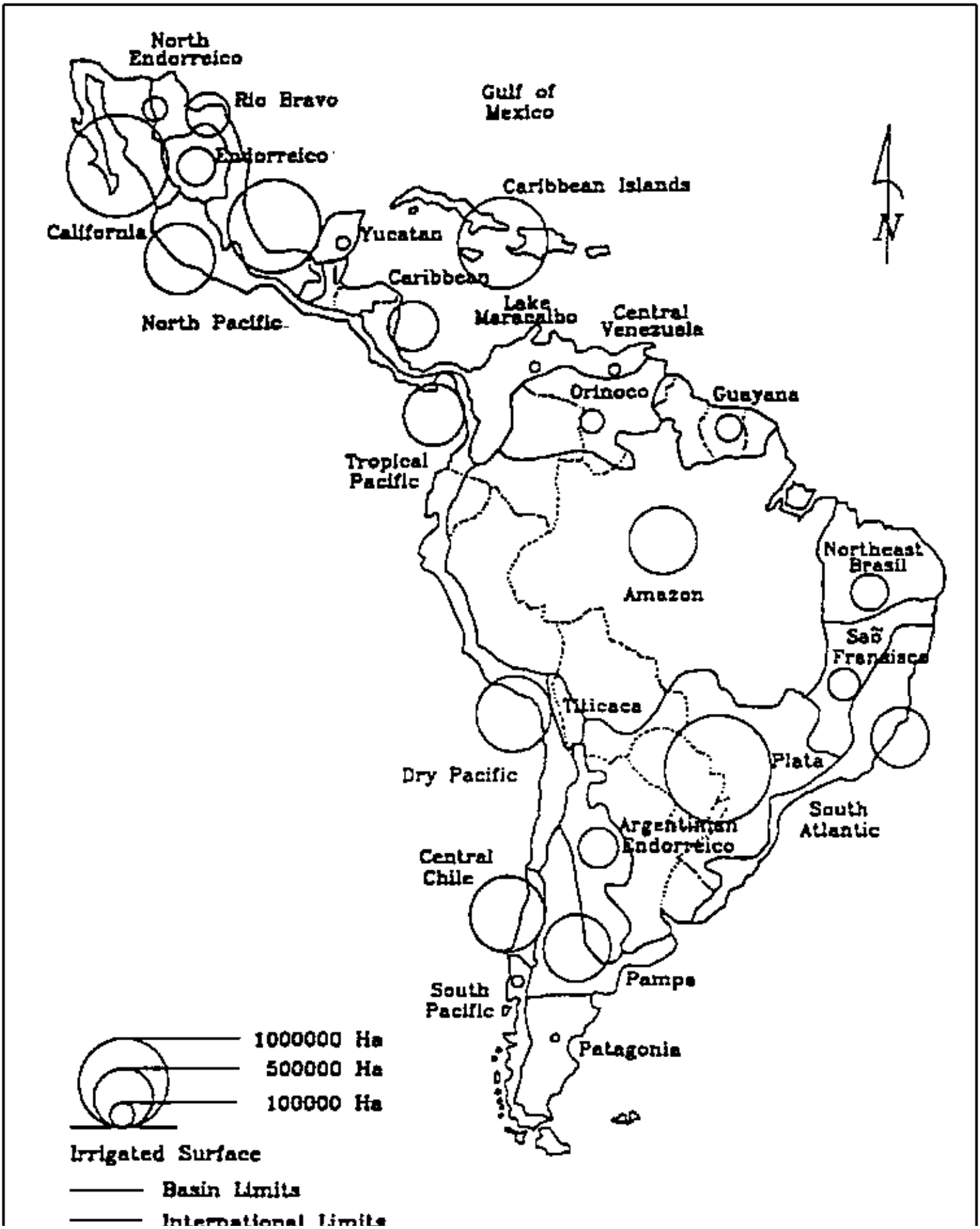
ABSTRACT

The current water legislation in Chile started in 1981 and has been produced within a framework of a social market economy. This legislation phased out through a series of new regulations many inefficiencies by introducing new water use and adjudication policies driven by National interests.

When the new authorities took office, the President of Chile delegated to the Ministry of Public Works, more specifically, to the General Directorate of Water, the responsibility of studying of the Water Code modification. This study would include unforeseen situations, establish policy in accordance to the national interests and the new government priorities, and to correct mistakes or omissions made in the previous code.

One of the goals of the current administration is to establish clear and definite national water policy. This will be done by taking specific actions in order to achieve rational and sustainable use of water resources in accordance with the economic development needs, taking into consideration the higher interests of the country, and conciliated with the legitimate rights of the private sector.

The objective of this presentation is to analyze the ambience under which the water code has evolved, by indicating the theoretical economic basis driving water adjudication rights, and analyzing their consequences. Likewise, this presentation will indicate which are principles served as the framework for national water policy reflex of the country's needs and desires. This national water policy will determine the actions for a more holistic approach for economic and social development as implemented in Chile. Finally, the presentation will describe the process of change under which the legal modifications of the Water Code took place, especially those regarding the restoration of water as a national interest of public use, implementation and enforcement, water resource restoration and protection policies, integrated watershed management policies, and betterment of water user organizations.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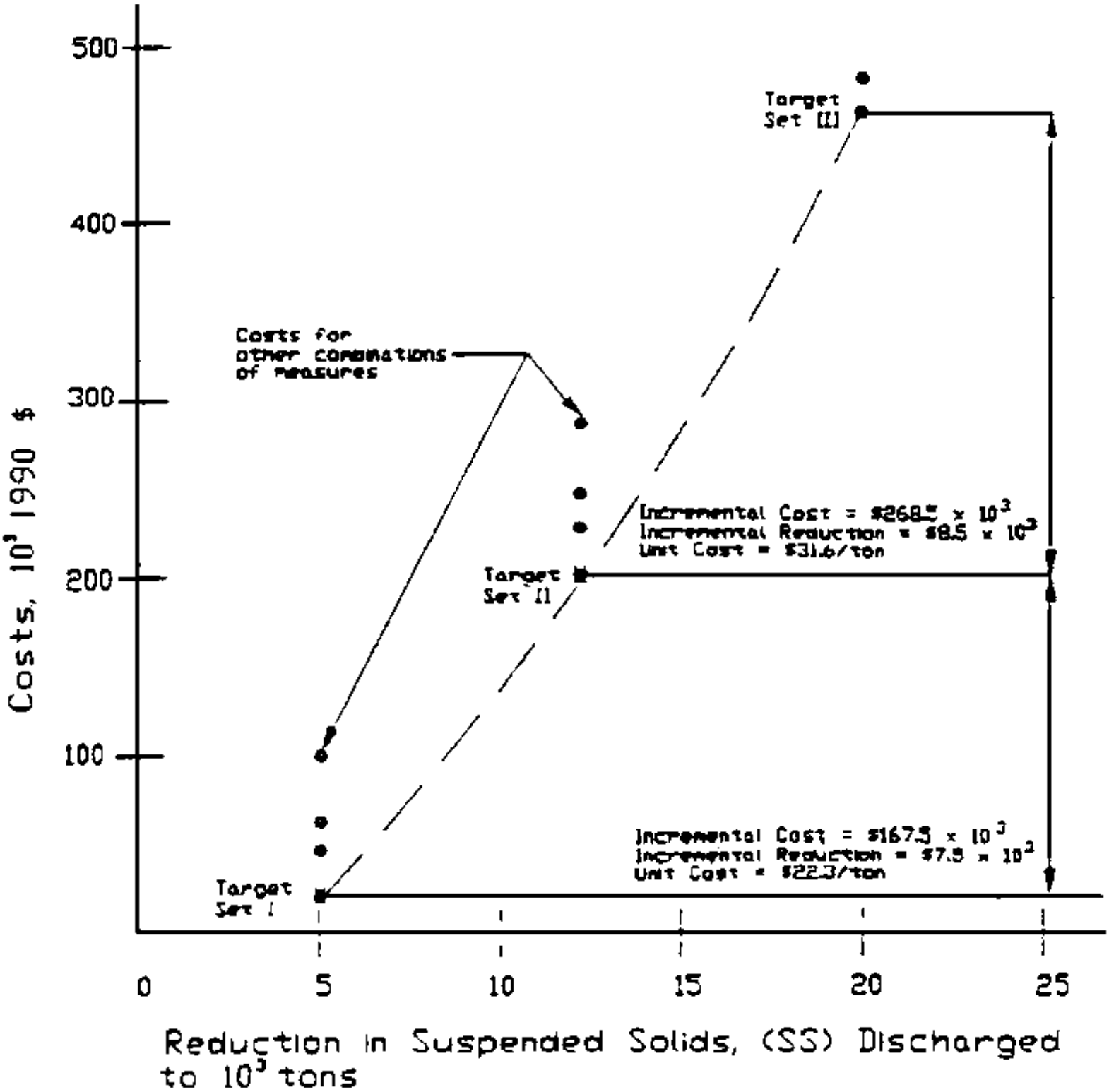
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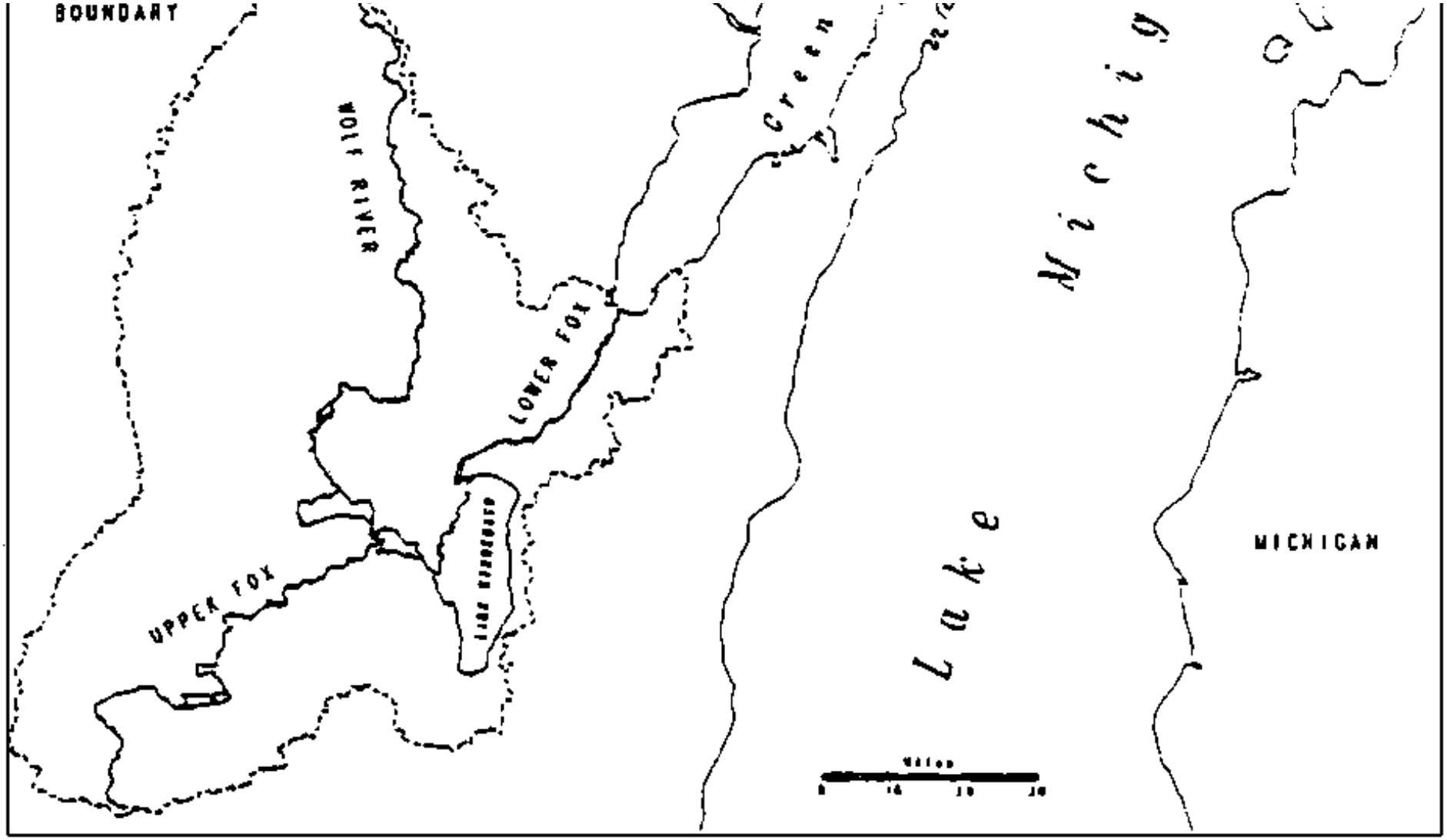
BOUNDARY
WOLF RIVER
LOWER FOX
UPPER FOX
Lake
MICHIGAN

Part VI - Concurrent Fora and Special Papers

Report of the Non-Government Organization Forum

Held on October 27, 1993, as part of the Concurrent Sessions of the Interamerican Dialogue on Water Management

On the afternoon of October 27, 1993, the opening day of the Interamerican Dialogue on Water Management, approximately 70 persons took part in a spirited NGO Forum at the Hotel Inter-Continental in Miami. The program, which was organized and conducted by the Global Tomorrow Coalition (GTC), in collaboration with the National Audubon Society, included presentations by:

- Mr. Peter A.A. Berle, President of the National Audubon Society, New York, USA
- Ms. Alicia Bárcena, Executive Director, The Earth Council, San Jose, Costa Rica
- Mr. Steven J. Parcells, National Audubon Society, Washington, DC, USA
- Mr. Donald R. Lesh, President, Global Tomorrow Coalition, Washington, DC

Among the materials available to participants was a four-page working paper entitled Water Quality as a Top Priority for the U.N. Commission on Sustainable Development, which had been presented in New York at the opening session of the U.N. Commission in June 1993, on behalf of CAPE, a consortium of major U.S. environmental organizations.

The results of the ensuing animated discussion in the NGO Forum were later summarized in the following statement:

1. The Miami NGO Forum provided a unique and valuable opportunity to continue the NGO dialogue that preceded the 1992 U.N. Conference on the Environment and Development (Rio Earth Summit), and that has continued since the Summit, especially as it relates to water management and policy issues in the Western Hemisphere. NGO networking is a positive and an irreversible process that needs

continuous strengthening and that is benefited from such fora as the Interamerican Dialogue on Water Management.

2. Enhanced public access to and public participation in water management decision making is essential to more efficient and equitable use of water resources. NGO interests in greater public participation and access to information does not lessen the recognition for the need of bold new water management initiatives in areas such as the development of new, low-cost, the clean technologies, regional and national water conservation strategies, and least-cost, demand-side water management policies.

3. Public information capacity strengthening is needed in these three areas: 1) greater political access to water management decision making and information, 2) greater technical capability for absorbing and processing water resource information, and 3) more financial resources available to gather and analyze information.

4. NGOs suggested a number of instruments or mechanisms to achieve greater access to information: 1) an “international ombudsman” approach, 2) a telecommunications network, 3) a “troubleshooter” group, 4) a “clearinghouse” office, and 5) a set of user-friendly guidelines on how to start and track information on water projects.

5. Regarding activities of international financial institutions (IFIs) such as the World Bank, increased informed access by NGOs is essential, and increased democratization of operations of these institutions at the local level must continue. Also, priority setting among the IFIs should reflect the goals of Agenda 21 and include grater public involvement.

6. The Rio Declaration agreed upon by 170 governments, specifically acknowledges that individuals have the right to information at the national level (Principle 10). NGOs need to reinforce this affirmative obligation among the parties.

7. U.S. NGO involvement in other countries should be conducted in cooperation and openness with local NGOs.

8. Existing NGO information gathering, analyzing, and policy formulating facilities should be improved before the creation of redundant facilities.

9. There is the need for a “best practice” catalogue for innovative best water management practices, and it should be distributed widely.

It was agreed that this statement of the views of the participant in the October 27, 1993, NGO Forum would be included in these proceedings.

For additional copies of the paper *Water Quality as a Top Priority for the UN Commission on Sustainable Development,* (in English or Spanish) please contact Mr. Steve Parcells, National Audubon Society, 666 Penn. Ave., SE, Washington, DC 20003, USA. Also, the Earth Council is disseminating, through a diskette, *The Rio Agreements and the NGO Treaties* at a cost of $2.00. Contact: Francisco Mata, Earth Council, P.O. Box 2323-1002, San Jose Costa Rica.

Binational Management of the San Juan River Basin: From War to Cooperation

a Roundtable Discussion held as part of the

INTERAMERICAN DIALOGUE ON WATER MANAGEMENT

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Introduction

The San Juan River has long been a focus of conflict. The strategic importance of the river as a route for trade and travel between the Atlantic and Pacific Oceans has been recognized for centuries. More recent attention has been directed at the ecological significance of the tropical forests, wetlands and estuaries of the lower San Juan, which Nicaragua and Costa Rica have agreed to protect through the Si-A-Paz binational complex of protected areas. Disputes have continued, however, over alleged pollution of the river, rights to navigation and potential diversions of water from the river for irrigation and hydropower development. As part of the Dialogue, a group of attorneys and water managers from Nicaragua and Costa Rica met to discuss the potential for cooperative management of the watershed. Staff from the Center for Governmental Responsibility at the University of Florida College of Law and two of Florida's regional water management districts facilitated the discussions. A broader regional perspective was provided by the participation of environmental lawyers from Honduras, Guatemala and Mexico. This paper will describe the background of the discussions and the resulting conclusions.

I. BACKGROUND

1. The San Juan River.

The San Juan River (Rio San Juan, also called Desaguadero) flows from the southeastern end of Lake Nicaragua at San Carlos, Nicaragua and flows approximately 199 kilometers (124 miles) into the Caribbean Sea at San Juan del Norte (formerly Greytown). The river forms approximately 115 kilometers (72 miles) of the border between Nicaragua and Costa Rica. Along its southeasterly course, its largest tributaries are the San Carlos and Sarapiquí Rivers from Costa Rica. In addition, numerous smaller watercourses flow into the River from both countries. Near its mouth the San Juan divides into three distinct arms that flow into the Caribbean Sea, forming a highly productive estuary. As the river branches off, the Juanillo Menor and the San Juan proper flow to the north and the Rio Colorado, the largest branch, flows south through Costa Rica. Navigation is impeded by rapids at Toro, El Castillo, and Machuca and is limited to boats with a shallow draft.

During the western migrations in the United States between 1850 and 1870, immigrants to

California transferred at San Juan del Norte from Atlantic steamers to small boats which went up the river and across Lake Nicaragua. They then travelled overland to the Pacific port of San Juan del Sur. This same route was once considered as a possible canal route between the Caribbean and the Pacific.

2. A History of Conflict.

The river has been the scene of conflict for centuries. During the last half of the 17th century, the Miskito Coast was controlled by the English, who harassed the Spanish by sailing up the San Juan to attack Nicaragua's largest city at that time, Granada. British and American forces, and their allies, contested control of the river during the mid-1800's, with devastating consequences for the region. Although both U.S. and British interests had secured equal access to a potential canal route across Nicaragua,[1] the flood of immigrants to the gold fields of California could not wait for such developments. At the height of the California Gold Rush 2000 people per month traveled this route. The entire journey from the Eastern seaboard of the United States to California took only 22 days.[2] Cornelius Vanderbilt controlled the route, though with British financing. The potential for British control of the route was of sufficient concern to the U.S. government that it apparently encouraged invasion of Nicaragua by an American adventurer named William Walker. Walker intended to annex Nicaragua to the U.S. as a new slave state. Ultimately, a Central American force, led by the Costa Rican President Juan Rafael Mora and supported by British funds and a naval blockade, defeated Walker.[3]

During the Nicaraguan Civil Wars from 1977-1987, the San Juan River was again a scene of conflict. Those years were marked by repeated skirmishes along the border and the escalation of political tension between Nicaragua and Costa Rica. As the violence has subsided, attention is being focused on the environmental degradation of the San Juan watershed and use of the River in the growing tourism market. Even though Nicaragua has possession of almost all the river bed, approximately 80% of the watershed lies within Costa Rica. The Costa Rican estuary, in turn, receives about 80% of the river's flow through the Rio Colorado branch. Consequently, there is an urgent need to develop an institutional framework for binational watershed management.

3. Legal Status.

The present legal status of the section of the river that forms the border between the two countries is defined by the Cañas-Jerez Treaty of 1858, as clarified through President Cleveland's arbitral awards in 18$8 and subsequently in 1905 when the joint border was drawn.[4] Under the Treaty, the river lies entirely within Nicaragua, while Costa Rica retains possession of the southern shore and rights to navigation for its citizens and for the transportation of “goods of commerce” and a right of consultation regarding development of the river.

4. Si-A-Paz.

The International System of Protected Areas for Peace or Si-A-Paz[5] is a binational system of protected areas along the lower San Juan River. A significant portion of the watershed of the San Juan River lies within this protected area complex. The idea for Si-A-Paz was developed in the 70's and was first proposed in 1988. After numerous bilateral agreements and declarations over the years, Costa Rican President Rafael Calderón and Nicaraguan President Violeta

Chamorro signed an official agreement in April 1993 that designated nearly five million acres of land in the two countries as Si-A-Paz International Park. Si-A-Paz is one of the binational protected areas designated for priority protection in the recently signed Convention on Biological Diversity and Priority Wild Areas in Central America.[6]

In Costa Rica, Si-a-Paz includes three protected areas: Tortuguero National Park, Barra del Colorado Wildlife Refuge and Caño Negro Wildlife Refuge. Much of the land in the wildlife refuges and in the corridors that connect these parks remains privately owned. In addition, banana plantations, cattle ranching, and logging operations have increased within the region, and within the watershed of the Rio San Juan.

In Nicaragua, Si-A-Paz divides the southern portion of the country into three zones under different levels of protection. This scheme is based on the concept of “directed colonization.” The western zone is open to development, the eastern zone is set aside as a forest reserve where farming is prohibited, and the middle zone is to serve as a buffer zone where land use is limited to “sustainable farming.” With peace, however, the region has begun to attract landless Nicaraguan farmers. The migration of agricultural colonists to the Southern frontier has grown to approximately 8,500, most having arrived within the last two years.

II. CURRENT ISSUES

1. Use of the River.

Tourism on the San Juan River has become an increasingly lucrative trade. Although political unrest and inadequate infrastructure have hampered Nicaraguan efforts to promote travel, Costa Rican guides are now transporting tourists on the River and obtaining the economic benefits of a growing ecotourism market. Nicaragua contends that this violates the 1858 Cañas-Jerez Treaty, since tourists do not constitute “goods of commerce” within the meaning of the agreement. At the time the Treaty entered into force tourism was not an issue and the phrase “goods in commerce” had an accepted meaning. Costa Rica had no viable means of transportation to the sea in the region and was compelled to use the San Juan to ship its agricultural goods to Caribbean ports. The question now presented by this agreement is whether it was the intent of the drafters to limit “goods of commerce” to agricultural goods and if not, do tourists fall within the scope of “goods of commerce?”

In an effort to resolve this aspect of the dispute, a binational commission was created and has made improvements in regulating the transportation of tourists between the two countries on the River. Foreign tourists, but not Costa Rican nationals, are now required to obtain visas to travel on the river and to pay a small fee to local officials for the privilege. In addition, each country has formed a national commission to follow these issues and coordinate each nation's institutional actions regarding the joint border and its problems.

2. Diversion of Water.

Although most of the flow of the San Juan River originates in Costa Rica, Lake Nicaragua makes a substantial contribution.[7] The only current diversion is to support irrigated agriculture along the Tempisque River in Costa Rica. There may be pressure to expand the extent of that diversion in the future. The greatest concern, however, stems from consideration by Nicaragua of the potential to cut a channel from Lake Nicaragua to the Pacific Ocean and harness the resulting

flow of water for hydroelectric power production. Such a development could lower the lake and significantly reduce flow to the river, especially during the dry season. Both Nicaragua and Costa Rica have substantial fisheries at the mouth of the river that could be adversely impacted by freshwater diversions. Costa Rica, in particular, derives considerable income from foreign anglers who come to pursue such estuarine-dependent species as snook and tarpon.

3. Contamination of the San Juan River.

There is increasing concern that pollution of the San Juan river, particularly from intensive agricultural practices within the Costa Rican portion of the watershed, has had an adverse impact on water quality within the River. There have been reports within the last two years of substantial fish kills downstream from the major Costa Rican tributaries, the Sarapiquí and San Carlos Rivers. Studies conducted by the Nicaraguan Center for Research on Water Resources (Centro de Recursos Acuáticos) found high levels of pesticides. There is also concern for pollution by nutrients, sediments, and solid waste (principally the plastic bags used in banana cultivation). Costa Rica has been unwilling to accept the results of studies conducted by Nicaragua.

In August 1992, the Foreign Ministers of Costa Rica and Nicaragua signed a joint declaration in which they agreed to carry out environmental impact studies on their respective sides of the border. Nicaragua has also brought the water quality issues associated with the San Juan River to the Central American Commission for Environment and Development (CCAD), a recently formed regional environmental integration organization. The CCAD is charged with developing plans and strategies relating to regional environmental protection. It is comprised of cabinet-level ministers from each of the Central American countries with responsibility for natural resource management. The CCAD is seeking to have a neutral international organization, the Interamerican Institute for Cooperation for Agriculture (IICA), to carry out research to assess the river's condition and the sources of its contamination, but currently lacks funding to undertake the kinds of studies necessary to assess the magnitude of the problem and determine appropriate remedial measures.

III. THE DIALOGUE

The Interamerican Dialogue on Water Management provided an opportunity to evaluate ongoing efforts and develop new approaches to the binational management of the San Juan River Basin. A balanced group of Nicaraguans and Costa Ricans was invited to participate and funding to support travel was provided by the North South Center at the University of Miami. It was agreed that the discussions would be informal and that none of the participants would be representing their governments. Thomas T. Ankersen, an attorney working at the University of Florida College of Law's Center for Governmental Responsibility was chosen to facilitate the discussions. Three different sessions were held during the Dialogue.

The representatives from Nicaragua were Marco González, an attorney specializing in international and environmental law, Jose León Talavera, Chairman of the Environment and Natural Resources Committee of the Nicaraguan legislative assembly, and Javier López Medina, an engineer working for the Nicaraguan environment ministry, IRENA (Instituto Nicaragüense de Recursos Naturales y del Ambiente). The representatives from Costa Rica were Rodrigo Barahona, an attorney and President of the Centro de Derecho Ambiental y de los Recursos

Naturales (CEDARENA) and Joaquín Tacsan, an attorney at the Arias Foundation. A broader regional perspective was provided by the participation of Alejandra Sobenes, an attorney from Guatemala and President of the Instituto de Derecho Ambiental y Desarrollo Sostenible (IDEADS), Clarissa Vega, an attorney from Honduras, and Diana Ponce-Nava, an attorney from Mexico and consultant to the United Nations Environmental Programme. Substantial technical assistance was contributed by three scientists and engineers from two of Florida's water management districts, Pat Frost and David Stites from the St. Johns River Water Management District and Horacio Wheelock from the South Florida Water Management District. All three had worked in Nicaragua.

After extensive discussion of the facts and issues described above, the participants came to several conclusions. Greatly enhanced cooperation in management of the basin was strongly supported by the group. There was recognition of the need to establish an institutional basis for such cooperation. Rather than seeking to establish new institutional structures, it was agreed that development of cooperative basin management should be pursued through the processes established for management of Si-A-Paz. To this end, the Costa Rican and Nicaraguan Parliamentary Commissions are planning a joint meeting, with part of the meeting to be held in Los Chiles, Costa Rica and part in San Carlos, Nicaragua.

The most pressing issues relate to water quality. There was concern that there is inadequate information currently available on the water quality characteristics of the San Juan River and its tributaries and on the water quality impacts of various land uses. A study that would be acceptable to both Nicaragua and Costa Rica is needed. A technical subgroup therefore met separately to develop the technical parameters of such a study.[8] The study they designed would be based on a compilation of available topographic, hydrologic, socio-economic and physiochemical data on the river. It would include three field trips: a reconnaissance trip to identify sampling sites and arrange logistics, and sampling trips during the dry and wet seasons. The entire study, including the presentation of a final report to the joint commission, could be accomplished within 18 months. The cost could be significantly reduced by the contribution of time and expertise by water resource professionals from Florida's water management districts, other interested agencies or the private sector. Although the importance of estuarine conditions was recognized, they would require a separate study.

Conclusion

These efforts merit presentation to the water management community as a model for international cooperation in water resource management and peaceful conflict resolution. During the course of the roundtable, it became apparent that similar binational watershed management issues exist throughout the region. The development of an appropriate approach to transboundary water management of the San Juan River may provide a model for similar frontiers in Central America, such as the Gulf of Fonseca, shared by Honduras, El Salvador, and Nicaragua, the Coco River Basin, shared by Honduras and Nicaragua, and the Sixaloa, dividing Costa Rica and Panama.[9] All of the participants felt that they would have benefited from understanding how other binational and multilateral efforts at river basin management have worked.[10]

Notes

1. The Clayton-Bulwer Treaty of 1850 guaranteed equal access to both nations and forbid efforts to colonize the region.

2. Diane Jukofsky, Along the San Juan, Lacsa's World 22, 21-23 (undated).

3. RALPH LEE WOODWARD, JR., CENTRAL AMERICA: A NATION DIVIDED, 137-145 (Second Edition, 1985 Oxford University Press).

4. FELIPE RODRÍGUEZ SERRANO, LOS DERECHOS DE COSTA RICA Y NICARAGUA EN EL RIO SAN JUAN (1983, Lehmann Editores).

5. The Spanish acronym for Sistema Internacional de Areas Protegidas para la Paz means “Yes to Peace”.

6. The nations of Central America have committed themselves under this agreement to establishing a system of protected areas extending throughout the region. Convention for the Conservation of Biological Diversity and Protection of Priority Wild Areas, Managua, Nicaragua (June, 1992). See generally, T. Ankersen & R. Hamann, The Mesoamerican Biological Corridor: The Legal Framework for an Integrated System of Protected Areas, Proceedings of the International Wildlife Management Congress, September, 1993, San Jose, Costa Rica; T. Ankersen, The Mesoamerican Biological Corridor: A Model Legal Framework for an Integrated Regional System of Protected Areas, Background Document (September, 1993, Center for Governmental Responsibility, University of Florida College of Law, Gainesville, Florida).

7. See generally, Claudio Gutierrez Huete, Caracterización de la Cuenca del Río San Juan (June 27, 1991).

8. The group consisted of Pat Frost, Javier López, David Stites and Horacio Wheelock.

9. All of the attorneys who participated in the roundtable are currently working together with colleagues from each of the other countries in Central America, Panama and Mexico on the MesoAmerican Biodiversity Legal Project, analyzing legal regimes for the management of protected areas in the region. The group plans to focus on watershed management in the near future. For further information, contact Tom Ankersen or Richard Hamann at the University of Florida College of Law, 230 Bruton-Geer Hall, Gainesville, Florida 32611-7629. (904) 392-2237 Internet: CGRTOM@NERVM.NERDC.UFL.EDU.

10. See e.g., JON MARTIN TROLLDALEN, INTERNATIONAL ENVIRONMENTAL CONFLICT RESOLUTION: THE ROLE OF THE UNITED NATIONS, Ch. 5, Case Studies: International River Systems (1992): Kenneth Brooks, Hans Gregersen, Peter Ffolliott & K.G. Tejwani, Watershed Management: A Key to Sustainability, in NARENDRA P. SHARMA (ED.), MANAGING THE WORLD'S FORESTS: LOOKING FOR BALANCE BETWEEN CONSERVATION AND DEVELOPMENT (1992); Guillermo J. Cano, Transboundary Freshwaters, in PETER SAND (ED.), THE EFFECTIVENESS OF INTERNATIONAL ENVIRONMENTAL AGREEMENTS: A SURVEY OF EXISTING LEGAL INSTRUMENTS (1992).

WATERDIALOGUE - A Communication Link for Water Resource Professionals in the Western Hemisphere

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The Together Foundation is providing a pilot network communications platform upon which the Interamerican Water Resource Network (WATERDIALOGUE) can host conferences, maintain a shared information base and provide intercommunicative services to its members. Network services are being custom configured for the membership at the direction of the Policy Council established at the Interamerican Dialogue on Water Management in October, 1993.

The Together Foundation is actively expanding its network, TogetherNet™, in the Americas. Currently the Together Foundation operates host computer sites in New York, NY; Burlington, Vermont at the University of Vermont; and in Caracas, Venezuela. The Foundation is presently installing a host computer sites in Rio de Janeiro, Brazil; and Geneva, Switzerland. The Foundation is actively seeking other organizations in the Americas to support network nodes. Members of the network not located in a city with a host computer node will have access the network via telephone call to the nearest network node. The network will be connected to SprintNet, an X.25 packet-switching network. Cost saving X.25 access will be available to WATERDIALOGUE members in the fourth quarter of 1993. Access to TogetherNet is also available through the global Internet.

The TogetherNet system is an advanced communications and information sharing system that makes access and operation extremely simple for its users. TogetherNet users with Macintosh and MS-Windows computers are able to use the system through advanced graphic user interfaces that ease operation and optimize participation in the Interamerican Dialogue on Water Management working group. TogetherNet continuously upgrades network software and hardware to optimize its effectiveness for users given the advent of new hardware, software and telecommunications technologies.

The purpose of The Together Foundation and TogetherNet is to facilitate cooperation related to sustainable development and the implementation of Agenda 21. Many organizations are already using the TogetherNet system for these purposes. Currently, TogetherNet is one of the major platforms in use by the United Nations information dissemination systems. Together Foundation maintains a liaison office in New York to assist in the management and distribution of information through the TogetherNet system. This has resulted in an additional benefit to TogetherNet members, since vast amounts of resources and valuable information on topics such as environment, human rights, democratization and poverty are daily updated and discussed in this electronic forum.

The Together Foundation's network will be made available to members to all interested members the Interamerican Water Resource Network. The Foundation is pleased to grant access to these services to (30) charter members of WATERDIALOGUE for the years 1994 and

1995 at the discretion of the Dialogue Project Manager and Policy Council. Other parties interested in joining WATERDIALOGUE will be given (3) month trial memberships to the system at no cost. After the (3) month trial period members will be billed a flat $10 per month not including telecommunications costs.

The Together Foundation will assist the Interamerican Dialogue on Water Management in the creation of a virtual organization composed of WATERDIALOGUE members from the Americas. These members are from different organizations in various locations and intend to cooperate to "Link International Water Resources Networks." The Together Foundation will be available to support WATERDIALOGUE members in the effective use of network communication services. Toll-free technical and customer support will be available Monday through Friday. The Foundation has created a prototype WATERDIALOGUE section within the TogetherNet system while working with Mr. Alberto J. Palombo, Dialogue Project Manager. More information is available about the TogetherNet system is available directly from the Together Foundation in Burlington, Vermont, USA, or by telephone (802) 862-2030.

Interamerican Survey of Water Resource Professionals

Note of the Editor: This survey instrument was designed and administered by the Global Tomorrow Coalition as directed by the Policy Council of the Interamerican Dialogue on Water Management. The Secretariat intends to continue the administration of this survey for the near future. If you need copies of the survey, please contact the Organization of American States - Department of Regional Development and Environment, Washington, DC, USA.

PURPOSE AND METHODOLOGY

The Interamerican Survey of Water Resource Professionals is intended to assess the potential benefits and services of an expanded Water Resource Partnership linking existing networks, associations, government agencies, businesses, organizations, and institutions in the Western Hemisphere. Since July 1993, it has been circulated to approximately 800 water resource professionals throughout the Americas to determine: (1) which water management networks are already functioning in the Western Hemisphere; (2) which information sources and services could be expanded through a new partnership to link these networks together with other water resource agencies, businesses, and institutions; and (3) how such a partnership might be established.

An interim report covering the first 105 responses was prepared and circulated at the time of the Interamerican Dialogue on Water Management in Miami, Florida, on October 27-30, 1993. A second, updated report was completed on January 31, 1994 as a part of the Grant Fulfillment Report presented to the South Florida Water Management District.

This third and final report is based on the answers contained in the total of 177 completed surveys received by the Global Tomorrow Coalition through March 25, 1994, of which 73 are South American and 104 are North American. The conclusions are intended to highlight those areas in which the views of water resource professionals from North America and South America coincide, and those in which they do not. Following the success of the Interamerican Dialogue on

Water Management, it is important to build on the foundation of agreement, and to reconcile areas of disagreement, in order to foster stronger and more effective cooperation between water resource professionals in the Western Hemisphere.

BACKGROUND OF RESPONDENTS

The water resource professionals responding to this survey from both South America and North America have extensive experience with the issue of water resource management. More than a third of those from South America (34%) and from North America (38%) indicated that they had been active in the water resource field for over 20 years. Approximately the same percentages from both areas (30% as compared to 32%) indicated that they had spent at least 13 years on water resource issues.

Most respondents also have extensive educational backgrounds. Among South Americans, 41% have received a B.A. degree, and virtually the same percentage have an M.A. The remaining 16% have received a Doctorate. In comparison, 20% of North American respondents indicated that they have received a B.A. degree, 40% have an M.A., and fully 36% have received a Doctorate.

An area in which significant contrasts emerged among the respondents is that of their knowledge of each other's language. Fully 36% of South Americans reported “high” proficiencies in spoken and written English, and nearly two-thirds (61%) of South Americans indicated that they have “low” to “medium” proficiency in spoken English, and 64% in written English. On the other hand, an overwhelming majority of North American respondents characterized their proficiency as “low” or “none” in spoken Spanish (76%) and written Spanish (79%).

Except among Brazilian respondents, the knowledge of Portuguese was at a modest level among South Americans and was very low among North Americans, only 12% of whom indicated any ability to speak or read Portuguese. This suggests that language competence will be among the obstacles to be overcome if a true water resource partnership is to be created in the Americas.

EXECUTIVE SUMMARY

A full tabulation of answers to all questions in the survey is contained in Appendix I. Appendix II contains the names and addresses of all the respondents, while Appendix III is a tabulation of all other associations or networks with which the respondents reported an affiliation. These are selected issues on which the level of agreement or disagreement between South American and North American respondents seemed worthy of attention.

Water Management Problems

Almost equal numbers of respondents from South America and North America (56% and 65%, respectively) felt that greater emphasis should be placed on ecosystem-based approaches in dealing with water resource problems. There was a significant difference, however, in the numbers of South Americans (56%) and North Americans (22%) who saw sanitation treatment systems as a major water management problem.

Communication

On adequacy of communication among water resource professionals and institutions, there was a significant convergence of opinions. Very few respondents rated existing communication in their country highly (4%-9%), while many from both South America and North America (47%-56%) characterized it as only “medium” at best, Indeed, 49% of South Americans and 35% of North Americans rated communication at their national level “low” or “poor.”

Sound Water Resource Management

Approximately two-thirds of all respondents (68% from South America and 62% from North America) indicated that funding was a hindrance to the implementation of sound, sustainable water resource management in their immediate areas. On the other hand, 52% of South Americans cited institutional capacity as an obstacle in achieving their goals, while a small minority of North Americans (30%) indicated that it was a “major problem.” Significant majorities (55%-76%) ranked public understanding in the latter category as well.

Water Resource Entities

When asked which international and national entities are prominent in water resource management in their area, the respondents assigned highest rankings to federal/national, state/provincial, and district agencies, with significant majorities of North American respondents citing the latter two. Fully 25% of South American respondents indicated that universities were important to water resource management, while only 14% of North Americans agreed with them. Not surprisingly, 22% of South Americans cited United Nations agencies as important in their area, while only a small minority of North Americans (3%) did so.

Need for Stronger Partnership

There was near-unanimity among all respondents (96% from South America and 94% from North America) that there is a need for a stronger partnership among water resource professionals in the Western Hemisphere.

Potential Benefits

Strong majorities of the respondents from both areas (77%-74%) felt that improved exchange of information among water resource professionals would be a benefit from the creation of a stronger water resource partnership in the Americas. Among South American respondents, even larger majorities cited enhanced communication, cooperation, and technology exchange (70%, 70%, and 78%, respectively) as potential benefits. While a majority of North Americans agreed on communication and cooperation (76% and 64%, respectively), only 54% ranked the exchange of technology highly. Almost precisely equal numbers of respondents from both South and North America (56%-54%) indicated environmental education as a strong benefit of a closer partnership. Fully 70% of South Americans ranked training as “high” as opposed to only 35% of North Americans.

Establishing a Partnership

When asked about important factors to consider in the establishment of an interamerican partnership, 75% of South Americans and 61% of North Americans assigned highest priority to access to financial support. Similarly large majorities (64%-55%) cited access to professional staffing. The next most important issue for both South Americans (59%) and for North Americans

(45%) was that of the location and ease of access to the proposed partnership. The independence of such an institution was regarded as less important, with high rankings by considerably less than half of the respondents (45%-20%).

Location of the Partnership

There was a distinct difference in view on the appropriate location of such a partnership. Among South Americans, 51% expressed high preference for a location in South America (only 10% of North Americans agreed), and 64% of North Americans felt that it should be located in North America (only 41% of South Americans agreed). Both South and North Americans (16% and 10% respectively) accorded Canada low preference as the site for the partnership. Approximately one-third (34%) of South American respondents and two-thirds (64%) of North Americans, however, agreed that the site of the partnership was “not important”.

APPENDIX I - RESULTS OF THE INTERAMERICAN SURVEY OF WATER RESOURCE PROFESSIONALS

The following is a copy of the survey distributed by the Policy Council. The number of South American and of North American respondents who answered particular questions are expressed in percentages. The first number always represents South American respondents, while the second number always represents those from North America.

1. How long have you been active in the water resource field? 16%-12% 1-5 years, 19%-19% 6-12 years, 30%-32% 13-20 years, 34%-38% over 20 years

2. What is your level of formal education? 0%-0% high school degree, 41%-20% university bachelor's degree, 42%-40% university master's degree, 16%-36% university doctorate, 0%-4% other

3. What is your level of proficiency in the following languages?

	High	Medium	Low	None
English-Spoken	36%-99%	34%-0%	27%-1%	3%-0%
English-Written	36%-98%	52%-1%	12%-1%	0%-0%
Spanish-Spoken	85%-13%	7%-10%	4%-33%	4%-43%
Spanish-Written	82%-12%	5%-9%	7%-30%	5%-49%
Portuguese-Spoken	11%-1%	10%-2%	21%-9%	58%-89%
Portuguese-Written	14%-1%	16%-3%	18%-8%	53%-89%

4. Did you or your institution/business/agency/organization participate in preparations for, or conduct of, the 1992 United Nations Conference on Environment and Development? 52%-33% Yes 48%-66% No

5. Are you familiar with recommendations from the following initiatives?

	Yes	No
Dublin Conference	49%-23%	51%-77%

Agenda 21	51%-38%	49%-62%
Mar del Plata Action Plan	47%-21%	53%-79%

6. Are you familiar with the following publications?

	Yes	No
Our Own Agenda	30%-14%	70%-86%
Compact for A New World	5%-14%	95%-86%
Our Common Future	27%-29%	73%-71%
Changing Course	4%-17%	96%-83%
Water Quality 2000	19%-42%	81%-58%

7. Are you a member of one or more professional associations and/or networks dedicated to water resource issues? 66%-68% Yes 34%-32% No.

Five most mentioned South American associations/networks:

1. Programa Hidrologico Internacional	5%
2. Asociacao Brasileira de Recursos Hidricos	3%
3. Asociacion Chilena Ingenieria Hidraulica	3%
4. Red Latinoamericana para el Manejo de Cuencas Hidrograficas	3%
5. Asociacion Mexicana de Hidraulica	3%

Five most mentioned North American associations/networks

1. American Water Resources Association	8%
2. American Society of Civil Engineers	7%
3. American Water Works Association	3%
4. International Water Resources Association	3%
5. Tennessee Valley Authority	1%

What is the main focus of these groups and what services do they provide?

South American respondents:

1. Programa Hidrologico Internacional: Founded 18 years ago, this group focuses on the analysis and the solution of water use and conservation problems. It provides water resource education, information exchange, technical assistance, and help in the development of water use projects.

2. Asociacao Brasileira de Recursos Hidricos: Since 1973, ABRH has worked in the field of water resource management. It organizes symposia, seminars, courses, etc.

3. Asociacion Chilena de Ingenieria Hidraulica: In the past 25 years, ACIH has dealt with the development and scientific investigation of water resources. It acts as a forum for water resource experts.

4. Red Latinoamericana para el Manejo de Cuencas Hidrograficas: For 12 years, this network has facilitated the transfer of watershed management technology between countries in South America.

5. Asociacion Mexicana de Hidraulica: Since its founding 20 years ago, the AMH has sponsored the dissemination of technical information and organized bi-annual congresses and monthly conferences.

North American respondents:

1. American Water Resources Association: In the past 29, years AWRA has concerned itself with American water resources policy by acting as a professional networking and development agency, and as a forum for communication between specialists.

2. American Society of Civil Engineers: Since its founding 141 years ago, the ASCE has as its objective “the advancement of the science and profession of engineering.” It does so by publishing monthly journals and holding meetings.

3. American Water Works Association: For over 50 years, AWWA has been involved in water supply and conservation issues. It provides water supply and utility standards.

4. International Water Resources Association: Since the early 1970s, the IWRA has focused on international water resource problems and issues. It publishes a journal and sponsors an annual international conference.

5. Tennessee Valley Authority: For 25 years, the TVA has worked on river navigation and economic development. It is a liaison with government agencies, and sponsors seminars.

8. Please rank the priority of water management problems in your immediate area (expand list as needed):

	High	**Medium**	**Low**
Sanitation Treatment Systems	56%-22%	18%-44%	26%-34%
Water Supply	34%-53%	36%-30%	30%-16%
Ecosystem-Based Approaches	56%-65%	25%-24%	19%-11%
Riparian Management	17%-32%	26%-30%	57%-38%
Health & Water-Borne Diseases	26%-10%	33%-26%	41%-65%
Water Policies and Laws	47%-53%	32%-34%	22%-12%
Irrigation	30%-30%	27%-37%	42%-32%
Non-Point Source Runoff	32%-66%	29%-17%	40%-17%
Underground Aquifers	38%-60%	37%-25%	25%-15%

9. How would you rate existing communication among water resource professionals in your:

	High	Medium	Low	Poor
Immediate Area	27%-33%	44%-51%	18%-9%	11%-7%
State/Province	11%-15%	45%-63%	32%-14%	12%-7%
Country	4%-9%	47%-56%	30%-25%	19%-10%

Three most common comments in this question:

South American respondents:

1.	Communications and activities are poorly coordinated and organized.	11%
2.	There is a lack of publications and of methods for exchanging information.	4%
3.	Water resource professionals and the political sphere do not coordinate their efforts well.	4%

North American respondents:

1.	Networking and communication are well established at the local level.	6%
2.	Coordination and communication among professionals is very poor at the national level.	5%
3.	There are too many conflicting interests in water resource management for communication to be good.	2%

10. What were the major benefits that you derived from attending water-related conferences, symposia, or training sessions in the last three years? Top three responses:

1.	Learning about new methodologies, technologies, policies, and ideas from peers.	30%
2.	Comparison of management experiences and problem solving strategies at the national and international level.	26%
3.	A chance to meet other water resource specialists and to make new contacts.	14%

1.	A chance to meet other water resource professionals, network with them, and make new contacts.	39%
2.	Information can be disseminated and collected, thus furthering professional development.	19%
3.	Through discussions, papers, and personal contacts ones knowledge base is expanded.	16%

11. In your own view, what are the major needs in the development and implementation of sound, sustainable water resource management in your immediate area? Please rank the priority

of the following (expand list as needed):

	High	Medium	Low
Infrastructure	42%-32%	45%-39%	12%-29%
Legal Framework	45%-28%	36%-41%	19%-31%
Institutional Capacity	52%-30%	37%-41%	11%-29%
Technical Assistance	36%-24%	42%-47%	22%-29%
Funding	68%-62%	18%-31%	14%-6%
Training	47%-34%	40%-49%	13%-17%
Communication	45%-54%	33%-38%	22%-8%
Enhancement of Expertise	39%-22%	45%-59%	16%-19%
Public Understanding	55%-76%	28%-23%	17%-1%
Political Will	54%-73%	28%-18%	19%-9%

12. Please rank the turnover rate in water resource jobs in your immediate area:

30%- 6% High 52%-43% Medium 18%-51% Low

13. Please rank the prominence of the following entities in water resource management at the present time in your immediate area:

	High	Medium	Low
United Nations Agencies	22%-3%	26%-7%	52%-90%
Org. of American States	9%-2%	30%-6%	61%-92%
Federal/National Agencies	41%-46%	27%-40%	32%-14%
State/Provincial Agencies	41%-72%	22%-20%	37%-8%
District Agencies	23%-64%	33%-16%	44%-20%
Private Sector	14%-24%	33%-42%	53%-34%
Nongovernmental Orgs.	7%-16%	33%-41%	62%-43%
Universities	25%-14%	34%-50%	41%-36%
Multilateral Lending Inst.	19%-1%	36%-17%	45%-82%
Individual Users	18%-15%	32%-39%	51%-46%

14. Are you incorporating the concept of integrated watershed management in projects within your institution/agency/business/NGO? 71%-69% Yes 29%-31% No.

Top three responses:

1.	In formulating and executing watershed management projects.	19%
2.	By treating watersheds in a comprehensive manner so as to protect the resource.	15%
3.	By fostering case studies on integrated water management.	11%

1.	Through protection and the restoration of the entire ecosystem of a watershed.	8%
2.	In the field of water supply planning watersheds must be viewed in a comprehensive manner.	7%
3.	In the development and implementation of multipurpose water use plans.	4%

15. Do you believe that sustainable development-meeting the needs of the present without compromising the ability of future generations to meet their own needs - should become the unifying principle for sound water resource policies and practices in the Western Hemisphere? 94%-91% Yes 6%-9% No. Four most relevant comments:

1.	Both the quality and the quantity of our resources must be maintained for future generations.	11%
2.	There is no other rational alternative solution to the	11%
3.	problems we face today. It should become the unifying principle for managing all natural resources.	5%
4.	Sustainable development can be used to coordinate our efforts and institutions and to reduce conflict.	5%

1.	Sustainable development is the key to ensuring the survival of our planet.	8%
2.	The concept needs to be improved because it is a buzzword and has few applications for the short term.	8%
3.	Every aspect of nature should be managed sustainably and natural resource needs should be a priority.	4%
4.	It must become the common goal of all concerned with the welfare of our planet and of future generations.	4%

16. Do you feel there is a need for stronger partnership among current water resource management networks, government agencies, businesses, and institutions in the Western Hemisphere? 96%-94% Yes 4%-6% No. Top three comments:

1.	In order to gather and exchange data, methodologies, and other information partnerships must be strengthened.	22%
2.	It could be used to enhance the level of communication and coordination among water resource specialists.	19%
3.	The present overlapping of activities and excessive expenditures could be reduced.	4%

1.	It would benefit the exchange of information and of problem-solving techniques between specialists.	8%

2.	Since many resources cross political boundaries, they require cooperative efforts to be preserved.	4%
3.	We must avoid the duplication of both the efforts and the errors we have made in the past.	3%

17. Considering your own specific needs, please rank the potential benefits and services you would anticipate from such a partnership.

	High	Medium	Low
Enhanced Communication	70%-76%	23%-19%	7%-5%
Cooperation	70%-64%	22%-29%	8%-6%
Technology Exchange	78%-54%	16%-39%	5%-7%
Training	70%-35%	21%-47%	10%-18%
Capacity Building	32%-23%	48%-45%	21%-32%
Internships	32%-14%	42%-42%	26%-44%
Information Exchange	77%-74%	16%-23%	7%-3%
Environmental Education	56%-54%	33%-36%	11%-11%
Peer Review	38%-25%	40%-47%	22%-28%
Contact Directory	53%-35%	27%-43%	19%-22%
Joint Projects	55%-51%	32%-32%	19%-18%

18. What information, assistance, or services do you think you and your agency/organization/business could contribute to such a partnership? Top three answers:

1.	Information exchange on South American watersheds, management experiences, policies, etc.	23%
2.	Technical exchange and assistance in the development and implementation of water management plans.	16%
3.	Experience and expertise in the management of water resources at local and national levels.	10%

1.	Expertise in water management, policy development and implementation, and conflict resolution.	25%
2.	Information on water management, conservation, flood control, reclaiming, etc.	20%
3.	Technical assistance and transfer of technology for project design and implementation.	19%

19. Please rank the following communication mechanisms in order of their importance and effectiveness in meeting your own needs.

	High	Medium	Low
Computer Bulletin Board	47%-23%	33%-31%	21%-46%
Teleconferencing	10%-16%	41%-42%	49%-43%
Mail	41%-51%	42%-38%	16%-11%
Fax	62%-53%	23%-31%	15%-16%
Telephone	30%-57%	36%-29%	34%-14%
E-Mail	27%-33%	33%-26%	40%-41%
Conferences	77%-40%	17%-49%	6%-11%
Newsletters/Bulletins	81%-49%	14%-41%	4%-10%
Technical Exchanges	78%-46%	17%-31%	4%-23%

20. From your own point of view, please rank the importance of the following considerations in establishing such a partnership (expand list as needed):

	High	Medium	Low
Location-Easy Travel Access	59%-45%	22%-39%	19%-15%
Independence	45%-20%	36%-48%	19%-32%
Linkage to Existing Inst.	53%-38%	36%-38%	11%-23%
Revolving Secretariat	18%-13%	36%-28%	47%-59%
Permanent Secretariat	43%-13%	22%-24%	35%-63%
Access to Professional Staff	64%-55%	25%-32%	11%-13%
Access to Financial Support	75%-61%	10%-27%	15%-13%

21. Please indicate your preference among the following areas for the site of the headquarters of such a partnership:

	High	Medium	Low
Canada	16%-10%	10%-39%	74%-51%
United States	41%-64%	16%-25%	42%-11%
Mexico	11%-12%	37%-41%	52%-47%
Central America	15%-10%	26%-44%	59%-46%
Caribbean Islands	9%-20%	27%-41%	66%-39%
South America	51%-10%	19%-38%	30%-52%
Not Important	34%-64%		

22. In any area that you marked as “High” in the previous question, please specify a preferred location, if any, such as a city within that area or country:

Canada	Toronto, Ontario	7%-5%
United States	Miami, Florida	25%-26%
Mexico	Mexico City	7%-4%
Central America	San Jose, Costa Rica	8%-8%
Caribbean	Puerto Rico	3%-8%
South America	Mendoza, Argentina	14%
	Brazil	5%

23. Please list in priority order the 5 agencies, institutions, NGOs, businesses, and/or development banks that you believe would be important to involve to enhance the effectiveness of this proposed new partnership:

South American Respondents

1.	Interamerican Development Bank	41%
2.	Organization of American States	23%
3.	World Bank	23%
4.	United Nations	15%
5.	FAO	12%

North American Respondents

1.	World Bank	29%
2.	Environmental Protection Agency	23%
3.	Interamerican Development Bank	13%
4.	Organization of American States	11%
5.	American Water Resources Institute	9%

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Address: Camino de Santa Teresa 187, Col. Parques del Peoregal, Mexico City, Mexico 14010
Tel: (91)(5) 666-0835
Fax: (91)(5) 606-2323 ext. 31

Group Name: Asociación Mexicana de Hidraulica
Address: Camino de Santa Teresa 187, Tlalpau, Mexico City, Mexico 14010
Tel: (5) 606-4798

Group Name: Asociación Nacional Nicaraguense de Ingenieria Sanitaria y Ambiental
Address: Reparto Miraflores 134, Managua, Nicaragua
Tel: 661-361/667-910
Fax: 667-911

Group Name: Asociación de Recursos Hídricos y Sanitarios
Address: Colegio Federado de Ingenieros y Arquitectos San José, Costa Rica

Group Name: Associacao Brasileira de Recursos Hidricos (ABRH)
Address: Av. Profesor Lucio Martins Rodrigues 120, Caixa Postal 11142, Sao Paulo, Brasil, 05499
Fax: (011) 813-5217

Group Name: Associazione Italiana Idrotecnica
Address: Rome, Italy

Group Name: Brasilian Water Resource Engineering Association
Address: 216 - BEIRAMAR - Ave 13th Floor, Rio de Janeiro, RJ, Brasil
Tel: (021) 220-3412

Group Name: Comisión Nacional Proyecto Hidrológico Internacional
Address: Shifting
Tel: 698-5341

Group Name: Comité da Bacia do Rio Paraiba do Sul
Address: Rua Padre Joao Manoel 755, 3rd Floor, Sao Paulo, Brazil 01411-900
Tel: (011) 282-4065

Group Name: Comité Chileño para el Programa Hidrologico Internacional
Address: Manuel Montt #1164, Santiago, Chile
Tel: 274-8946
Fax: 209-6407

Group Name: Comité Executivo de Estudos Integrados da Bacia Hidrografica do Rio Sao

Francisco-CEEIVASF.
Address: Av. Sussuarana, 485 -Ed. DNOCS- S/309, Salvador, Bahia, Brazil 41-200
Fax: (071) 231-2000

Group Name: Comité Executivo de Estudos Integrados da Bacia Hidrografica do Rio Grande
Address: Rua Real Grandeza 219 -Bloco C- Sala 1.404, Rio de Janeiro, Brazil 22.283

Group Name: Comité Inter Inst. Agua, Saneamiento, Medio Ambiente
Address: Panama City, Panama

Group Name: Comité Nacional de Recursos Hidraulicos
Address: Departamento de Estudios Basicos, Instituto Costarricense de Electricidad, San José, Costa Rica
Tel: 207-309
Fax: 314-737

Group Name: E.S.B.
Address: S.C.S. -Quadra C- Bl A, #18119 Ed. Hermes, 1o Andar, Brasilia, DF, Brazil
Tel: (065) 226-3292

Group Name: Grupo Y'Guazu
Address: Av. Americo Carlos da Costa 320, Campo Grande, Brazil 79080-170
Tel: (55) 067 742-1891
Fax: (55) 067 742-3388

Group Name: Institution of Water and Environmental Management
Address: 15 John Street, London, WC1N 2EB, England
Tel: (071) 831-3110
Fax: (071) 405-4967

Group Name: Instituto de Derecho de Minas y Aguas
Address: Moneda 673, 8o Piso, Casilla Postal 3004, Santiago, Chile
Tel: 632-8290
Fax: 638-3452

Group Name: Instituto Argentino de Recursos Hídricos (IARH)
Address: Moreno 1257, 2do Piso, Capital Federal, Argentina, 1091
Tel: (01) 814-3689

Group Name: International Association of Hydrologists
Address: IAH Secretariat, P.O. Box 9, Kenilworth, UK CV8 1J9

Group Name: IPTRID
Address: HR Wallingford Ltd., Howbery Park, Wallingford, Oxon, England, OX10 8BA
Fax: (44) (491) 832-233

Group Name: Mexican Academy of Engineering
Address: Mexico City, Mexico

Group Name: Mexican Association of Hydraulics

Address: Camino de Santa Teresa 187, Mexico City, D.F., Mexico

Group Name: Mexican Committee for the International Hydrologic Program
Address: Paseo Cuauhuahuac 8532, Cuernavaca, Morelos, Mexico, 62550

Group Name: Programa Hídrologico Internacional (PHI)
Address: Santiago, Chile

Group Name: Red de Gestion en Recursos Hídricos
Address: ECLAC (CEPAL) Santiago, Chile

Group Name: Red Latinoamericana de Cooperacion Técnica en Manejo de Cuencas Hidrográficas de FAO
Address: Sede Regional de FAO, Santiago, Chile
Tel: 218-5323

Group Name: Red Nacional de Manejo de Cuencas Hidrográficas (REDNAMAC)
Address: Calle Diecisiete #355, Urb. El Palomar, San Isidro, Lima, Peru 27
Tel: (5114) 410-425
Fax: (5114) 414-606

Group Name: Sociedad Chileña de Ingenieria Hidraulica
Address: San Martin 350 Santiago, Chile

Group Name: Sociedad Chileña de Ingenieria Hidraulica
Address: Santiago, Chile

Group Name: Sociedad Venezuelana de Ingenieria Hidraulica
Address: Colegio de Ingenieria de Venezuela, Parque los Caobos, Caracas, Districto Federal, Venezuela

North American Respondents

Group Name: American Bar Association
Address: 750 N. Lake Shore Drive, Chicago, IL 60611
Tel: (312) 988-5724
Fax: (312) 988-5572

Group Name: American Fisheries Society
Address: 5410 Grosvenor Ln., Suite 10, Bethesda, MD 20814
Tel: (301) 530-8502
Fax: (301) 897-8616

Group Name: American Geophysical Union
Address: 2000 Florida Avenue N.W., Washington, DC 20009
Tel: (202) 462-6900
Fax: (202) 328-0566

Group Name: American Institute of Hydrology
Address: 3416 University Avenue S.E., Minneapolis, MN 55414-3328

Tel: (612) 379-1030
Fax: (612) 379-0169

Group Name: American Mosquito Control Association
Address: P.O. Box 5416, Lake Charles, LA
Tel: (318) 474-2723

Group Name: American Public Works Association
Address: 106 W. 11th Street, Suite 1800, Kansas City, MO 64105
Tel: (816) 472-6100
Fax: (816) 472-1610

Group Name: American Society of Civil Engineers
Address: 345 E. 47th St.. New York, NY 10017-2398
Tel: (800) 548-2723
Fax: (212) 980-4618

Group Name: American Water Resources Association
Contact: Nancy Lopez, President
Address: 5410 Grosvenor Lane, Suite 220, Bethesda, MD 20814
Tel: (703) 648-5014
Fax: 301-493-5844

Group Name: American Water Works Association/Conservation Committee
Address: 6666 W. Quincy Ave., Denver, CO 80235
Tel: (303) 794-7711

Group Name: Association of American Geographers
Address: 1710 16th St.. N.W., Washington, DC 20009
Tel: (202) 234-1450

Group Name: Association of Ground Water Scientists and Engineers

Group Name: Association of State Wetlands Managers
Address: P.O. Box 2463. Berne, NY 12023

Group Name: Bream Fishermen Association
Address: Pensacola, FL

Group Name: Florida Engineering Society
Group Name: Florida Water Well Association

Group Name: International Association for Great Lakes Research
Address: University of Michigan, 2200 Bonisteel Blvd., Ann Arbor, MI 48109
Tel: (313) 498-2007

Group Name: International Association of Hydrogeologists
Address: 2614 Checkerberry Court, Reston, VA 22091
Fax: (703) 648-5295

Group Name: International Irrigation Management Institute
Address: P.O. Box 2075, Colombo, Sri Lanka
Tel: (94-1) 867-404
Fax: (94-1) 866-854
E-Mail: iimi 1571cgil29

Group Name: International Water Resources Association
Address: 205 North Mathews Drive, Urbana, IL 61801
Tel: (217) 333-0536
Fax: (217) 244-6633

Group Name: Interstate Council on Water Policy
Address: 415 Hamm Building, 408 St. Peter Street, St. Paul, MN 55102
Tel: (612) 223-5828
Fax: (612) 223-5815

Group Name: Irrigation Management Network
Address: c/o The Overseas Development Network, 94 Victoria Street, London, SW1 E5JL, England

Group Name: Miami Geological Society

Group Name: Mississippi Water Resources Association
Address: P.O. Box 1393, Ridgeland, MS 39258
Tel: (601) 957-6536
Fax: (601) 957-6536

Group Name: National Ground Water Association
Address: 6375 Riverside Dr., Dublin, OH 43017
Tel: (614) 761-1711
Fax: (641) 761-3446

Group Name: National Society of Professional Engineers

Group Name: National Water Well Association

Group Name: North American Benthological Society
Address: Dept. of Research, SFWMD, P.O. Box 24680, West Palm Beach, FL 33416-4680
Tel: (407) 687-6601
Fax: (407) 687-6442

Group Name: North American Lake Management Society
Address: 1 Progress Blvd., Box 27, Alachua, FL 32615-9536
Tel: (904) 462-2554

Group Name: Ohio River Consortium For Research and Education
Address: 6978 Presidio Court, Cincinnati, OH 45244
Tel: (513) 232-3511

Group Name: Salt Water Conservation Society

Address: 7515 N.E. Ankeny Rd., Ankeny, IA 50021
Tel: (515) 289-233

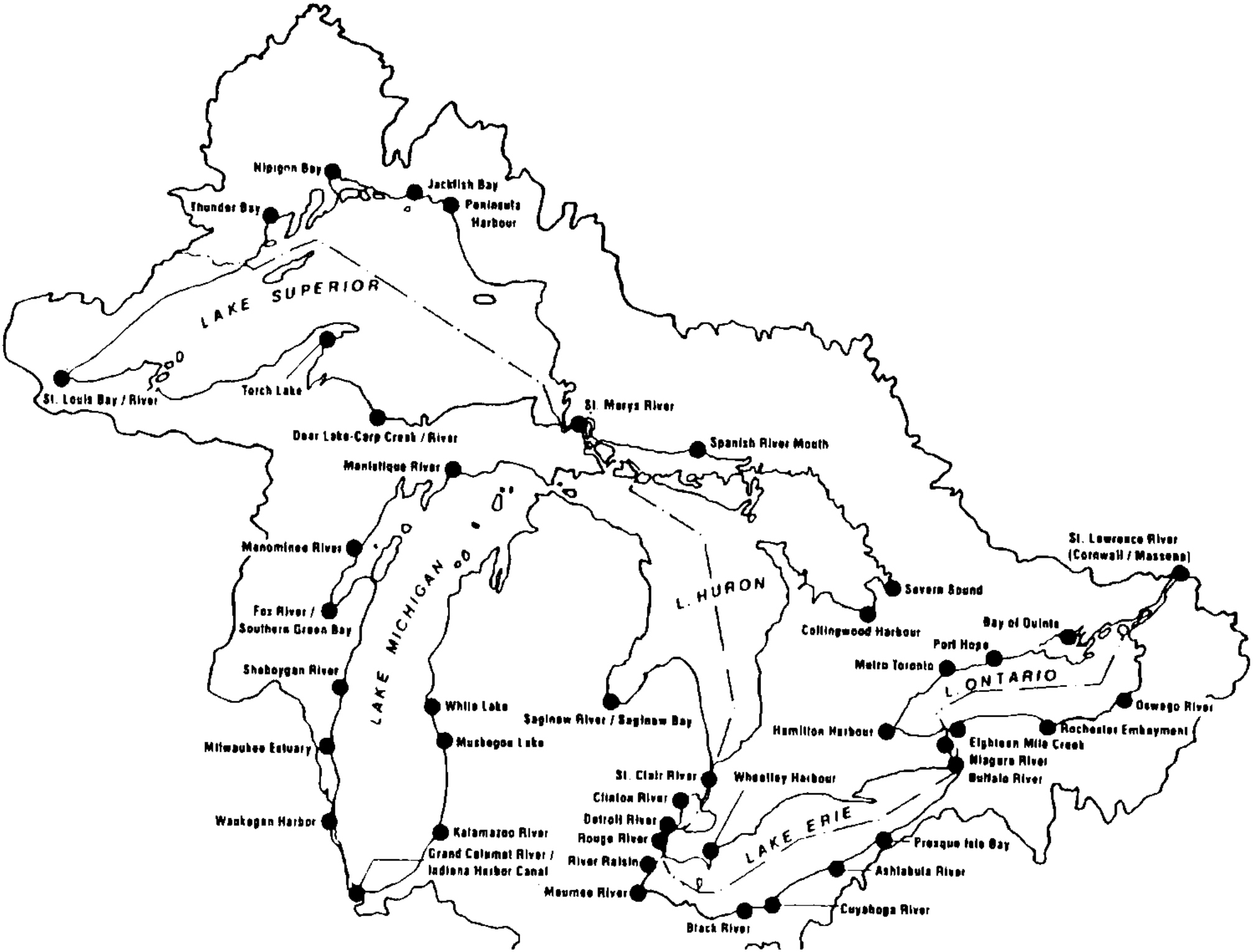
Group Name: Southwest Florida Water Management District
Address: 2379 Broad Street, Brooksville, FL 34609-6899
Tel: (813) 920-5392

Group Name: Tennesee Valley Authority
Address: P.O. Box 1745, Decatur, AL 35602
Tel: (205) 355-4660
Fax: (205) 351-8257

Group Name: U.S. Committee on Irrigation and Drainage (USCID)
Address: 1616 Seventeenth Street, Suite 483, Denver, CO 80202
Tel: (303) 628-5430
Fax: (303) 628-5431

Group Name: Universities Council on Water Resources
Address: c/o UCOWR Headquarters, 4543 Faner Hall, Southern Illinois University, Carbondale, IL 62901
Fax: (618) 453-2671

Group Name: Water Quality 2000
Address: 601 Wythe St. Alexandria, VA 22314-1994
Tel: (800) 666-0206


Nipigon Bay
Jackfish Bay
Peninsula Harbour
Thunder Bay
LAKE SUPERIOR
St. Louis Bay / River
Torch Lake
Deer Lake-Carp Creek / River
St. Marys River
Spanish River Mouth
Menistique River
Menominee River
Fox River / Southern Green Bay
Sheboygan River
LAKE MICHIGAN
White Lake
Muskegon Lake
Milwaukee Estuary
Waukegan Harbor
Kalamazoo River
Grand Calumet River / Indiana Harbor Canal
L. HURON
Saginaw River / Saginaw Bay
St. Clair River
Clinton River
Detroit River
Rouge River
River Raisin
Maumee River
Wheatley Harbour
LAKE ERIE
Black River
Cuyahoga River
Ashtabula River
Presque Isle Bay
Severn Sound
Collingwood Harbour
St. Lawrence River (Cornwall / Massena)
Bay of Quinte
Port Hope
Metro Toronto
L. ONTARIO
Oswego River
Rochester Embayment
Hamilton Harbour
Eighteen Mile Creek
Niagara River
Buffalo River

Part VII - Committee Lists

Honorary Committee

Alicia Bárcena	Executive Director, The Earth Council
Peter A. A. Berle	President, National Audubon Society
Lawton Chiles	Governor, State of Florida
Rodrigo Carazo	Former President of Costa Rica
Ella Cisneros	President and Founder, The Together Foundation for Global Unity
Adalberto Gabaldón	Minister of the Environment and the Renewable Natural Resources, Venezuela
Bob Graham	U.S. Senator, State of Florida
Carlos Hank González	Secretary of Agriculture and Water Resources of Mexico
Thomas E. Lovejoy	Assistant Secretary for External Affairs, The Smithsonian Institution
Heraldo Muñoz	Ambassador of Chile, Organization of American States
Henry Nowak	Special Counsel, Ecology and Environment, Inc.
Nathaniel P. Reed	Chairman, 1000 Friends of Florida
Xavier Suarez	Mayor, City of Miami, Florida
Absalón Vásquez	Minister of Agriculture, Peru
Lt. Gen. Arthur E. Williams	Chief of Engineers, U.S. Army Corps of Engineers
Andrew Young	Chairman, Law International, Inc.
Norman A. Zigrossi	President of the Resources Group, Tennessee Valley Authority

Policy Council

Alvaro Aldama	Executive Director, Mexican Institute of Water Technology (IMTA)
Douglas Ban	Executive Director, Northwest Florida Water Management District

Ralph Brooks	Vice-President, Water Management, Tennessee Valley Authority
Joe Browder	Partner, Dunlap and Browder
Jo S. Clark	Director of Programs, Western Governors' Association
Tom Collins	Vice President of Research, Oklahoma State University
Tilford C. Creel	Executive Director, South Florida Water Management District
James M. Davidson	Vice-President, Agriculture and Natural Resources, Institute of Food and Agricultural Sciences (IFAS), University of Florida
Henry Dean	Executive Director, St. Johns River Water Management District
Carolyn Dekle	Executive Director, South Florida Regional Planning Council
G. Edward Dickey	Assistant Secretary of the Army for Civil Works, U.S. Army Corps of Engineers
Axel Dourojeanni	Director of Natural Resources and Energy, United Nations Economic Commission for Latin America and the Caribbean (ECLAC)
Marc-Jean Dourojeanni	Chief, Environmental Protection Division, Inter-American Development Bank
Alfred M. Duda	Senior Water Resources Specialist, Environment Department, The World Bank
María Flores de Otero	President, Interamerican Assoc. of Sanitary and Environment Engineers (AIDIS)
Henry J. Hatch	President and Chief Operating Officer, Law Companies Group
Robert L. Herbst	Washington Representative, Tennessee Valley Authority
Peter Hubbell	Executive Director, Southwest Florida Water Management District
Jaime Incer	Minister, Nicaraguan Institute of Natural Resources (IRENA), Nicaragua
Donald R. Lesh	President, Global Tomorrow Coalition
William F. MacCalpin	Director of Investment Programs, MacArthur Foundation
Jim McDaniel	Chairman, Interstate Council on Water Policy
Arsenio Milian	President, Milian, Swain & Associates
Ambler H. Moss	Dean and Executive Director, North-South Center, University of Miami
Horst Otterstetter	Director, Environment and Health, Pan-American Health Organization
Steven J. Parcells	International Water Specialist, National Audubon Society
Ernesto Pérez	Chief, Technology Transfer, U.S. Environmental Protection Agency, Region IV
Sandra Postel	Vice-President for Research, WorldWatch Institute
Walter Rast	Senior Programme Officer, UN Environmental Programme/Water & Lithosphere Unit
Emiko K. de Resende	Secretary of Environment, State of Mato Grosso do Sul, Brazil
Elizabeth Ann Rieke	Assistant Secretary for Water and Science, U.S. Department of Interior
Kirk P. Rodgers	Director, Department of Regional Development and Environment, Organization of American States

Anibal Rosales	Director of International Relations and Professional Development, Ministry of Environment and Renewable Natural Resources, Venezuela
Richard Rudy	Southeast Regional Manager, Ecology and Environment, Inc.
Jerry Scarborough	Executive Director, Suwannee River Water Management District
Emma Torres	Chief, Division for the Regional Programme, United Nations Development Programme, Regional Bureau for Latin America and the Caribbean
Absalón Vásquez	Minister of Agriculture, Peru
Evan Vlachos	Associate Director, International School of Water Resources, Colorado State University
Virginia Wetherell	Secretary, Florida Department of Environmental Regulation
Estus Whitfield	Environmental Advisor, Executive Office of the Governor of Florida
John R. Wodraska	General Manager, Metropolitan Water District of Southern California

Planning Committee

Cathleen Vogel Anclade	Director, Office of Government and Public Affairs, South Florida Water Management District
Bart Bibler	Florida Department of Environmental Protection
Nelson da Franca dos Anjos	Principal Water Resources Specialist, Organization of American States
Lisa St. John Dority	Public Communications Officer, South Florida Water Management District
Vinio Floris	Supervising Professional-Civil Engineer, South Florida Water Management District
Patrick Frost	Director, Orlando Office, St. Johns River Water Management District
Edwin Fry	Senior Financial Analyst, South Florida Water Management District
Neil S. Grigg	Professor and Head, Civil Engineering Department, Colorado State University
Dulce Herrera	Administrative Secretary, South Florida Water Management District
Susan Kessel	Community Relations, Southwest Florida Water Management District
Susan Liebermann	Graduate Research Assistant, North-South Center, University of Miami
Steve Light	Senior Policy Advisor, South Florida Water Management District
Diane G. Lowrie	Vice President, Global Tomorrow Coalition
Jorge A. Marban	Senior Professional, South Florida Water Management District
Linda McBride	Director of Public Affairs, South Carolina Water Resources Commission

Alberto J. Palombo	Project Manager, Interamerican Dialogue on Water Management, South Florida Water Management District
John R. Paulk	Manager, Environmental Cooperation Programs, Tennessee Valley Authority
Alton F. Robertson	Vice-President and Florida Branch Manager, Law Companies Group
James Robinson	Contract Administrator, South Florida Water Management District
Claudia Santos	Regional Programs Specialist, United Nations Development Program, Regional Bureau for Latin America and the Caribbean
Holly Stoerker	Executive Director, Interstate Council on Water Policy
David J. Smith	Director, Southeast Regional Climate Center
Jim Stone	Chief Environmental Scientist, Ecology and Environment, Inc.

Dialogue Associates

Jose Ochoa-Iturbe	Director of the Environmental Program and Professor, Universidad Católica Andrés Bello, Caracas, Venezuela
Hector R. Fuentes	Professor, Civil and Environmental Engineering, Florida International University, Miami, Florida
Jim MacIntyre	Executive Director, Together Foundation for Global Unity, Burlington, Vermont
Marco A. Gonzalez	Environmental Lawyer, FUNDESOS, Managua Nicaragua
Medardo Molina	Chief Technical Advisor, World Meteorological Organization, PRIMCEN Project for Central America, San Jose, Costa Rica
Phillip Kirpich	Water Resources Consultant, Miami Beach, Florida
Newton V. Cordeiro	Coordinator for South America, Department of Regional Development and Environment, Organization of American States
Mary Uebersax	Director of Grants Programs, North-South Center, University of Miami, Florida
Richard Hamann	Center for Governmental Responsibility, College of Law, University of Florida, Gainesville, Florida
Alfred Duda	Senior Policy Advisor, Policy and Research Division, Environment Department, The World Bank
Larry Aggens	President, Involve, Inc., Wimette, Illinois

Part VIII - Conference Agenda

Wednesday, October 27, 1993

Concurrent sessions of the Annual Conference on Water Management in Florida and the Annual Meeting of the Interstate Council on Water Policy (ICWP) will take place throughout the day. A joint luncheon of the Florida Water Management Districts, the Florida Department of Environmental Protection, the Interstate Council on Water Policy, and the Non-Governmental Organization Forum is scheduled at noon with Governor Lawton Chiles of Florida. Starting at 1:30 pm. an NGO Forum will be held to discuss sustainable development of water resources. A concluding plenary session on The Future of Aquatic Ecosystem Restoration will reconvene all three groups at 4:15 pm.

Annual Meeting of the Interstate Council on Water Policy
ICWP Mini-Conference on Aquatic Ecosystem Restoration

7:30 am - 8:00 pm	**Registration Open**	Mezzanine
7:30 - 8:30 am	**ICWP Board Meeting**	Gusman
9:00 - 10:15 am	**Legislative Committee Meeting**	Versailles
10:15 - 10:30 am	Break - Interamerican Water Exhibit Hall Resource Room	Mezzanine Escorial/Alhambra
10:30 am - 12:00	**ICWP Caucuses**	Flagler
12:00 - 1:20 pm	**ICWP/WMD/NGO Joint Luncheon Program and Awards Presentation** Keynote Address: **The Honorable Lawton Chiles**, Governor of the State of Florida	Bayfront
1:30 - 1:45 pm	**Introductions and Welcome** **James U. McDaniel**, Chairman; and **Tilford C. Creel**, First Vice Chairman; Interstate Council on Water Policy	Versailles
1:45 - 2:15 pm	**Examples of State-Federal Partnerships on Aquatic Ecosystem Restoration** Moderator: **Tilford C. Creel**, Executive Director, South Florida Water Management District **Holly Stoerker**, Executive Director, ICWP, Upper Mississippi River Restoration Projects **Chuck Padera**, St. Johns River Water Management District, Restoration of St. Johns River Headwaters	Versailles
2:15 - 3:15 pm	**Panel: Role of Federal Agencies in Aquatic Ecosystem Restoration**	Versailles

	Moderator: **John N. Morris**, Director, Division of Water Resources, North Carolina Department of Environment, Health, and Natural Resources Panelists: **William L. Klesch**, Chief, Office of Environmental Policy, U.S. Army Corps of Engineers; **T. Niles Glasgow**, State Conservationist, U.S. Soil Conservation Service; **Bob Misso**, Chief of Private Lands, U.S. Fish and Wildlife Service (Partners for Wildlife); **John Meagher**, Director, Wetlands Division, U.S. Environmental Protection Agency	
3:15 - 4:00 pm	**Opportunities and Obstacles to Restoration Efforts** Moderator: **Del Downing**, Director, New Hampshire Department of Environmental Sciences Panelists: **Stuart J. Applebaum**, Chief, Central and Southern Florida Study Section, U.S. Army Corps of Engineers; **Timothy D. Searchinger**, Attorney, Environmental Defense Fund; **David L. Harrison**, President, Moses, Wittemyer, Harrison, and Woodruff, P.C.	Versailles
4:00 - 4:15 pm	Break - Interamerican Water Exhibit Hall Resource Room	Mezzanine Escorial/Alhambra
4:15 - 5:00 pm	**Keynote Address: The Future of Aquatic Ecosystem Restoration - Needs and Priorities** **Dr. Charles R. Goldman**, Professor of Limnology, Division of Environmental Studies, University of California, Davis	Versailles
5:00 - 6:00 pm	**ICWP Members' Annual Business Meeting**	Flagler

Wednesday, October 27, 1993

XVIII Annual Conference on Water Management in Florida

7:30 am - 8:00 pm	**Registration Open**	Mezzanine
8:30 - 8:45 am	**Welcoming Remarks** **Valerie Boyd**, Chairman, South Florida Water Management District, Naples, Florida	Trianon
8:45 - 9:15 am	**Update on Florida Department of Environmental Protection** **Virginia Wetherell**, Secretary, Florida Department of Environmental Protection	Trianon
9:15 - 10:30 am	**Water Management Year-In-Review**	Trianon

	Secretary Virginia Wetherell, and Executive Directors of the five Water Management Districts of Florida: **Jerry Scarborough**, Suwanee River Water Management District; **Douglas Barr**, Northwest Florida Water Management District; **Henry Dean**, St. Johns River Water Management District; **Tilford C. Creel**, South Florida Water Management District; and **Peter Hubbell**, Southwest Florida Water Management District	
10:30 - 11:00 am	Break - Interamerican Water Exhibit Hall Resource Room	Mezzanine Escorial/Alhambra
11:00 am - 12:00	**Keynote Address: Lessons Learned from the Great Mississippi Basin Flood of 1993** **Dr. Michael D. Hudlow**, Director, Office of Hydrology, National Oceanographic and Atmospheric Administration (NOAA)	Trianon
12:00 - 1:20 pm	**ICWP/WMD/NGO Joint Luncheon Program and Awards Presentation** Keynote Address: **The Honorable Lawton Chiles**, Governor of the State of Florida	Bayfront
1:30 - 2:45 pm	**Panel on District Water Management Plans: View from the Public** Moderator: **Valerie Boyd**, Chairman, South Florida Water Management District, Naples, Florida Panelists: **Peter Hubbell**, Executive Director, Southwest Florida Water Management District, Brooksville, Florida **Carolyn Dekle**, Executive Director, South Florida Regional Planning Council, Hollywood, Florida **Karen T. Marcus**, County Commissioner, Palm Beach County, Palm Beach Gardens, Florida **Teresa B. Tinker**, Policy Coordinator, Growth Management and Strategic Planning Policy Unit, Governor's Office of Planning and Budget, Tallahassee, Florida **Jacob F. Stowers III**, Assistant County Administrator for Planning and Development, Pinellas County, Clearwater, Florida Respondents: **Wade Hopping**, Senior Partner, Hopping Boyd Green & Sams, Tallahassee, Florida **Sam Poole**, Attorney, Holland & Knight, Miami, Florida	Trianon
2:45 - 3:45 pm	**Permit Streamlining: Nuts & Bolts**	Trianon

	John Fumero, Senior Supervising Attorney, South Florida Water Management District, West Palm Beach, Florida **Kathryn Mennella**, Senior Assistant General Counsel, St. Johns River Water Management District, Palatka, Florida **Jeff Elledge**, Director, Resource Management Department, St. Johns River Water Management District, Palatka, Florida **Janet Llewellyn**, Chief, Bureau of Wetland Resource Management, Florida Department of Environmental Protection, Tallahassee, Florida **Janice McLean**, Attorney, Southwest Florida Water Management District, Brooksville, Florida	
3:45 - 4:00 pm	**Florida Water Management Annual Conference Concluding Remarks** **Peter Hubbell**, Executive Director, Southwest Florida Water Management District, Brooksville, Florida	Trianon
4:00 - 4:15 pm	Break - Interamerican Water Exhibit Hall Resource Room	Mezzanine Escorial/Alhambra
4:15 - 5:00 pm	**Keynote Address: The Future of Aquatic Ecosystem Restoration - Needs and Priorities** **Dr. Charles R. Goldman**, Professor of Limnology, Division of Environmental Studies, University of California, Davis, California	Versailles

Wednesday, October 27, 1993

The Non-Governmental Organization Forum

9:30 am - 8:00 pm	**Registration Open**	Mezzanine
12:00 - 1:20 pm	**ICWP/WMD/NGO Joint Luncheon Program and Awards Presentation** Keynote Address: **The Honorable Lawton Chiles**, Governor of the State of Florida	Bayfront
1:30 - 2:00 pm	**NGO Forum: Welcoming Remarks** Forum Co-Chairs: **Peter A.A. Berle**, President, National Audubon Society of the United States, New York, USA **Alicia Bárcena**, Executive Director, The Earth Council, San Jose, Costa Rica	Sevilla
2:00 - 2:30 pm	**Water Policy and Role of NGOs - Historical Context**	Sevilla

	Emma Torres, Chief, Division of the Regional Programme, United Nations Development Programme, Regional Bureau for Latin America and the Caribbean **Deborah Moore**, Environmental Defense Fund, Washington, DC, USA **John Baldwin**, President, North American Association of Environmental Education, Eugene, Oregon, USA	
2:30 - 2:45 pm	**Survey Results and Next Steps - NGO Partnerships in an International Water Resource Network** **Donald R. Lesh**, President, Global Tomorrow Coalition, Washington, DC, USA **Arsenio Milian**, President, Milian, Swain and Associates, Miami, Florida, USA	Sevilla
2:45 - 3:45 pm	**Open Dialogue - Water Policy and Future Role of NGOs**	Sevilla
3:45 - 4:00 pm	**Summary Key Points by NGO Forum Co-Chairs**	Sevilla
4:00 - 4:15 pm	Break - Interamerican Water Exhibit Hall Resource Room	Mezzanine Escorial/Alhambra
4:15 - 5:00 pm	**Keynote Address: The Future of Aquatic Ecosystem Restoration - Needs and Priorities** **Dr. Charles R. Goldman**, Professor of Limnology, Division of Environmental Studies, University of California, Davis	Versailles

Inaugural Reception

6:30 - 8:00 pm	**Inaugural Reception** Grand Opening ceremonies for the Interamerican Water Exhibit Hall. Welcoming Remarks by **The Honorable Xavier Suárez**, Mayor of Miami, Florida, USA Acknowledgement of Dialogue Sponsors.	Mezzanine
8:00 - 9:00 pm	**Opening Session - From Rio to Miami: Personal Expectations for the Dialogue** Invocation: **Chairman Cypress***, Miccosukee Tribe, Florida Moderator: **Donald R. Lesh,** President, Global Tomorrow Coalition, Washington, DC, USA Reflections by sector leaders from: **Government: The Honorable Absalón Vásquez,** Minister of Agriculture of Peru, Lima, Peru **Education: John Baldwin,** President, North American Association of Environmental Education, Eugene, Oregon, USA **NGOs: Aldemaro Romero,** Executive Director, Fundación BIOMA, Caracas, Venezuela	Versailles

Science: Dr. Medardo Molina, Chief Technical Advisor, PRIMCEN Project, World Meteorological Organization, Costa Rica

Youth: Susan Lieberman, Graduate Student, University of Miami, Miami, Florida, USA

Arts: Clyde Butcher, Naturalist Photographer, Fort Myers, Florida, USA

Business: Nancy Roen, Director, Environmental Affairs, Florida Power & Light Co., North Palm Beach, Florida, USA

Thursday, October 28, 1993

Each day, the Interamerican Dialogue on Water Management is co-chaired by two prominent individuals, one from North America, and one from Central America, South America, or the Caribbean, to reflect the spirit of the conference. Simultaneous English/Spanish translation equipment is available at the registration booth in the Mezzanine.

7:30 am - 8:00 pm	**Registration Open**	Mezzanine
8:30 - 8:45 am	**Welcoming Remarks** **Valerie Boyd**, Chairman, South Florida Water Management District, Naples, Florida, USA **James U. McDaniel**, Chairman, Interstate Council on Water Policy, Sacramento, California, USA	Versailles
8:45 - 9:00 am	**Program Introductions** Daily Co-Chairs: **Ella Cisneros**, President and Founder, The Together Foundation for Global Unity, Caracas, Venezuela **Patricia Eaton**, Chair, Oklahoma Water Resources Board, Oklahoma City, Oklahoma, USA	Versailles
9:00 - 9:30 am	**Keynote Address: Agenda 21, Water, and the Road Ahead** **Alicia Bárcena**, Executive Director, The Earth Council, San José, Costa Rica **Peter A.A. Berle**, President, National Audubon Society, Washington, DC, USA	Versailles
9:30 - 10:00 am	**First Case Study: A Comparison of the Florida Everglades and South American Pantanal Ecosystems** **Jeff Wade**, Assistant Director, Center for Governmental Responsibility, University of Florida, Gainesville, USA; with the cooperation of the Secretariat of the State of Mato Grosso do Sul for the Environment (SEMA), Campo Grande, Brazil	Versailles
10:00 - 10:30 am	Break - Interamerican Water Exhibit Hall Resource Room	Mezzanine Escorial/Alhambra

10:30 - 11:00 am	**Second Case Study: Infrastructure Comparison for Water Supply and Sanitation in the Hemisphere** **Dr. Neil S. Grigg**, Head, Civil Engineering Department, Colorado State University, Fort Collins, Colorado, USA; with the cooperation of Center for Environmental and Territorial Research and Development (CIDIAT), of Mérida, Venezuela; and Fundação Centro Tecnológico Hidráulica, São Paulo, Brazil	Versailles
11:00 am - 12:00	**Panel: From the Case Studies to the Dialogue** Moderator: **Nathaniel P. Reed**, Chairman, 1000 Friends of Florida and former Under-Secretary of Interior, Hobe Sound, Florida, USA Panelists: The six Co-Chairs of the Dialogue Roundtables comprise this panel to discuss the bridges and barriers to achieving sustainable development in water management in the hemisphere. **Joe Browder**, Partner, Dunlap and Browder, Inc., Washington, DC, USA **Dr. Emiko Kawakami de Resende**, Secretary of the Environment, State of Mato Grosso do Sul, Brazil **Arsenio Milian**, Founder and President Emeritus, Citizens for a Better South Florida, Miami, Florida, USA **María C. Flores de Otero**, International President, Asociación Interamericana de Ingeniería Sanitaria y Ambiental (AIDIS), Río Piedras, Puerto Rico **Axel C. Dourojeanni**, Director of Natural Resources and Energy, U. N. Economic Commission for Latin America and the Caribbean (ECLAC), Santiago, Chile **Dr. Evan Vlachos**, Assistant Director, Water Resources Institute, Colorado State University, Fort Collins, Colorado, USA	Versailles
12:15 - 1:30 pm	**Luncheon** Keynote Address: **Sandra Postel**, Vice President for Research, Worldwatch Institute, Washington, DC, USA	Bayfront

Thursday, October 28, 1993

Concurrent Roundtable Sessions

Participants will attend one of three concurrent Roundtable Tracks. Each track is headed by two Co-Chairs, and assisted by a team of Moderators and Facilitators. Please refer to the respective Roundtable Track Section for further information and presentation schedules

1:30 - 3:00 pm	**Track I: Management of Aquatic Ecosystems**	Versailles

	Co-Chairs: **Joe Browder**, Partner, Dunlap and Browder, Inc., Washington, DC, USA **Dr. Emiko Kawakami de Resende**, Secretary of the Environment, State of Mato Grosso do Sul, Brazil	
	Track II: Infrastructure for Water Supply and Sanitation in the Context of Sustainable Development	Sandringham
	Co-Chairs: **Arsenio Milian**, Founder and President Emeritus, Citizens for a Better South Florida, Miami, Florida, USA **María C. Flores de Otero**, International President, Asociación Interamericana de Ingeniería Sanitaria y Ambiental (AIDIS), Río Piedras, Puerto Rico	
	Track III: Water Governance and Policy	Trianon
	Co-Chairs: **Axel C. Dourojeanni**, Director of Natural Resources and Energy, U.N. Economic Commission for Latin America and the Caribbean (ECLAC), Santiago, Chile **Dr. Evan Vlachos**, Assistant Director, Water Resources Institute, Colorado State University, Fort Collins, Colorado, USA	
3:00 - 3:30 pm	Break - International Water Exhibit Hall Resource Room	Mezzanine Escorial/Alhambra
3:30 - 5:30 pm	Concurrent Roundtables Sessions continue	
6:30 - 7:30 pm	**Interamerican Dialogue Reception**	Mezzanine

Interamerican Banquet

7:30 - 10:00 pm	**Interamerican Banquet**	Versailles
	Premiere: **"The Power of Water"** Except from the upcoming National Geographic Television Special on water that will be broadcast on November 10. Presented by **Terry Smith**, Executive Director, National Geographic Educational Foundation, Washington, DC. USA	
	Dinner	
	Keynote Address: **The Honorable Rodrigo Carazo**, Former President of Costa Rica	

Friday, October 29, 1993

8:00 am - 5:00 pm	**Registration Open**	Mezzanine
8:00 - 8:15 am	**Program Introductions**	Bayfront

	Daily Co-Chairs: **The Honorable Adalberto Gabaldón**, Minister of the Environment and Renewable Natural Resources, Caracas, Venezuela **Robert L. Herbst**, Washington Representative, Tennessee Valley Authority, Washington, DC, USA	
8:15 - 8:45 am	**Roundtable Discussion Progress Report** Roundtable Co-Chairs will address the plenary and report on discussion from the previous day	Bayfront
8:45 - 9:45 am	**Keynote Panel: Linking Networks for Sustainable Development in Water Management** Moderator: **Henry J. Hatch**, President and Chief Operating Officer, Law Companies Group, Atlanta, Georgia, USA Panelists: **Armando Llop**, Executive Director, Center for Water Law, Economics and Management (INCYTH-CELAA), Mendoza, Argentina **Kirk P. Rodgers**, Director, Department of Regional Development and Environment, Organization of American States, Washington, DC, USA **Jim McIntyre**, Vice-President, The Together Foundation for Global Unity, Burlington, Vermont, USA, and Caracas, Venezuela **Henry Nowak**, Special Counsel, Ecology & Environment, Inc., Buffalo, New York, USA	Bayfront
9:45 - 10:15 am	Break - Interamerican Water Exhibit Hall Resource Room	Mezzanine Escorial/Alhambra

Friday, October 29, 1993

Concurrent Roundtable Sessions

The individual roundtables will resume discussion and presentations in individually designated rooms. Please report to your designated Roundtable subtrack as agreed with the Roundtable Co-Chairs. Please refer to the respective Roundtable Track section for further information and presentation schedules.

10:15-12:30 pm	**Track I: Management of Aquatic Ecosystems**	Sevilla/Jr. Ballroom
	Track II: Infrastructure for Water Supply and Sanitation in the Context of Sustainable Development	Sandringham/Michelangelo
	Track III: Water Governance and Policy	Trianon/Versailles
12:40 - 1:45 pm	**Luncheon**	Bayfront

Keynote Panel: International Trade, Finance and Water Management

Moderator:
Robin Rosenberg, Assistant Director for Research, North-South Center, University of Miami, Florida, USA

Panelists:
François-Marie Patorni, Director, Economic Development Institute, The World Bank, Washington, DC, USA
Dr. Chris Harwell, Assistant Dean, University of Miami's Rosenstiel School of Marine and Atmospheric Science, Key Biscayne, Florida, USA
Axel C. Dourojeanni, Director, Division of Natural Resources and Energy, United Nations Economic Commission for Latin America and the Caribbean (ECLAC), Santiago, Chile

Friday, October 29, 1993

Concurrent Roundtable Sessions

Water Management Roundtable Tracks will focus on plans for linking international water resources networks. Discussion and drafting of the Miami Agenda.

1:45 - 4:45 pm	**Track I: Management of Aquatic Ecosystems**	Sevilla/Jr. Ballroom
	Track II: Infrastructure for Water Supply and Sanitation in the Context of Sustainable Development	Sandringham/Michelangelo
	Track III: Water Governance and Policy	Trianon/Versailles
4:45 - 5:00 pm	Break - Refreshments	Bayfront A
5:00 - 5:30 pm	Keynote Speech: **Water Management: Nearctic and Neotropical** **Dr. Thomas E. Lovejoy**, Assistant Secretary for External Affairs, The Smithsonian Institution, Washington, DC, USA	Bayfront B
5:30 pm	Friday Evening - Open	

Saturday, October 30, 1993

The last day of the Interamerican Dialogue on Water Management will be devoted to the presentation of conclusions and recommendations, and consideration of The Miami Agenda before an international audience of water managers.

7:30 - 12:30 pm	**Registration Open**	Mezzanine

8:00 - 8:30 am	**Breakfast Buffet**	Bayfront B
8:30 - 8:45 am	**Program Introductions** Daily Co-Chairs: **Barbara Pyle***, Vice-President of Environmental Policy, Turner Broadcasting System, Atlanta, Georgia, USA **Mario De Marco-Naon**, President, National Institute of Water Resource Sciences and Technology (INCYTH), Buenos Aires, Argentina	Bayfront A
8:45 - 9:30 am	**Keynote Address - Update on Clean Water Act Reauthorization** **Scott Slesinger**, Assistant Counsel to the Subcommittee on Water Resources & Environment, House Committee on Public Works and Transportation, U.S. Congress, Washington, DC, USA	Bayfront A
9:30 - 10:30 am	**Final Roundtable Track Reports and The Miami Agenda** Conclusions and recommendations of the Interamerican Dialogue on Water Management and presentation of The Miami Agenda.	Bayfront A
10:30 - 11:45 am	**Building an International Water Resource Network** Opening Remarks by: **The Honorable Heraldo Muñoz**, Ambassador of Chile, Organization of American States Responses by: **The Honorable Carrie Meek***, U.S. Representative-Florida, Miami, Florida, USA **The Honorable Adalberto Gabaldón**, Minister of the Environment and Renewable Natural Resources, Caracas, Venezuela **Norman A. Zigrossi**, President, Resources Group, Tennessee Valley Authority, Knoxville, Tennessee, USA **Horst Otterstteter**, Director of Environmental Health, Pan-American Health Organization, Washington, DC, USA	Bayfront A
11:45 - 12:00	**Closing Remarks** **Tilford C. Creel**, Executive Director, South Florida Water Management District, West Palm Beach, Florida, USA	Bayfront
12:30 pm	**Field Trips Depart** Field Trip 1: Everglades National Park Tram Tour Field Trip 2: National Hurricane Center at Coral Gables Field Trip 3: Everglades Agricultural Area - Water and Wastewater Treatment Plants	Lobby Entrance

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