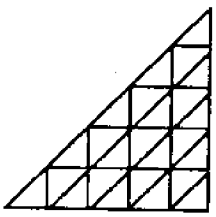
Zero Discharge and Virtual Elimination in the Great Lakes

A Collection of Viewpoints
from
Prominent Great Lakes Specialists

Great Lakes Sea Grant Network



Great Lakes Sea Grant Network

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Sea Grant supports greater knowledge and stewardship of Great Lakes and ocean resources. Through its network of advisory agents, researchers, and communicators, the Great Lakes Sea Grant Network supplies the region with usable solutions to pressing problems and provides the basic information needed to better manage the Great Lakes for both present and future generations.

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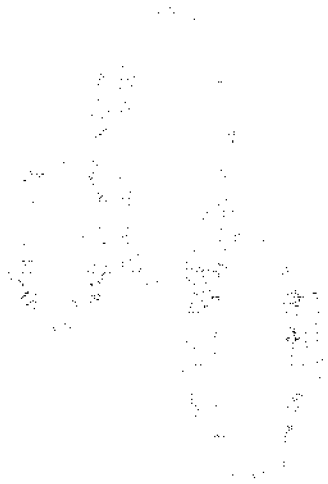

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Contents

PREFACE

This booklet is the result of a special project by the Great Lakes Sea Grant Network, Water Quality Committee. The Network is composed of Sea Grant programs in the states of New York, Ohio, Michigan, Indiana, Illinois, Wisconsin and Minnesota. Individuals from throughout the Great Lakes Basin were invited to provide an opinion paper about zero discharge and virtual elimination. The individuals selected were chosen because they could provide a mixed yet balanced set of viewpoints from the basis of law, economics, environment, physics, ecology, policy, and industry. The only ground rules were that the essay must not exceed four pages, it should not be an historical document, and it should not be a technical/scientific summary.

Most authors followed these guidelines closely, providing an opinion paper as intended. The seventeen essays included here represent all that were submitted. The viewpoints and technical arguments are solely those of the authors. The essays were edited only to correct grammar, and all changes were checked with the authors. Thus we offer to the reader a mosaic of opinions, writing styles, and rationale that collectively form a basis for insightful deliberation about one of the most important controversies in Great Lakes management.

INTRODUCTION

The Great Lakes watershed is a vast continental basin that drains all the surface water and much of the groundwater to the five Great Lakes—Superior, Michigan, Huron, Erie, and Ontario. Having very limited outflow, the Lakes are huge reservoirs, storing decades of runoff and precipitation. If it were possible to halt all inputs to the Lakes above Niagara Falls, the system would take approximately 118 years to drain completely. But this can never happen, because the Lakes' depths are greater than the sills over which they drain, and of course it is impossible to prohibit inflow.

Over the long term, the Great Lakes gain as much water as they lose, even though on a yearly basis the net gain or loss can represent several feet in lake level. If there is a net gain, the excess water eventually drains away and the Lakes return to normal. If there is a net loss, cool wet weather eventually causes the levels to rise again. Whatever pollution that entered during any year acts to reduce the amount of pollution lost. Any substance that is captured by the sediments or organisms of the system, continues to recycle despite changes in lake water.

The Lakes' water discharge rates have been measured for decades and when expressed in relation to their volume, provide a measure of water retention time, which is also known as flushing rate. Lakes Ontario has a flushing time of six years, Lake Huron 22 years, Lake Michigan 99 years, and Lake Superior 200 years. These are estimates only. This does not mean every molecule of water in a lake will be gone after that time, being replaced with new water. The bulk of the water will have been replaced however.

Thus the Great Lakes are like a huge bucket with a very small hole up near the rim. As water is added to the bucket, some flows out. If the original water has just a tiny bit of soap in it, it is practically impossible to flush it all out by adding clear water. If the incoming water also has some soap in it, the bucket will never be free of some level of soapy water. This simple analogy is the concept behind the tremendously complicated field of mass balance mathematics. Many very talented people are working on mass balance calculations for the Great Lakes, and refinements are being made yearly. However, the

only way to really clean up the bucket is to stop any more additions of soap. It will still take many decades to have pristine water in the bucket, but eventually that state will be approached again.

The Great Lakes states, North America, and the world overall have steadily increased their capacity to satisfy the needs of modern man with industrial and chemical components of increasing complexity. The manufacture, transport, use, disposal, and breakdown of these products have placed foreign substances into our atmosphere and waters worldwide. Population growth and technological development, coupled with chemical agricultural technology, have placed all natural resources at risk of impairment or reduction. Examples abound of thousands of areas that have had their water and land resources partially impaired or destroyed.

Water can be thought of as a living organism because it has the capacity of taking things into itself, modifying them, and passing the benefits along to co-inhabitants. In the natural state, water takes in minerals and nutrients from rainfall, fallen debris, runoff, and groundwater inflow. These nutrients are as essential to aquatic plants as they are to corn or beans. Phytoplankton and microorganisms at the bottom of the food pyramid then provide energy to higher levels. Evolution has allowed the world of plants and organisms to create species and adaptations for nearly every type of local environment, and tolerances to wide ranges of extremes. For the most part, these systems and relationships are well balanced and self generating, if the base materials upon which the system depends remain similar to the evolutionary framework that produced the system.

Therein lies the rub. Our modern society is finding that it (we) is negatively affecting the very thing we most want and need to sustain ourselves in a healthy manner. As the evidence of air and water pollution has accumulated over the decades, our approach has been to provide better treatment. When it became clear that some chemicals were outright poisonous, we began to ban their use and manufacture. With more and more scientists becoming involved, concurrent with greater sophistication of analysis and event detection, we steadily found more and more insidious chemicals that were putting the environment, the organisms, and us at high risk. The concept (or working theory) that every water body has some assimilative capacity for pollutants, was being challenged on every front.

Between 1960 and 1985, we adopted the basic pollution strategy

that unless something could be concretely demonstrated to cause harm in a system, then it was acceptable to release it in "small" amounts per discharger. Regulatory agencies in every state enacted effluent discharge laws that limited concentrations allowed out the pipe. Dilution and assimilation theory held that all (or most) waters were capable of some receiving capacity without harm to the ecosystem.

Since the 1980s, evidence has mounted that some chemicals do not break down into harmless components. Instead, they remain toxic for years and years. Their effects are long-term and often very subtle, usually increasing in impact higher up the food chain. Thus, while fish and minnows may not show overt signs of chemical poisoning, fish-eating eagles and terns do. More detailed research has demonstrated the potential human effects of eating products contaminated with small amounts of toxic substances. The controversy continues over the actual human consequences of consuming Great Lakes fish and ingesting chemicals in other ways, but the trend lines of probable effects are very clear.

The scientific community and policy makers concerned with the health of the Great Lakes, concurrently with environmental action groups, have concluded that the only guaranteed way to reverse air and water degradation, is to stop putting anything out that is harmful. This means abandoning the old theory of estimating how much is acceptable and replacing it with a new basin-wide theory that any amount is too much.

The term "zero discharge" was coined to express this theory that any amount is too much. Zero discharge has gained increasing acceptance and has become the watchword of the Great Lakes environmental strategy championed by the International Joint Commission (IJC) and many others. The term "virtual elimination" refers to the result of practicing complete zero discharge. No one expects the Great Lakes to ever be completely free from all harmful manmade chemicals, largely because pollution enters the watershed through the atmosphere from all areas of the globe, in addition to what we generate within the watershed. However, many believe the only reasonable approach to reducing pollution as much as possible within the basin is to eliminate discharges at the point of manufacture and disposal.

The IJC has identified over 300 chemicals it considers the harmful. Thousands of others are used and disposed of in the Great Lakes basin. These are under close

scrutiny too. The IJC lists 11 chemicals they consider the worst. These are:

Mirex
Hexachlorobenzene
Dieldrin
DDT and metabolites
2,3,7,8-tetrachlrodibenzo-p-dioxin (2,3,7,8-TCDD)
2,3,7,8-tetrachlorodibenzofuran
Benzo-a-pyrene
Alkylated lead
Toxaphene
Mercury
Polychlorinated biphenyls (PCBs) (all forms)

These have been selected for concentrated action and increased research activity. They are the chemicals selected for the trial implementation of zero discharge in many areas, while realizing they merely are the tip of an unknown iceberg of pollution.

Considerable debate continues on the rationale and feasibility of zero discharge. Not all of the arguments are openly expressed, because all sides must avoid the appearance of favoring an approach that would lead to continuing pollution. Since the entire fabric of modern society depends heavily on the manufacture, consumption, and disposal of complex machines and chemicals, each one of us is affected by the social costs and consequences of a strict zero discharge policy. We may want cleaner waters, but will we actually give up materials we now buy for reasonable prices for substitutes which may cost far more? Can we expect the general public to just quit using materials known to be hazardous? What are the mechanisms to control hazardous products worldwide? How can pollution control measures be implemented in countries that can barely feed themselves now? Every close look at the ramifications of zero discharge in the Great Lakes and the world leads to hundreds of questions about the practicality of the approach.

The essays in this book can be considered one approach to clarifying these problems and answering some of the questions. Taken in totality the diverse views offered by the authors provide a context for further thought on the topic.

For an in-depth background and analysis of zero discharge, write for the *Sixth Biennial Report on Great Lakes Water Quality*, International Joint Commission, 100 Ouelette Blvd., Windsor, Ontario, Canada N9A 6T3. This report frames the issue on page 4, "Surely it is time to ask whether we really want to continue attempts to manage persistent toxic substances

after they have been produced or used, or whether we want to begin to eliminate and prevent their existence in the ecosystem in the first place."

WALTER J. HOAGMAN
Michigan Sea Grant Extension
Lansing, Michigan

A Skeptical View of Zero Discharge/Virtual Elimnation

Daniel A. Bronstein, S. J. D.
Professor, Environmental Policy & Law
Department of Resource Development
Michigan State University
East Lansing, Michigan

The concept of zero discharge/virtual elimination (ZD/VE) has considerable appeal to the average person and, of course, to politicians who are ultimately responsible to the public. I wish to argue here, however, that there are many problems with the concept that would have to be solved before it could be implemented.

At first blush ZD/VE would seem to mandate a simple "nothing may be discharged" legal requirement, but that is clearly impossible. There is no known engineering process, whether we are discussing paper making, manufacturing automobiles, or sewage treatment, that can be performed in that way. All industrial processes have effluents, even if they are simply the discharge of water and carbon dioxide from the combustion of fuels. We could, of course, ban all discharges into surface water, but the effluents still have to go somewhere, perhaps into the air or the ground; but this is merely a temporary delay because the effluents will eventually move into surface water through airborne deposition or groundwater contamination and eventual discharge.

Thus we could fall back on the old "undetectable" criterion. The major problem with this has been discussed many times, so I will merely note it briefly. As analytic capabilities improve, do we require dischargers to redesign to meet the new detection levels? This would put the Great Lakes region at a considerable comparative economic disadvantage; who could justify building new plants that would constantly need to be redesigned? The same can be said for any version of undetectability that provides some sort of "grace period" during which plants would not have to be updated. The most common answer to this, of course, is to provide a "lifetime" permit (or a specified long time, perhaps that allowed for depreciation under the tax codes) for plants which meet the undetectable level when built or modified. In many ways this is similar to the current U. S. system of best available technology, except that

the best available technology is required to meet the ZD/VE level at the time of construction/modification.

Assuming, then, that we go to a version of ZD/VE which grants a "useful lifetime" permit for plants which meet the undetectablity standards at the moment of licensing, we may be considered to have solved the point source problem, for plants will either achieve undetectable levels of discharge or will be banned if they do not have a technology capable of reaching undetectability. The region will still have put itself at a comparative economic disadvantage, but one which might be more acceptable to citizens as it will not ban *all* development. Nevertheless, we still have to face the problem of nonpoint sources.

Nonpoint sources of surface pollution are one of the orphans of the current regulatory scheme. Although they are supposed to be regulated, they are, for all practical purposes, unregulated. The primary nonpoint sources appear, at the moment, to be runoff of fertilizers and chemicals from agricultural activities (including silviculture), urban/suburban runoff that is not collected into storm sewers, and soil erosion from both agricultural and construction activities. In fact, some believe that nonpoint sources are the primary sources of surface water pollution in the region. Thus, to achieve ZD/VE will require regulation of nonpoint sources of pollution. The technical, administrative and regulatory problems of nonpoint source control are legion and many of the necessary changes would impinge so deeply on the "life-style" of the average citizen as to be politically unacceptable.

Furthermore, ZD/VE also implies that chemicals used for ecological stabilization (lampricides, zebra mussel killers if any are found, etc.) will also be banned. To do this may likely result in ecological changes that would prove extremely distasteful to the average citizen. The failure to ban government agency use of such chemicals, however, would result in complaints that "the Government goes ahead and does what it wants, but tells me how often I can fertilize my lawn" and thus undermine public support for the entire concept of ZD/VE.

So far we have been discussing the "zero discharge" side of the phrase; some thought needs also to be given to "virtual elimination." I believe that the public conceives virtual elimination as the elimination of the pollutants currently found in the Lakes. Aquatic scientists tell us that the elimination of pollutants will take between several decades and several centuries, even if all discharges were stopped immediately. Further,

since analytic techniques are constantly improving, and we have no baseline data concerning the status of the Lakes before industrial development started, we will face the persistent problem of "how clean is clean?" When would we be able to proclaim success? How will we convince the public that we are making progress when new analytic techniques will continue to show pollution present in the Lakes for the foreseeable future?

I hope that none of the foregoing will be taken to mean that I disapprove of ZD/VE. It is merely to point out that such a concept will require considerable time to implement initially and even more time to demonstrate perceptible change in the water column. During this entire period it will be necessary to maintain public understanding and support. The term ZD/VE may be a problem in this respect as it amounts in some ways to over-promising. A massive program of public education (*not* public relations) will be needed to keep the necessary political support for the length of time it will take for ZD/VE to produce results.

Zero Discharge—Pollution Prevention, Not Pollution Management

Gayle Coyer
Lake Superior Project
Great Lakes Natural Resource Center
National Wildlife Federation
Ann Arbor, Michigan

The term "zero discharge" represents a fundamental paradigm shift in how we address toxic pollution in the Great Lakes basin. Zero discharge prescribes a strategy of pollution *prevention*, rather than pollution *management*. Zero discharge recognizes the only way to stop toxic contamination of fish, wildlife, and humans in the basin is to prevent the use, generation, or discharge of persistent toxic pollutants in the first place.

The terms zero discharge and virtual elimination are often misused. Zero discharge means zero—none. It does not mean reducing discharges to a level where no impacts can be demonstrated. It does not mean discharges below levels that can be measured

with current monitoring techniques. Zero discharge does not mean using best available technology to reduce toxic discharges. It means changing production processes to end the use, generation, and discharge of these pollutants.

Virtual elimination describes the state of the Great Lakes basin after we've prohibited the discharge of additional persistent toxic substances and cleaned up, to the maximum extent possible, the contaminants already released. Because of past releases, we can never totally eliminate the toxics already in the Great Lakes. But we can stop any additional input. Only through a strategy of zero discharge can we ever have virtual elimination of persistent toxic pollutants in the Great Lakes basin. The International Joint Commission, in its recent *Sixth Biennial Report on Great Lakes Water Quality*, summarized the two terms very succinctly, " . . .the Commission believes that virtual elimination is the necessary and reasonable goal, and zero discharge . . . is the necessary and not unreasonable tactic for achievement of the virtual elimination strategy."

Lake Superior is the arena where the governments' commitment to—and understanding of—zero discharge will be tested. In the fall of 1991, the six governments with jurisdiction on Lake Superior—the United States, Canada, Wisconsin, Michigan, Minnesota, and Ontario—committed to a "Binational Program to Restore and Protect Lake Superior." The Binational Program contains a Zero Discharge Demonstration Program, which is "devoted to the goal of achieving zero discharge or emission of certain designated persistent bioaccumulative toxic substances, which may degrade the ecosystem of the Lake Superior basin."

The governments should be commended for undertaking the Binational Program. However, the Program contains some fundamental flaws in its approach to zero discharge that need to be addressed. Let's examine some of the problems:

1. **The chemicals of concern should include all chemicals that currently are affecting Lake Superior, or *that have the potential to affect Lake Superior in the future*.** The Program, however, only designates nine chemicals (dioxin, octachlorostyrene, hexachlorobenzene, chlordane, DDT, DDE, toxaphene, PCBs, and mercury). These chemicals were chosen because they have been identified in fish tissue in Lake Superior. The list must be expanded to include, at a minimum, the chemicals of greatest concern identified by the Great Lakes Initiative, a list of about fifty chemicals.

2. New or increased discharges of these persistent toxic pollutants must be prohibited. The Program designates certain portions of the Lake to receive an "Outstanding National Resource Waters" classification, the highest level available under the Clean Water Act. However, only a few small areas, like national parks or lakeshores, would receive this designation. Since pollution knows no boundaries, the designation will only work if new or increased sources are prohibited in the entire Lake.

Outside of these few small areas, the rest of the Lake would receive a designation of "Outstanding International Resource Waters." New facilities would be required to use "best technology" and pass an antidegradation test in order to site a new pollutant-dumping facility. This is the same time-worn approach that has already failed us—pollution management, and not pollution prevention. The only solution is to prohibit new or increased sources entirely.

3. Existing sources of persistent toxic pollutants must be phased out, but according to a specific timetable. The Program merely requires voluntary toxic reduction plans in discharge permits. The toxic reduction plans will not be mandatory or enforceable. This is a weak toxics reduction strategy instead of a zero discharge strategy. Instead, the governments should examine each industrial sector in the basin, identify the persistent toxic pollutants used by that sector, and implement a phase-out schedule for each sector.

The environmental community in the Great Lakes basin has a vision of an environment where fish are safe to eat and where wildlife and humans are safe from the effects of toxic contamination. The Binational Program for Lake Superior shows how far we still need to go to achieve zero discharge. We will continue to push for zero discharge in the Great Lakes basin until that vision becomes a reality.

The Feasibility of Zero Discharge/Virtual Elimination A View from Green Bay, Wisconsin

Harold J. Day
Green Bay Metropolitan Sewerage District
Green Bay Remedial Action Plan Public Advisory Committee
Green Bay, Wisconsin

The implementation of a zero discharge/virtual elimination policy is feasible for those sources associated with present day, ongoing industrial, commercial and residential activities. This can be done in most Areas of Concern, including Lower Green Bay, through a combination of regulations and public education including demonstration projects and programs like "clean sweep."

It is not realistic, however, to expect success with such a policy for either contaminated river sediments, caused primarily by past industrial practices, or for toxic chemicals in agricultural runoff, caused by inadequately regulated land use practices. It is even less realistic to expect the Great Lakes themselves to be free of toxic substances in the immediate future. The largest single source of toxic substances to Lake Michigan is the atmosphere.

This rather pessimistic evaluation of the feasibility of implementing zero discharge/virtual elimination is based upon the judgment that there are insufficient public funds and inadequate public support for the required significant increases in abatement activities.

Recent information from Wisconsin may be used to support this statement. An estimate of the abatement cost for just two of the five Areas of Concern in our state, Green Bay and Milwaukee, approaches $2 billion. Most of the money would be needed for cleaning up contaminated sediments. Yet, the most recent state budget is reported to contain $1.5 million for Remedial Action Plan (RAP) implementation. The Governor has vetoed a bill that would have provided an additional $70 million for nonpoint pollution abatement across the state. It is clearly his judgment that increased funding for such environmental concerns is not a high priority.

Major changes in at least three segments of government policy will be needed before public support for RAP implementation can be expected to change positively. The first involves the mechanism of

achieving virtual elimination. Existing regulations have highlighted end-of-pipe treatment, with limited emphasis on pollution prevention. This strategy has proved to be woefully inadequate. A philosophy of pollution prevention needs to be firmly established at the federal level. Programs designed to provide up front economic disincentives for purchasing toxic materials need to be developed, as are now in use in the Puget Sound basin. Product bans for the most hazardous compound classes need to be expanded.

The second is the federal budget. The executive and legislative branches of our nation's government will have to face the reality of increasing taxes and reducing spending in order to address the pending financial crisis rooted in the continuing budget deficits. A move is underway to pass a constitutional amendment requiring a balanced federal budget. If passed and approved by the required number of states, an awesome challenge, major changes in federal programs would occur.

The third required government policy change is in the planning and management policy of the federal and state environmental regulatory agencies. Management by regulation has been effective for the past thirty years since most of the money used to pay for enlarged and improved sewerage services came from the federal government and since there was general public support for the pollution abatement projects. The recent shift of funding responsibilities from federal to state and local governments, coupled with the increasing competition for public funds, has changed the situation. Measures of cost effectiveness will be needed in the future to demonstrate to local officials that investments in water pollution abatement are wise. New planning procedures are needed. To be successful, these procedures should include the integration of ecology, economics, institutions, and technology within a watershed. Sufficient local cost sharing is not likely to be provided in the future without more evidence of wise and frugal planning. Regulatory actions will still be necessary, but those provided without evidence of cost effectiveness are not likely to be politically endorsed. Most RAP implementation activities in the future can be expected to be evaluated according to measures that include cost effectiveness.

Zero discharge and virtual elimination of toxic substances is a very important part of the effort to pass on a cleaner and more healthy Great Lakes to the next generation. The goals on this subject endorsed by the International Joint Commission are excellent as written. Some parts of this problem can be

addressed quickly and effectively. Other parts will have to wait for major changes in public policy. It is time to address the funding problems in our nation directly. An improved water quality planning and management practice would be one of many consequences of a responsible federal budget. That action, in turn, would help to reestablish local voter confidence in public decision making, which is necessary for funding increases.

The zero discharge/virtual elimination of toxic substances is not achievable without these major policy changes.

This article represents the opinions of Harold Day. It has not been reviewed or endorsed by the Green Bay RAP Public Advisory Committee.

The Role of the Atmosphere in Zero Discharge and Virtual Elimination of Toxic Chemicals in the Great Lakes

S.J. Eisenreich, Director
Gray Freshwater Biological Institute
University of Minnesota
Navarre, Minnesota

The atmosphere continues to be a major pathway for entry of toxic organic chemicals and trace metals into the Great Lakes. Achievement of zero discharge will entail eliminating near and distant sources of these pollutants to the atmosphere. Even so, local emissions and long-range transport from other regions of the continent and the northern hemisphere will establish a base discharge via the atmosphere. Virtual elimination, once inputs are diminished, must wait for the lakes' natural detoxification mechanisms to clean these large ecosystems.

The North American Great Lakes are especially sensitive to atmospheric deposition of toxic chemicals and trace elements because they have high surface area to drainage basin ratios, are near and downwind of urban and industrial centers (pollution sources), and receive a dominant or major fraction of their water by direct precipitation on the lake surface. Chemicals emitted into the atmosphere nearly anywhere in the northern hemisphere may be found falling into the Great Lakes. Major centers like the Chicago, Illinois—Gary, Indiana corridor may exert a

significant influence on the total loading of certain chemicals and trace metals to the neighboring lake.

Sources distant from the Great Lakes may also be sources of toxic chemicals. DDT, now banned in North America, is still used in Central and South America, and in even larger quantities in the Persian Gulf, Egypt, and the Near East. Fresh DDT still enters the Great Lakes basin riding the winds of transport. Toxaphene, an especially pernicious pesticide once used widely in the southern U.S. on cotton and sunflower pests (banned in 1983), has been found at high concentrations in Lake Michigan fish, in sediments of northern peatlands, in the air flowing from south to north, and in the remote ecosystem of Isle Royale in the center of Lake Superior. PCBs were banned in the early 1970s from use in open systems and later banned for use altogether. Yet, PCB concentrations in the remote atmosphere over Lake Superior have not decreased noticeably in the last decade, and there is growing evidence that PCBs loaded by surface and atmospheric sources over the last 50 years to the lakes are being delivered back into the atmosphere, at least during some times of the year.

Many toxic organic chemicals exhibit seasonal patterns in air; higher concentrations in the summer (warmer) periods, and lower in the winter (colder) times. This has led some scientists to suggest that toxic organic chemicals emitted into the North American atmosphere may find their final resting place in areas which are seasonally or permanently cold (the Arctic and the cold waters of Lake Superior and the North Atlantic Ocean). This is the so-called "cold finger" phenomenon. So, where are all the millions of kilograms of PCBs, DDT, toxaphene, etc. which were emitted into the North American atmosphere, hydrosphere, and terrasphere over the last 50 years? The logical conclusion is that they are in the terrestrial ecosystem, where they will continue to cycle for decades to come, driven by seasonal fluctuations in temperature.

Since the early 1980s, increased emphasis has been placed on detecting and identifying toxic chemicals in the atmosphere and rain/snow, because scientists have suggested that the atmosphere is a dominant or at least important contributor of toxic chemicals to the lakes. It is this emphasis that has led to the formation of the Integrated Atmospheric Deposition Network (IADN), a binational monitoring and research network dedicated to quantifying atmospheric loadings and identifying source(s) and source regions and

their emission strengths. In November 1990, President Bush signed into law the Clean Air Act Amendments, a significant portion of which was dedicated to the Great Waters Study (the Great Lakes, Chesapeake Bay, etc.). All of this attention should have alerted the public that the Great Lakes, *all* of the Great Lakes, receive important quantities of toxic chemicals from the atmosphere. As long as these chemicals are emitted into the atmosphere, they will be transported on the winds and deposited in the Lakes. Of course, there are new chemicals (high-use agricultural herbicides) and old chemicals (PCBs; PAHs of combustion origin) that are and will remain a concern in the Lakes for years to come.

What does all this have to do with zero discharge and virtual elimination? Emission of toxic chemicals and trace elements into the atmosphere will continue to be loaded into the Great Lakes in proportion to their emissions. If emissions continue, then atmospheric loading to the Lakes continues. The concept of zero discharge is then relegated to establishing base loading rates equivalent to atmospheric deposition. The Lakes have an amazing capacity to rid themselves of pollutants in a relatively short time through natural "detoxification" processes. For zero discharge and virtual elimination of pollutant inputs to be realistic goals, we must recognize that the atmosphere will be a source of toxic chemical input to the Lakes for decades to come. The rate of response in the Lakes will depend on the rate at which emissions to the atmosphere decrease, and the efficiencies with which the atmosphere and aquatic and terrestrial ecosystems remove, bury, and destroy incoming chemicals.

Practical Solutions Needed to Transcend Philosophical Differences Regarding Definitions

G. C. Granville and P. Toft
Environmental Health Directorate
Department of National Health and Welfare
Ottawa, Ontario

For many years, we have been actively consulting with many international, national, federal, and provincial agencies, as well as providing input and advice to industries, environmental lobbies, and others, on matters relating to the concepts of zero discharge and virtual elimination. We are firmly of the opinion that it is time to stop the unproductive debate over definitions and philosophies and to redirect those energies into more positive directions.

In many respects, the current debate is reminiscent of the one relating to safety management. Theory states that "all accidents are preventable." This is true, but all those who have been involved in enhanced safety programs have found that a primary focus on reducing the most frequently occurring accidents pays much larger dividends than focusing on the broad, non-prioritized philosophy of prevention.

We also find the concepts of "zero discharge" and "virtual elimination" to be misused and over-interpreted, often resulting in confusion, particularly when the terms are applied to the different problems of discharge and remediation. This paper, therefore, proposes two discrete messages. Firstly, it will address the issues of definition and, secondly, the need to focus on practical solutions.

1. Definitions

We repeat our thesis that the terms "zero discharge" and "virtual elimination" are over-emphasized, thus tending to redirect energies away from other important areas. We suggest that the terms be used somewhat less in the next year or two, and that we be more focused on specific situations. For example, with respect to the DISCHARGE of persistent toxic substances, the concept of "virtual elimination" should be applied when considering reduction of inputs. Such a narrowing of focus, for the time being, avoids the largely irrelevant argument relating to the meaning of "zero" in our sophisticated analytical environment. Further, we suggest that, for a while, the

concept of "zero discharge" be applied in a sense that relates to process design, such that no emissions will enter the ecosystem under study because such a pathway does not exist; e.g., a physical absence of a discharge line to a lake will ensure no direct discharges of liquid effluent to that lake. Provided "zero discharge" can be used in this engineering sense, it will provide a useful philosophical support to IJC activities without being an obstacle to progress.

With respect to REMEDIATION, neither "zero discharge" or "virtual elimination" adequately covers the concern. The primary practical focus for remediation activities relates to the complexities involved in clean-up procedures, and to adequately answer the question "how clean is clean enough?" We suggest that remediation activities require policies which are based on practical values, and that an interim working definition for an acceptable level of remediation is based on a level which is expected to result in no future health or environmental effects in the ecosystem(s) of concern.

2. Practical Solutions

It is time to commit our major efforts to a long-term process of reduction. It is time to stop debating philosophical terminologies and definitions, and begin to negotiate real reductions in actual emissions. It is vital for industries to achieve significant reductions in emissions to all media over specified periods of time; and it is equally vital for environmentalists to acknowledge that many changes will require substantial time and financial commitments. This means that priorities have to be developed and the most significant health and environmental priorities tackled first. Our common experience over the past years has shown that this is no easy task; nevertheless, we surely have learned enough to be able to respond effectively to the issues and thereby develop a series of reductions that will show real results. Finally, it is vital for governments to create and contribute to a climate in which meaningful reductions and phase-outs can be achieved through consensus rather than adversarial approaches.

Zero Discharge and Environmental Improvement

Bruce Hansen
President, Nelson-Superior Consultants Ltd.
Thunder Bay, Ontario

Most of the industrialized world's population treasures the idea of a natural environment that can sustain a healthy economy. This idea is particularly appealing when that environment holds the promise of economic living standards normally reserved for highly populated and fully developed industrial societies.

There is a general consensus in the North American population that the Great Lakes environment and especially that of Lake Superior does hold out this unusual promise. At the same time, there is increasing unease that the welfare of the population at large will somehow be negatively affected by activities of those in and around the Great Lakes basin, particularly as those activities affect the quality of Great Lakes water. As can be expected, this discomfort produces fertile ground for discussion and debate, advocacy and lobby, and legislation. Finally, it also produces the potential for commercial and political exploitation within the region, and elsewhere in the world, as advantage is taken of local sensitivities and changes made in response to those sensitivities.

The fight for control of the Great Lakes agenda is moving on many fronts, with several hundred organizations and agencies involved, and with the current leaders in popularity being the environmental advocacy groups. These groups are generally fighting from ground that is safe, but that is also difficult to work from. This is so since, regardless of political popularity, greater fundamental power still lies within the economic issues as controlled by the industrial agencies of the general population and economic power groups, and to some extent by governments representing economic development issues for voter wealth.

A few environmentalists, recognizing the popularity of their stand and with enough insight to see that real money is needed to effect real change, have begun to seek some common or new ground for discussion. Industrial leaders, still expecting a basic impossibility in working directly with diverse advocacy groups, have generally not accepted the challenge of discussions of substance, any more than most advocacy groups have. Environmental advocacy agendas,

which range from change in management practices to de-industrialization, are perceived to provide little potential for discussions of real value with industrial, commercial or political leaders. This standoff may satisfy a larger international political agenda for these groups, but in the case of regional issues can lead to a failure to accomplish either environmental or economic goals. Money is required for improvement, but capital is valuable, will be protected, is mobile, and those responsible for placing it are singular in their demands for return.

An interesting new development seems to be occurring in that government agencies, recognizing an essential political validity and sensitivity in environmental statements, have actually begun to look increasingly to the outcome of direct advocacy/industrial development discussions. These discussions were originally being prompted by increasing bureaucratic difficulty in dealing with new development and relicensing issues, more than by any attempt to deliberately produce a discussion forum. But, regardless of origin, there is another level of negotiation being inserted into the regulatory development and approval process. The full success and the durability of this new process are not yet know. Nevertheless, it has recently been used to control development in the pulp and paper industry, wherein industrial development has been stopped in several cases. This was done without the need for regulatory support, and in at least one case prevented the installation of cleaner technologies, and influenced a subsequent mill closure.

Industrial and municipal leaders are certainly aware of this phenomenon, but even those with special needs, such as extreme economic distress caused by or associated with environmental issues, have rarely looked for opportunities for discussions of substance with other groups. Instead those with the means will naturally rely on fundamental shifts, such as change in environmental sensitivity, to produce opportunity for development of different businesses, and to indicate direction and opportunity in markets and technology within existing businesses. Others fail to react at all and in either case this may leave environmental problems solidly in place. Once again, capital will be protected and will move to find return.

Within the confines of an economy heavily dependent upon the resource-based industries, such as mining and pulp and paper, this phenomenon of direct environmental advocacy/industrial group confrontation has the potential for not only decreasing regional

economic standards of living, but for reducing the environmental well-being of the area. It is unlikely that simple imposition of "zero discharge" can produce beneficial change under such circumstances.

The terms "zero discharge" and "virtual elimination," inasmuch as they cannot be easily defined and can encourage a new hands-off approach, thereby represent one of the most significant challenges to both regional economic development and environmental improvement that has emerged in recent years.

The continuing inability of the environmental groups to legitimize their agendas by including the concept of development, and the difficulty that most industrial and municipal concerns have in working with the environmental issues, is of real environmental consequence in this matter. Natural processes of market drive and worldwide political and free market opportunism will quickly settle the questions of industrial and economic survival, and will direct needed capital quite independently of any sensitivity to local environmental concerns.

What is of further consequence is that even without the use of moratoriums or other actions to stop development, inaction on the disputed problem is the normal result of dispute. Withdrawal of political agencies from real leadership in such crucial regulatory issues and the related withdrawal of industrial agencies from development in face of inability to make a deal, will certainly leave the region poorer both economically and environmentally. Capital is mobile and will find return, regardless of environmental needs.

In an attempt to broaden the input on such disincentives to economic growth and environmental improvement, there has been some cautious attempt at fostering real consultation as a mechanism to both bring agendas to the surface and to provide for some input to the legislative and regulatory process. In recent work, such as that done by the Lake Superior Forum, it was encouraging to note that there was some consensus that zero discharge, if it means zero effluent, was not useful as a means of working with much of anything, including the environment. More importantly in groups such as this, the skepticism that normally comes with attempts to reach a common understanding of vision and goals, has been absent in most of those participating. Work such as this, although it has yet to provide any new value measurement, just may provide an opening for discovering the common ground in environmental and economic concerns.

Perhaps there is reason to believe that economic development and environmental performance can yet be effectively brought together. Certainly there is good reason to believe that without such a marriage, economic poverty is closer and environmental improvement is farther away.

Alignment on environmental goals with real tangible trade and exchange value represents the only effective solution. Zero discharge/ virtual elimination brings with it both tremendous opportunity and tremendous responsibility.

The Meaning of Zero: A Misleading Debate

John Jackson
Great Lakes United
Kitchener, Ontario

Zero discharge means *no release* of a substance into the environment as a result of human activity.

Persistent toxic substances are having sometimes insidious, sometimes dramatic, but always serious, impacts on the wildlife, birds, fish, and people who live in the Great Lakes basin. We cannot afford to continue building up the toxic legacy we are passing on to our children and grandchildren. The only rational, sane approach for dealing with persistent toxic substances is zero discharge.

Surprisingly, considerable debate swirls around the meaning of the very straightforward word "zero." It means "none." Those who try to redefine zero to mean "some," are people who pretend they believe in zero discharge when they really don't.

"Zero" does not mean "virtual." We realize that we cannot completely remove all persistent toxic substances from the Great Lakes ecosystem. Some of them occur naturally; in addition, we will not be able to remove all of the huge amounts that we have already released into the environment. Our goal is to virtually eliminate these substances from the Great Lakes environment. To achieve this goal, we must stop all discharges of these chemicals. This means we must have zero discharge, not "almost zero."

Zero discharge does not mean reducing discharges to the point where they have no impact on life. We cannot risk waiting to eliminate

discharges until we can measure the impacts. It is too late at that point; damage has already been done and the hazardous chemicals have been irretrievably dispersed throughout the environment.

Zero discharge does not mean reducing discharges to the point where we cannot detect them. This approach does not guarantee safety; even very tiny, unmeasurable quantities of persistent toxic substances build up over time to dangerously high levels in living organisms.

Zero discharge does not mean ensuring that contaminant levels in the discharge are at concentrations no higher than in the water or air the user took from the environment. Our concern is with total quantities of a chemical discharged, not with the concentrations. The build-up of persistent toxic substances over time causes the serious impacts.

Zero discharge does not necessarily mean using the best currently available technology to control pollutants. The urgency to achieve zero discharge is so great that we must develop new technologies and change or stop our use of persistent toxic substances to eliminate their release into the environment.

Many people say that, if we define "zero" to mean "none," we are proposing something that is not achievable. We can achieve zero discharge if we stop using hazardous persistent toxic substances.

Defining zero discharge in its literal way means that we shift our focus from the futile and misleading effort of trying to measure releases to looking for ways to avoid using toxics in the first place. This is why a literal definition of "zero" as "none" is critical.

Zero Discharge: The Fault Lies Not in the Waters, but in Ourselves

Lorraine Lamey and Wayland R. Swain
EcoLogic International, Inc.
Ann Arbor, Michigan

In 1972, the United States Congress changed the standard against which pollution would be measured by making "zero discharge" our national goal. The revolutionary principle of zero discharge was joined with a system of permits to create a regulatory framework that would reduce and eliminate all releases into the navigable waters by 1985. The only remaining excuse for non-attainment was technological infeasibility. Twenty years later, zero discharge has not been achieved. Why?

Zero discharge, virtual elimination of toxic substances, and technology-based effluent limitations were intended to disperse the regulatory and enforcement fog that water quality standards had produced. The eternal debate of "How clean is 'clean'?" had led to paralysis in the effort to improve water quality. In the early Congressional hearings for the Clean Water Act, it was apparent that EPA clearly favored cleaning up the nation's waters by way of water quality standards. Representative Bella Abzug stated emphatically that the goal was zero discharge, which could be achieved by technology-based effluent limitations. She asked, rhetorically, if you knew that a certain amount of sewage (diluted accordingly) complied with water quality standards, would you let anyone pour that sewage into your bath? Zero discharge and technology-forcing principles won the day, and heralded a decade of great advancements in water quality.

These growing feathers plucked from Caesar's wing
Will make him fly an ordinary pitch,
Who else would soar above the view of men
And keep us all in servile fearfulness.
—William Shakespeare, Julius Caesar
Act I, Scene 1, lns. 73-76.

However, the bureaucracy developing water quality standards simmered in its discontent: its past efforts merited a greater statutory role than mere "benchmark" status under the new Act. And within another decade, the science of water quality and environmental impacts flourished anew within the debate of "How clean does 'clean' mean in a water quality standard?" Now, we quibble endlessly, and at

great cost, about magnitudes of risk, and vanishingly small quantities of contaminants, while dilution continues to remain "the solution to pollution." The rhetoric has become far more sophisticated; e.g., "waste load allocation" and "assimilative capacity;" but we still do not know "How clean is 'clean'?" and we still have not achieved zero discharge.

Men at some time are masters of their fates.
The fault, dear Brutus, is not in our stars,
But in ourselves, that we are underlings.
Act I, Scene 2, lns. 135-41.

In Shakespeare's *Julius Caesar*, Cassius, in his jealousy and ambition, sought to convince Brutus that there was little, except their own inaction, that made Julius Caesar lord, instead of either of them. The foundation for the Roman conspiracy to assassinate Caesar was laid in his apparent human weaknesses; the past, and therefore much grander, glory of the late general, Pompey; and, the naked fear of an uncertain future for Rome under Caesar.

Similarly, zero discharge is slowly being murdered by conspiracy. As we have implemented it to date, it is not the ultimate cure as we had hoped back in 1972. The apparent weaknesses and excessive time-frame in the elimination of "the discharge of pollutants into the navigable waters" make us doubt our original zero discharge goal, despite the fact we have continually expanded its application and, correspondingly, its achievements and failures. Furthermore, twenty years of zero discharge imperfections have all but expunged from our memory the blemishes of a system based solely on water quality standards. Finally, like Cassius and Brutus, always lurking in the recesses of our conscience, collective and individual, is the terror—*What if* we followed zero discharge to its logical conclusion, with full implementation? Where will that take us as a society?

But if you would consider the true
cause- [...]
Why birds and beasts from quality
and kind; [...]
Why all these things change from their
[natural order],
Their natures, and pre-formed faculties,
To monstrous quality—why you shall find
That heaven hath infused them with
these spirits
To make them instruments of fear
and warning
Unto some monstrous state.
Act I, Scene 3, lns. 62-71.

Like the portents for the Ides of March, the birds, beasts, and children of the Great Lakes now ring tocsin as "instruments of fear and warning." Cross-bills. Club feet. Total and partial reproductive failure. Diminished learning potential. Each tolling of the species

bell for each bird, beast, or child, peals out the warning that toxic substances are changing the world around us—and by consequence, who we are, and our ability to determine our future. Like the Romans, we must consider what the portents mean. Cassius "knew" the portents to signal the end of Julius Caesar. Others would not even admit their existence. Brutus needed to ponder the omens' meaning, because he both loved Caesar greatly, and feared an uncertain future under his rule.

Well, Brutus, thou art noble; yet I see
Thy honorable mettle may be wrought
From that it is disposed. Therefore it is meet
That noble minds keep ever with their likes,
For who so firm that cannot be seduced?
Act I, Scene 2, lns. 311-15.

Cassius convinced Brutus that Caesar was unstable and a threat to Rome's greatness. As a result, Brutus joined the conspiracy to assassinate Caesar. Brutus became a conspirator *when he agreed* to the foul deed. It was not his doubts and fears that signaled him a conspirator, nor the assassination itself, but his agreement to the purposes and ends of the assassination. Similarly, each of us, as individuals and as participants in different levels of government, of corporations, of non-profit advocacy groups, and of communities, must be careful of becoming a conspirator against zero discharge. Any agreement, in words or action, to undermine, dilute, or abandon zero discharge constitutes a conspiracy.

The Roman conspirators feared their country's fate under a powerful Caesar. They failed to step forward boldly with their leader, and instead, a conspiracy of cowardice tried to eliminate their fears with a dagger in Caesar's back. Ultimately, however, their early fears paled in comparison to the consequences of their conspiracy—civil war, devastating fires, and deaths of outstanding citizens. Such was their stab, so to speak, at self-determination.

Many within our nation fear the future under a full and powerful implementation of zero discharge. Its current implementation means that nonpoint sources must be controlled and eventually eliminated, and that contaminated sediments must be removed and treated. Less obvious, but a nonetheless logical extension, is that the sources of airborne toxic substances must be eliminated, and that chemicals must be proved harmless before manufacture or use. Full implementation means that each of us must live "zero discharge" lifestyles—for the fault lies not in the waters, but in ourselves.

It seems, then, that we can either accept the unknown future with a powerful zero discharge goal and its complete implementation, or, in our fear, join a conspiracy of cowardice to paralyze the elimination of the sources of pollutants to the nation's waters.

Et tu, Brute?

A Vote for Children

James Ludwig, Senior Ecologist
The SERE Group, Ltd.
Stockbridge, Michigan

The goal of zero discharge is like sainthood—a lifetime goal pursued in the full knowledge that while failure in life is certain, only the Higher Power will recognize ever so few candidates. Yet we continue to strive for it. Zero discharge is not attainable in a technology-driven society using chemical syntheses to combine halogens with organic carbon rings. Further, we have inherited huge, leaky reservoirs of these chemicals. Yet we remain intentionally ignorant about the full impacts of common persistent chemicals. We do not recognize these chemicals as potent reproductive toxins which act across generations and subtly change ecosystem integrity. We cling to a most significant delusion that there is an assimilative capacity for persistent bioaccumulative toxic chemicals. Policy makers hold the view that trace quantities of toxic chemicals in the Great Lakes are not important unless the exposed organism dies.

Our toxicological literature, replete with arcane acronyms, betrays our biases. We test lethal concentrations of chemicals for 50% (LC_{50}) or 95% (LC_{95}) of adult populations, somehow believing the implied nonsense that the 50% left function normally. Worse, we extrapolate acute toxicological tests to all life stages, while ignoring reproductive processes and offspring. We address cancer through elaborate testing schemes for carcinogenicity, feeding adult test animals massive (usually near-lethal) doses of chemicals and then looking for induced tumors. Then we back off the "acceptable" concentrations by orders of magnitude, adopting elaborate assumptions that only serve to produce controversy instead of enlightenment. We generate impressive acronyms for this sledgehammer toxicology—Lowest Observable Adverse Effect Levels (LOAELs) become No Observable Adverse

Effect Levels (NOAELs) when diluted 10-fold, and tenfold less than the NOAEL becomes the Reference Dose, which defines acceptability. How ironic is that homonym of Noel, subtly reminding us of joy of the birth of the Christian savior. We delude ourselves that this approach will be protective *by assuming without evidence or serious debate that cancer is the most important or only adverse endpoint.*

Those who actually look into the real world finding ecological and reproductive disasters in wildlife and inexplicable effects in our own children are treated as scientific pariahs. A peer-reviewed regulatory system based on this toxicological science as the context for the zero discharge argument is objectionable. I contend that the effects of persistent bioaccumulative toxic substances across generations are much more important endpoints. We must treat these chemicals as though they were very potent hormone analogs and teratogens. Further, we must accept the truth that these chemicals have profound biological effects that our current toxicological paradigms do not address.

The Great Lakes experience with DDT is a fine example of poor toxicological science and muddy regulation. DDT use led rapidly to severe reproductive bioeffects in peregrines within a decade (mid-1950s), then in eagles (early 1960s), and finally in herring gulls (1964), neatly stepping down the food chain from obligate tertiary to tertiary/secondary and finally to a secondary avian predator, in the time order expected from their feeding habits. Egg shell thinning (a subtle estrogenic effect of DDT homologs) was the overt effect seen most often, followed by feminization of males and even direct mortality in severely contaminated adults.

But after two decades of field and elaborate modeling studies, punctuated by Rachel Carson's clarion call, still no action to ban the use of DDT was taken until one very high-dose feeding study in rats showed an equivocal connection to liver cancer. Then, finally empowered by *possible* carcinogenesis, the EPA finally moved to ban DDT use in 1972—22 years *after* the first published papers identified DDT as a potent synthetic estrogen with a specific activity similar to the now infamous diethyl stilbesterol. The flood of field studies showing damage to wildlife and laboratory test animals had made no discernible impact on the regulatory decision. Every other endpoint but cancer was resisted. And so it remains today. If a chemical is not carcinogenic, that chemical may be licensed for use and discharge.

The zero discharge debate is now entangled in this morass. It is repugnant to step into this morass, thereby acceding authority to those who stretch traditional toxicological science over regulatory questions and values that it cannot address. For example, is the potential of DDT to cause male feminization, or of PCBs to cause learning disabilities and lowered immunocompetence in children born to exposed mothers less, more, or as important as cancer? How do we answer such questions? Do we want answers? Are we afraid to ask?

Reproductive rights mean reproductive competence of the next generation. We are morally bankrupt to condemn generations to a chemically altered world where their reproductive competence is compromised before birth. Whether chemicals are produced intentionally like DDT and PCBs, or as unwanted by-products like the dioxins, we must turn the regulatory debate upside down. The burden of proof belongs on the producer/user to demonstrate *before manufacture or use* that their chemicals will not be persistent, bioaccumulate, nor cause reproductive damage. Society simply cannot afford to test chemicals that may have subtle reproductive effects on children. Altering sexuality and reducing immune competence and intelligence in our children is a threat of equal or greater importance than cancer. We must invoke the alien dictum of Napoleanic justice—we must require that a chemical is incapable of causing harm in the next generation before it can be made, used, or discharged.

The debate on toxicity must be opened to include all endpoints besides cancer. Cancer frightens everyone. That is reasonable, since one in four North Americans will die of cancer. But, to base a regulatory program only on cancer when many chemicals are *functional teratogens robbing children of their potential at doses well below those that induce cancers* is truly myopic and stupid. Remember our derisive laughter directed at medieval clerics who endlessly debated how many angels could dance on the head of a pin? I suspect that 25th century thinkers will be able to teach this same lesson from the writings of 20th century toxicologists who argued endlessly about carcinogensis, while children suffered many subtle reproductive and developmental effects, all because political and regulatory leadership could not find courage to address the subtle but socially devastating impacts of persistent toxic chemicals.

If we choose not to insist on zero discharge, then we should acknowledge the primacy of the

cancer paradigm, and let the current regulatory structure endure without debate. That makes sense for closed debates about carcinogens. Dissenters can be ostracized from toxicological science. Of course, there *is* another alternative. Open the debate. Consider *all* the subtle impacts of exposures to these substances, regardless of whose oxen are gored. *Reform the practice of regulatory toxicology to consider all endpoints.* This way is contentious and difficult. We will have to admit we do not understand environmental toxicology. Controversy and uncertainty will be our companions on this path, along with the unvarnished truth that zero discharge is the only rational course. We must embrace this truth to have a human future replete with attained potential of our children. Indeed, do we care more about offering children lives of full potential or the length of our own life spans? Whose lives are more important? Saints will always vote for children, risking being treated as pariahs during their lives.

The Research Implications of Zero Discharge

Jack Manno, Associate Director
Great Lakes Research Consortium
SUNY College of Environmental Science and Forestry
Syracuse, New York

Great Lakes observers and field investigators have for some time worried about the health implications of releasing persistent bioaccumulative toxic compounds into the Lakes ecosystem. The specific concerns need not be repeated here. Although the biochemical details remain uncertain, there is broad agreement that the pervasive and enduring chemical contamination of the Great Lakes food web is unacceptable. Even when these compounds are measured in extremely minute concentrations in water, they still concentrate in living tissue to levels that threaten health. The only reasonable public policy goal, therefore, is to eliminate them as fast as possible. Some toxic substances occur naturally, and some past releases will circulate indefinitely. Bringing levels in the environment to zero, therefore, is simply not feasible. Hence the commitment made by the U.S. and Canadian governments has been

virtual elimination—doing the best that we can with what's already in the environment. Virtual elimination is the ecosystem clean-up goal. Zero discharge, by contrast, is the public policy objective. It is best not to confuse them.

It seems absolutely reasonable given the commitment to the goal of virtual elimination that public policy would insist that no new inputs be allowed—zero discharge. Granted, what seems reasonable in the abstract can be very difficult and costly in the real world. The argument will no doubt be made elsewhere that the cost of each additional increment of concentration reduction in industrial discharges will rise exponentially as you approach zero. Millions of dollars will be spent eliminating the last toxic molecule from the outfall pipe while tons blow in from the atmosphere and wash in from the fields.

This type of cost-benefit argument is often a ruse to avoid the policy implications of zero discharge. With any policy objective—eliminating hunger, fighting AIDs—we can debate the feasibility of 100% success or we can get about formulating and implementing strategies to achieve our goal. Debates about the meaning of zero get locked into the mechanics of treatment or dilution. But zero discharge policy forces a reconsideration of pollution control and encourages the invention of new materials and improved methods of reduction, reuse, and recycling. The zero discharge goal challenges our creativity and in doing so has the potential of unleashing positive economic forces along with the apparent costs.

Zero discharge policy and virtual elimination goals focus the attention of government, the public, and environmental researchers on the problems of prevention and clean-up. They can encourage entrepreneurship in environmental technologies. Zero discharge policy in the Great Lakes will place this region well ahead of its competitors in the development of toxic-free industrial processes. It may not occur immediately, but the ubiquity and pervasive nature of the toxics problem will eventually force others to adopt new techniques as well. If individual nations don't develop zero discharge strategies, an international regime such as that emerging from the Montreal Protocol covering ozone depleting chemicals probably will. It would be wise industrial strategy now for state and federal governments to assist industry in this transition.

Zero discharge policy and virtual elimination goals also have implications for the direction of research done and supported by organizations such as the research

consortium I manage. Obviously the first priority is for applied research into the whole range of process changes in the major Great Lakes industries: steel, automobile, electrical power, aluminum, and paper. Policy research is needed into how to facilitate and encourage clean technology development. New dredging, clean-up, decontamination, and bioremediation techniques must be developed. We need improved understanding of the biochemistry of persistence and bioaccumulation in order to better characterize classes of compounds subject to zero discharge rules. Biomonitoring research is needed to develop methods for measuring concentrations of chemicals that would be otherwise undetectable in the environment. Better understanding is needed of the role of economic policy, incentives, and disincentives in attracting capital to pollution prevention entrepreneurship. Considerable work needs to be done in developing new legal and public policy tools to facilitate the transition from regulation to prevention. Improved modeling tools are needed to understand the fate and transport of toxic compounds in the environment so as to identify the best place for public investment in clean-up.

The list could go on and on. The point I want to make is that applied research is driven by the kinds of questions society asks, and these questions in turn are determined by our environmental goals and our policy decisions. The importance of zero discharge policy is not exclusively its ability to completely eliminate the presence of persistent bioaccumulative toxic chemicals, but instead its ability to shift society's resources and tap its creativity in the only direction likely to resolve the problem in the future—prevention.

Zero Discharge/Virtual Elimination of Persistent Toxic Chemicals: A Tribal Fisheries Perspective

Amy L. Owen
Chippewa/Ottawa Treaty Fishery Management Authority
Sault Ste. Marie, Michigan

The Chippewa/Ottawa Treaty Fishery Management Authority (COTFMA) was created by three tribes to manage and regulate a commercial and subsistence fishery in Lakes Huron, Michigan, and Superior. The three tribes are: the Sault Ste. Marie Tribe of Chippewa Indians, the Bay Mills Indian community, and the Grand Traverse Band of Ottawa and Chippewa Indians.

In the 1836 Treaty, the tribes ceded land that comprised 2/3 of what is now the State of Michigan to the United States, but retained certain rights of occupancy including commercial and subsistence fishing rights. Since the late 1970s federal courts have upheld the tribes' right to self-regulate their fisheries in the Great Lakes. Negotiations regarding allocation of the fishery resource between competing users resulted in the 1985 Consent Order entered into by the three tribes, the State of Michigan, the federal government, and several sport fishing groups. The Consent Order remains in effect until the year 2000, and is intended to protect and allocate fishery resources, provide mechanisms for resolution of disputes between the parties, and reduce social conflict.

The three tribes continue to fish commercially and for subsistence as they have for hundreds of years in the waters of the Great Lakes. However, rapid population growth and industrialization in the Great Lakes region has resulted in habitat degradation and contamination of the aquatic resource. Pollutants such as polychlorinated biphenyls (PCBs), pesticides, heavy metals, dioxins, and sewage have been routinely discharged directly into the Lakes for decades. The fishing tribes had no control over the discharge of harmful and toxic chemicals into the Lakes, yet their fishery resources and opportunities are being seriously threatened as a result.

The concern over bioaccumulation of toxic substances in Great Lakes fish disproportionately impacts the treaty tribes since the commercial fishing industry is the cornerstone of the tribes economy, and because Indian people tradi-

tionally consume larger quantities of fish per capita than the general population. Various studies have attempted to link the eating of fish containing certain contaminants (PCBs) with subtle reproductive problems in humans. Although the link between consumption of PCB contaminated fish and adverse health effects has not been established, much damaging negative publicity has resulted. Many tribal families are dependent upon commercial fishing, and could lose their livelihood if the fishery was closed or further depressed due to negative, misleading publicity.

Statements in the media related to the issue of fish contaminants are often sensationalized and omit important distinctions. For example, regional differences in contaminant levels are rarely mentioned. Fish taken adjacent to heavily farmed or industrialized areas are obviously likely to contain much higher contaminant levels than fish from more remote areas. Similarly, certain species tend to accumulate contaminants at different rates based on their physiology. Organochlorines, for example, tend to accumulate in fat tissue; therefore, fish with a higher fat content may accumulate more toxins. In addition, monitoring studies have shown a dramatic decline in fish contaminant levels in most areas of the Great Lakes over the past two decades. Consumption advisories based on health studies using fish contaminant levels of a decade ago grossly exaggerate any risks currently associated with consuming Great Lakes fish. Updated health impact studies must be performed using contaminant levels as they exist today incorporating differences between regions and species.

In addition to commercial use, many tribal members fish for subsistence in the Great Lakes watershed and may therefore consume larger quantities of fish than other groups. If this subsistence use occurs in the more contaminated areas, families which rely heavily on subsistence fishing may be at higher risk for adverse health effects resulting from eating *unusually* large amounts of fish containing toxic residues.

From a tribal perspective, zero discharge of harmful and toxic substances into the waters of the Great Lakes is a goal that must be vigorously pursued. While zero discharge may not be possible in the immediate future, elimination of *additional* discharge of toxic contaminants into the Great Lakes is imperative. Cooperation from federal, state and tribal agencies, industry, environmental groups, and the public sector is required to meet the goals of a healthy Great Lakes ecosystem.

Native Americans believe that man is one with his environment, not master of it. In this view, to discharge chemicals into the environment and cause it damage is to cause damage to oneself. Unfortunately, the truth of this philosophy is becoming painfully obvious as evidenced by the tremendous damage man has already inflicted upon his environment. As stewards of our environment, we must recognize the Great Lakes as a fragile, irreplaceable treasure that represents a system which we are all part of and dependent upon. The Great Lakes have sustained life for many generations of Native Americans and a commitment must be made to protect and preserve this resource for future generations.

The Debate Behind Zero Discharge: It's All Over But the Shouting

Stephen Sedam
Great Lakes Regional Vice President
National Audubon Society
Columbus, Ohio

Because persistent toxic substances remain in the environment for long periods of time and become widely dispersed, and because they bioaccumulate in plants and animals—including humans—that make up the food web, the ecosystem cannot assimilate these substances. We conclude that persistent toxic substances are too dangerous to the biosphere and to humans to permit their release in any quantity.

—*Sixth Biennial Report on Great Lakes Water Quality*, International Joint Commission, March 1992.

The debate behind what is zero discharge has been with us for many years. It will remain with us for many years. Though the debate is not superfluous, it is being used as an impediment to real action that can produce positive, long-term benefits to the health of the Great Lakes ecosystem and all of its residents, including humans.

What is zero? Zero is what we all learned it was in our first math class. As the findings of the International Joint Commission (IJC) in their *Sixth Biennial Report on Great*

Lakes Water Quality clearly tell us, zero means the absence of any quantity. Zero means emptiness, nothing. Zero is not "no detect." Zero is zero. The answer to "Why zero?" is becoming more clear every day.

In conjunction with the September 1991 Biennial meeting of the IJC, the Michigan Audubon Society, the largest chapter of the National Audubon Society in the Great Lakes region, did a great service to the Great Lakes community by sponsoring an important conference where the latest research on the effects of toxic substances on wildlife and humans in the Great Lakes basin where revealed.

This scientific research presents alarming evidence of the effects of past and ongoing toxic pollution of the Great Lakes on human health and wildlife. As we consider the meaning of zero discharge and why regulatory policy should seek the virtual elimination of toxic substances, this information must be at the forefront of our thinking. To do otherwise ignores the realities for living things in the basin.

Fish-eating waterbirds of the Great Lakes have shown a variety of reproductive anomalies such as crossed bills and clubbed feet, attributed to toxic chemical contamination. Many dioxin-like symptoms in fish-eating waterbirds continue to persist. The eggs of Forster's terns, common terns, Caspian terns, double-crested cormorants, and bald eagles in the Great Lakes have been found to be contaminated with some of the most potent of toxic chemicals known, PCBs, dioxins, and dibenzofurans.

Eagles and mink occurring on Great Lakes-influenced waters have shown much lower reproductive rates than those living on land-locked "inland" waters. The concentrations of PCB and DDE in bald eagles in Great Lakes breeding areas are significantly greater than those found in nestlings in more interior areas. Bald eagles nesting within about five miles of a Great Lakes shore are unable to reproduce at a rate necessary to maintain a stable population.

The more abundant toxic compounds found in the tissue of St. Lawrence beluga whales are among the most "critical chemicals" in the Great Lakes. At least half of the total toxic organochlorine chemicals found in the St. Lawrence beluga population originate directly from the Great Lakes through migrating eels.

The IJC, based on the weight of scientific evidence, has articulated the adjustment government policy and human behavior must make to help the Great Lakes recover from this human-induced injury. Yet government agencies still allow

some cities and industries to dump even the most harmful chemicals, PCBs, mercury, and others, directly into the Great Lakes.

The link between toxic substances and human health and environmental quality is widely recognized. We must now make the link between economic activity and phasing out the injury posed by the proliferation of toxic chemicals. This requires the retooling of environmental and economic policy in line with the mounting weight of scientific evidence.

Congress recognized that this new day has dawned by enacting the Great Lakes Critical Programs Act in 1990. One of its most important features was a requirement for the U.S. Environmental Protection Agency to develop uniform water quality standards for Great Lakes states.

To comply with the law, the Region V office of the U.S. Environmental Protection Agency created a series of committees to recommend how the uniform water quality standards should be crafted to meet environmental goals. Though not nearly as complete as it should be (e.g., nonpoint sources are largely ignored), the Great Lakes Water Quality Initiative (Initiative) is one of the most significant policy steps in years that embraces the vision of the Great Lakes Water Quality Agreement.

The Initiative is needed to set water quality standards to protect wildlife and people from toxic contamination in the food chain, to prohibit polluters from using dilution and mixing zones to hide their wastes instead of treating them, and to protect high quality waters by requiring polluters to install pollution prevention technologies before being given discharge permits. The IJC calls the Initiative "... an important, positive step on the road to zero discharge and virtual elimination."

The recommendations, written as guidance to the states, were released late in 1991. They will guide how each of the states in Region V develop, implement, and enforce water quality standards and other pollution control programs under the Clean Water Act. Water quality standards are in turn used to determine what levels of pollution can be discharged into rivers, lakes, and streams by cities and industries.

While U.S. EPA was nearly a year late in even publishing the new water quality guidance in the Federal Register, scientific evidence continued to pound a steady drumbeat, marking the toll toxic chemicals are taking on the Great Lakes ecosystem.

There are now reports that substances such as DDT and its

metabolites, PCB, dioxin, PAHs, lead, and mercury have demonstrated the ability to disrupt the endocrine systems of laboratory animals, pro-ducing symptoms significant to wildlife. Some of these effects, particularly disruptions in the extent and pace of development in an individual, are thought to be more evident in off-spring than in the exposed parent. The experts who offer this conclusion believe that humans are being adversely affected as well.

Regardless of these and other findings, many cities and industries are endeavoring to shout down the Initiative. They want it stuffed in a drawer, never to see the light of day. The U.S. EPA is facing intense pressure from these forces to indefinitely delay or greatly weaken the Initiative. Calling themselves the "Great Lakes Water Quality Coalition," industrial and municipal polluters across the region are using misleading economic forecasts to discourage this basinwide approach to reducing the level of toxic chemicals in the Great Lakes environment.

Inaction, study, and debate have brought us to the situation where we are today. The growing weight of evidence is before us. The Great Lakes Water Quality Initiative is on the table. Later is too late.

Only when there are tough new restrictions and bans on the discharge of toxic substances in the basin, starting with new uniform water quality standards, will this persistent problem facing the Great Lakes begin to disappear.

Carpe diem!

Virtual Rumination

Steven Skavroneck
Milwaukee Metropolitan Sewerage District
Milwaukee, Wisconsin

The oldest existing map of North America depicting the Great Lakes was produced in 1656 by N. Sanson d'Abbeville, Royal Geographer to the French Court. In 1656, Europeans had a pretty good fix on the location and shape of Lake Ontario (a.k.a. Lac de St. Louys). The position of Lake Erie (a.k.a. Lac du Chat) was fairly well known but it was depicted as much longer than we now know it to be. Lake Huron was called Karegnon and seems to have been on a serious diet since then. Lake Michigan was Lac de Puans and had an East-West orientation, a 90 degree shift from its current North-South configuration. Its major tributary from the South drained the Floridian highlands! The eastern end of Lac Superior was known, but the western terminus was a total mystery.

Despite the above, Europeans thought that they knew a lot about the Great Lakes. Four hundred years later, we think we know a lot about the Great Lakes. But do we know enough? What we don't know can hurt us. What we don't know may do immeasurable harm to the Great Lakes ecosystem.

What we now know that we didn't know twenty years ago (when the Great Lakes Water Quality Agreement was first signed) could fill volumes. Who would have believed in 1972 that atmospheric deposition and contaminated sediments are major sources of toxic substances to the system? Twenty years from now (when, hopefully, the Great Lakes Water Quality Agreement will be fully implemented), what critical information about persistent, toxic substances will we have uncovered that we are not privy to now? Can we afford to wait to find out?

Even with our current state of knowledge of the Lakes—physical, chemical, biological and cultural data—there are many different perceptions of the truth as it relates to the impacts of persistent, toxic substances. However, one of the few absolute truths is that no one group has a monopoly on the truth. Scientists, engineers, farmers, industry representatives, Native Americans, environmentalists, and local, state, provincial, and federal officials all have different visions of the problem and the solutions.

Being the Great Lumper that I am, I have managed to classify all these people and groups into two categories—those for whom it is critical to develop a universally acceptable definition of virtual elimination and those who have already embraced the concept and focus on trying to make it happen. One group has stayed focused on the "what" question. For the other group, the "what" question is irrelevant. The key questions for them are "how" and "how long."

Folks on all sides of the issue realize that virtual elimination will not happen overnight. But, how meaningful is it to set a five-year target, or a ten-year target, when so many efforts must be undertaken by so many different people, groups, and institutions? Three ingredients seem to be critical to a successful recipe for virtual elimination: a solid understanding of where we are now and where we need to be, reasonable yet ambitious expectations for the rate of change, and the means to measure change as it occurs.

We have not mastered all these capabilities as yet, but that is not sufficient reason to refrain from moving ahead. Research, monitoring, pollution prevention, and remediation must all move forward simultaneously.

Many changes are in order and some of them are being undertaken right now. Building upon these efforts will require new approaches and an integrated package of incentives, disincentives, education, technical assistance, and regulation. For example, a new relationship between manufacturers and suppliers must evolve. This will involve cooperatively identifying and minimizing inputs of persistent toxic substances so that outputs of these substances will also be minimized or eliminated.

Another example relates to household hazardous wastes. As industrial loadings of toxic substances to sewage treatment plants decline, the percentage of loadings of toxics due to residential sources will increase. There will never be enough "sewer cops" to control what people pour in the sink or flush down the toilet. What is needed is a combination of incentives and disincentives so that consumers will not buy, and eventually manufacturers will not make, products that should not be disposed of in the sewers or elsewhere in the environment. Education programs are also needed so that people understand that each home is a potential pollution source and each home can become a "pollution-free zone."

Potentially most important of the new approaches is a different way of thinking about the Great Lakes. Many people think of the Lakes as an infinite resource which can absorb massive amounts of pollution and take any amount of abuse while still providing all the benefits that we have come to expect from them—drinking water, food, sport, power, navigation etc. What if, instead, we think of the Lakes as a living organism? The analogy is both an appropriate and powerful one. The complexity and fragility of ecosystem function are surely comparable to those of biological function.

The Lakes breathe, through the exchange of gases with the atmosphere. They take in food and nourishment from tributaries and precipitation and process these through energy and nutrient cycles. The Great Lakes system excretes surplus water, nutrients, and pollutants via the St. Lawrence River to the sea. And they are subject to a variety of ills—from the buildup of sediment deposits (ecosystemic cholesterol?) to the invasion of unwanted parasites and foreign bodies (e.g. lampreys and zebra mussels).

Like many other living organisms, the Great Lakes system is being exposed to harmful doses of persistent, toxic substances—through the air it breathes (atmospheric deposition), through its water supply (tributaries) and through direct exposure (municipal and industrial discharges). As with most other complex organisms, the chronic effects of exposure may take a long time to develop and are potentially of much greater consequence than the acute impacts. The treatment regimens prescribed by the veterinarian, the doctor, or this observer of the Great Lakes Condition all start off the same—remove the source(s) of exposure. The prescription is virtual elimination.

Response of Great Lakes Fish and Wildlife to Virtual Elimination of Chemicals

Jon G. Stanley
National Fisheries Research Center-Great Lakes
Ann Arbor, Michigan

As the debate heats up over virtual elimination of toxic chemicals entering the waters of the Great Lakes, I believe it would be appropriate to examine recent changes in the status of fish and wildlife and to use them to measure successes of past efforts to virtually eliminate toxic chemicals. Past successes in banning specific chemicals give hope that the current efforts will also be successful in eliminating all toxic chemicals.

Definition and Purpose of Virtual Elimination

The idea of virtual elimination of toxic substances was presented in the 1978 Great Lakes Water Quality Agreement between the United States and Canada as a goal of "zero discharge." The Great Lakes environmental community vigorously embraced the slogan "virtual elimination of persistent toxic substances" after it became an obligation of the United States and Canada in the 1987 amendments to the 1978 Agreement. Public agencies plan to implement virtual elimination, with a goal of restoring and maintaining ecosystem integrity, as the way to help the Great Lakes environmental community achieve its vision—a clean and healthy environment.

In defining "virtual elimination of persistent toxic substances," I believe the emphasis should be on the process of elimination—altering industrial processes and use patterns so that input is avoided. By focusing on decreasing loadings through strict controls, bans, and phase-outs of polluting industrial processes, I believe that a clean and healthy environment can be achieved. In addition, pollutants are to be cleaned up at leaking landfills, non-secure chemical dumps, and exuding lake sediments. Sources outside the Great Lakes basin that lead to atmospheric transport and deposition of toxic chemicals in the basin are to be identified and national and international efforts made to eliminate them.

Instrumentation is now so sensitive that toxic substance levels can be detected well below concen-

trations causing biological effects. The word "virtual" indicates that the aim is to reduce toxic chemicals to levels where there are no effects, rather than to non-detectable levels. Unfortunately, effects on animals have been documented for only a few toxic chemicals. In addition, there are likely compounds and effects that are not yet recognized.

Ecosystem Integrity as an Indicator of Virtual Elimination

If the virtual elimination approach focuses on effects rather than concentrations, then good indicator species must be identified and biological effects specified (Council of Great Lakes Research Managers 1991). Because species of fish and wildlife are constantly exposed to the Great Lakes environment, their health is a good indicator of a clean environment. In addition, some fish and wildlife are top predators and get high doses of those chemicals that bioaccumulate. Bioaccumulation happens when chemicals accumulate in predatory animals who ingest them with their food faster than they can be excreted or metabolized. This magnification in animals relative to the low concentrations in water increases up the food chain. Lake trout, snapping turtles, bald eagles, mink, otter, and beluga whales are some of the predators high in the food chain that are so exposed. These species are good indicators of widely dispersed contaminants. Toxic effects include cessation of reproduction, reproductive impairment, egg shell thinning, and congenital malformations (Gilbertson 1989). Fishes such as carp and bullheads feed on benthic organisms and have high contaminant burdens if feeding in areas with contaminated sediments. They are good indicators of local contamination, especially in Areas of Concern. Of the 43 Areas of Concern, 40 had impairments that affected fish and wildlife (Great Lakes Water Quality Board 1991).

Fish and wildlife serve as sentinel species to predict and assist in identifying problem contaminants and their potential adverse effects on humans. Tumors and deformities in fish are listed as use impairments in 14 of the 43 Areas of Concern and as likely impairments in two others (Water Quality Board 1991). There is an assumption that if the environment is polluted enough to cause tumors in fish, then humans could also be affected.

Feasibility of Virtual Elimination

There are indications that the integrity of the Great Lakes ecosystem is improving. Compared with 20 years ago, there is a better ecosystem balance between producers, planktivorus fish, and predators. Problem algal blooms have lessened, the fisheries are

booming, cormorants are thriving, eagles are returning to nest near the shores (but are still not self-sustaining), some of the native fish species have rebounded, and some of the exotic invaders have declined. Populations of bloater chubs and whitefish are replacing the alewife and rainbow smelt in Lakes Huron and Michigan. Spoonhead sculpin have returned to Lake Michigan after a 20-year absence. Lake herring are abundant in Lake Superior. Lake whitefish are now appearing in eastern Lakes Erie and Huron. Although all of these changes have not been directly linked to improvements in the quality of the Great Lakes environment, the rebound of some native species might not have happened without clean water.

In my opinion, the progress toward eliminating DDT and other persistent pesticides and PCBs from the environment gives hope that a program of virtual elimination for all persistent toxic chemicals will work. The banning of these pesticides and other chemicals in the United States and Canada has resulted in significant declines in concentrations and effects. Some preliminary results show that concentrations of contaminants in most areas have declined significantly (Environment Canada 1991). Levels of contaminants in biota have also declined. In bloaters, for example, DDT concentrations have decreased by about 90% and PCBs by about 70% in less than 20 years (Hesselberg et al. 1990). Biological effects have lessened. Mortality rates for lake trout swim-up fry have been reduced since 1981 (Mac and Edsall 1991). Cormorants have fewer abnormalities, and their populations have exploded to 20-30 times their previous levels (Environment Canada 1991). In my opinion, these responses of fish and wildlife over the last 20 years indicate that virtual elimination of all contaminants can also work.

The difficult job has just begun. Of the hundreds of chemicals listed in the Water Quality Agreement, as amended, there is little guidance on which ones to eliminate. Considerable research needs to be conducted to show which are toxic, the sources of the contaminants, and which of the toxic ones are feasible to eliminate. Those chemicals that have widespread effects should be priorities for elimination. Dioxin, a by-product in paper manufacture, is one chemical obviously in need of more critical evaluation. In my opinion, virtual elimination of toxic chemicals is possible, but we need a better idea of where to start. Answers from research are needed, damage assessment programs must be implemented, contaminant monitoring must be improved, and the Lakewide Management Plans need to be completed.

The 43 Areas of Concern should be addressed immediately. Fish and wildlife in many of these areas are severely affected by contaminants and degraded habitat. Pollution cleanup in these Areas of Concern will benefit fish and wildlife locally and may also have ecosystem wide benefits.

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Which Comes First, Environmental Protection or Economic Growth?

Editorial, U.S. Water News, July 1992*

We have been hearing and reading a lot in the media lately about the status of our Earth's environment. Stories reached a frenzied peak at the 1992 Global Earth Summit in Rio De Janeiro. As we are well aware, developed countries of the world have environmental problems, and, yes, the United States has environmental problems. But to close the doors of industry and put our economic growth in reverse to achieve an end to pollution is not the answer to our environmental concerns.

Economic growth, coupled with self-regulation, produces environmental quality. Many of those deep into the green movement wince at that kind of statement, saying that economic growth and protection of the environment are not compatible. But these two concepts are and must be compatible. Growth, however, must take into account environmental costs or it will not improve the general well-being of the people.

A new World Bank study, "World Development Report 1992, Development and the Environment," stresses it is more important to address the basics in developing countries before tackling environmental problems. The report points out that developing countries must first have clean water, clean air, and minimal soil erosion if they are to improve the quality of their environment and the quality of life. These are not pressing considerations for those concerned with biological diversity or climate change.

But how can development and growth go hand-in-hand with the environment? The World Bank study says the quality of the environment is an integral part of improving the welfare of the people, thus allowing economic growth to occur.

Take, for example, water resources. The World Bank estimates that 1 billion people in developing countries have no access to clean water. In addition, 1.7 billion people lack access to sanitation. The result is a huge toll in disease and death. A people cannot raise themselves up in the

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face of such a basic problem, and economic growth, producing a better quality of life, cannot occur as long as access to clean water is a problem.

The poor suffer the most from environmental degradation. The rich can afford decent drinking water while the poor cannot. If we invest in clean water and clean air in a pocket of a developing country, the people become healthy. When the people are healthy, they are productive. Production brings economic growth. And economic growth brings the ability to clean up the water and air in the next pocket. Line up your dominoes and you will see the end result.

The collapsed Soviet Union is a prime example of a country seeking growth without paying attention to the quality of its environment. A new book by Murray Feshbach and Alfred Friendly, Jr., titled *Ecocide In The USSR*, gives an authoritative account of the ecological breakdown of the country. In 103 Soviet cities, home to 70 million people, the air is unfit to breathe. Pollution fouls 75 percent of the surface water. And four out of five rural hospitals lack hot water.

The absence of Soviet environmental policies coupled with inefficient farming practices caused the Soviets to use massive amounts of agricultural chemicals, according to *Ecocide*. They even spread tons of DDT long after other nations banned it, in such large quantities and for so long that 25 million acres of cropland are still overloaded with the poison, ac-cording to Feshbach and Friendly.

The book also notes the Soviet policies that caused the Aral Sea, once larger than Lake Huron, to shrink by two thirds. A drive was mounted to raise Central Asia's cotton output through extensive irrigation and intense application of pesticides and defoliants. The overextended practices dried up and contaminated the rivers that sustained the Aral Sea. As the sea shrank, storms carried the toxic wastes from the exposed sea bed to fertile farm fields. *Ecocide* notes that, "So much contamination by chemical wastes has been dumped into the drinking water supply that mothers in the Aral region cannot breast feed their babies without running the risk of poisoning them."

In contrast to the 75 percent of Soviet surface waters that are polluted, the U.S. Environmental Protection Agency found in a 1989 survey that only 10 percent of America's rivers, streams, and bays are significantly polluted. That wasn't always the case, though. The U.S. had to spend $24 billion per year from 1972 through 1987 to achieve the 90 percent cleanliness rating.

Some would argue that our economic growth caused this

nation's water to become polluted in the first place. Perhaps. But it is our growth and resulting improved quality of life that has provided us with the resources to tackle the problem. To force industry to close its doors to improve our way of life is not the best approach to curbing pollution. We must allow our economic growth and resultant improved quality of life to work in harmony with environmental protection.

Economics and the Environment: A Challenge to Manufacturing

Martin E. Visnosky
Erie County Environmental Coalition
Erie, Pennsylvania

To me zero discharge means just that—the discharge of no persistent toxic substances into the environment which we share with all other living species. To achieve this goal is not beyond our reach and is limited only by the concept itself. The word, ZERO, is daunting; I hear from corporations that "it isn't possible," that the "market just will not support the changes necessary to implement and achieve it." This is the first hurdle that must be cleared, and it is a high one. It requires a systemic change in the way corporate America thinks, a fundamental change in the way America conducts business. Manufacturers must aggressively move to capital investment strategies that focus on long term investment, forsaking short term profit gain. Capital investment of this genre is common in Japan and Germany, countries with which we compete internationally. Change of this magnitude will necessarily require the coordination and cooperation of the various actors in our national economy.

The benefits of this approach not only touch the corporate establishment. It also touches the communities and labor force in our country in a fundamental way, perhaps ushering in a period of economic stability so badly needed in our times. The implementation of zero discharge practices in manufacturing should be looked at in a way similar to any other engineering task faced by industry. Throughout the history of the

industrial revolution, challenges were met and overcome to "make America the greatest industrial power of the 20th Century." Does corporate America remember what it means to be innovative, to be challenged?

The goal of zero won't be reached overnight, but I believe that the goal that must be set is the year 2000. In a particular instance that I'm familiar with, patents were filed in 1974 by the Scott Paper Company for a process that bleaches pulp without the use of chlorine. The patent documents cite the fact that chlorine and chlorine containing compounds are "difficult to handle, introduce the problem of corrosion of the paper making equipment, and render the effluents from the bleached plant incapable of being recovered and recycled. In addition waste liquors and wash water from the bleach plant incorporating such compounds can cause a serious pollution problem." That was almost two decades ago and what has the paper industry in the United States done since? To my knowledge, chlorine-free paper has only recently been manufactured. Why hasn't the industry aggressively pursued a plan to phase in this process, particularly in light of the Great Lakes Water Quality Agreement? I realize that research and development takes time and money, but time has passed and money has been (and continues to be) invested in paper making processes that use chlorine as the bleaching agent. It would seem prudent to me that some of this investment should have been directed at perfecting nonchlorine-based technologies.

The goal of zero discharge, while meeting resistance from industry, has spurred new research into the human health effects of many of the persistent toxics that are released into our environment. Traditionally the risk of cancer has driven the listing of certain compounds that are released and the amounts of them that are "acceptable" when released. Within the last decade, though, a persuasive body of science has been developed suggesting a different criteria must be implemented. This ever-growing body of knowledge on the more subtle effects of persistent toxic substances and their effect on human development has provided reason enough to call for immediate action to sunset their release. We now find ourselves embroiled in a debate over whether this body of research is good or bad science. This debate misses the point that a consensus had developed within the academic community that steps must be taken now to alleviate this toxic burden.

The benefits of beginning now to reach the goal of zero far outweigh any other alternative. Economically it would put our nation in the forefront once again in solving serious environmental threats. By setting specific target dates, long-term investment strategies whose end result would be clean toxic-free processes and new technologies would lead to sustained, constant growth without fear of vagaries of future regulatory practices. It would also lead to reduced health risks for future generations and most probably to reduced medical costs and public health costs that can be tied to continued degradation of our environment. The time is fast approaching when it will be too late to turn this discharge battle into a victory for our world and the future generations to come. The longer we wait, the longer we ignore the fact that we cannot conduct "business as usual," the greater the price will be in both dollars and health in the future.

Alternate Strategies to Reduce Effects of Persistent Toxic Chemicals on the Natural Environment

Grace Wever, Ph.D.
Vice President, Economic Affairs
Council of Great Lakes Industries
Ann Arbor and Detroit, Michigan

The goal of the Canada/U.S. Water Quality Agreement is to *"protect human health and to ensure the continued health and productivity of living aquatic resources and human use thereof."* The 1987 revision of the Agreement recognized the need to control levels of persistent toxics in the Great Lakes, and recommended virtual elimination and a philosophy of zero discharge as a means to that end. As implementation moves forward, stakeholders need to become fully involved in developing a rational strategy to protect health and environment. They also need to understand the differences between the two approaches of virtual elimination and zero discharge, as well as their environmental and economic consequences.

The New Directions Group has initiated a stakeholder process, bringing together business and advocacy group leaders to develop consensus positions. This group recently took a blueprint for the

reduction of persistent toxics releases to the Canadian government. Jean Charest, Federal Environment Minister, has endorsed their proposal and charged his ministry with implementation. The starting point for the New Directions Group was a position developed by the Canadian Chemical Producers' Association, which includes prioritization of chemicals based on toxicity, persistence, and bioaccumulation potential, and implementation of the following strategy:

- For persistent, bioaccumulating toxic chemicals where acceptable substitutes are available, the strategy would be to phase-out their use where risks clearly outweigh benefits.
- An interim strategy is recommended for chemicals where substitutes are not immediately available, i.e., the responsible application of treatment technology and continued investigation of acceptable substitutes and processes.
- For persistent non-bioaccumulating toxic chemicals, good science should be used to set discharge standards, consistent with protection of public health and environment.

The focus for implementation, therefore, needs to be on effects of toxic chemicals, rather than on chemical discharge levels. The presence of chemicals in *influent* waters from both natural and man-made sources actually precludes achievement of *zero discharge levels*, since no treatment process can accomplish complete and absolute removal. In addition, as analytical capabilities continue to improve, a requirement of zero would require dischargers to meet increasingly stringent limits that extend beyond what is needed to protect health and environment. The blanket extension of a zero discharge strategy to broader categories of chemicals, even those that are synthetic pathway precursors, poses a concern that risk/benefit may not be adequately addressed (for example, chlorination of drinking water).

The virtual elimination strategy on the other hand, recognizes that pollution prevention is essential to eliminate toxic effects, that phased-in reductions will accommodate development of new technologies and products, and that prohibitions on chemical use are only one of many options in an integrated strategy.

Today, public policy choices and private interest initiatives based on this strategy *are* reducing materials and energy usage as well as waste levels. Many firms have announced voluntary pollution prevention programs beyond what

is required by law. These choices are in turn reducing and in some cases virtually eliminating risks. Firms are making large capital investments to separate streams with toxic contaminants from discharge waters (e.g. the Dow facilities at Sarnia and in Alberta). Both the Canadian and U.S. pulp and paper industries have invested significantly to reduce dioxin levels to nondetectable levels in mill effluents and significantly reduce discharge of other chlorinated organics.

Canadian and U.S. automakers are working with their respective governments to develop reduction strategies for about 70 persistent toxic chemicals, recently prioritized for attention. The program is unique in that it involves not only the automakers, but also their suppliers. Discharge volumes from Stelco's new state-of-the-art steel mill on Lake Erie are reduced by 90% compared with older mills, and contaminants are virtually eliminated from the discharge stream. A Dofasco mill has retrofitted closed loops in some process areas. Industry and government are developing methods to analyze product lifecycles, including the true cost of materials and operations. This is a newly emerging technical tool, evolving through use.

Effective environmental management processes and systems are another key element of stewardship, recognized by businesses that accept their role as integral members of local and world communities. Programs such as Responsible Care, created in Canada by the Canadian Chemical Producers Association and transferred to a number of other countries, including the U.S., provide a credible management framework. Under this program, the chemical industry pledges to develop, manufacture, transport, and use chemicals responsibly, and to practice sound waste management including waste reduction. Corporate culture and behavior is beginning to change as a result of such programs.

Other associations have created consensus principles and measures of performance for environmental management, such as the International Chamber of Commerce's Charter for Sustainable Development. The United Nations' Center for Trans-national Corporations has published Criteria for Sustainable Development Management to strengthen participation of large industrial enterprises in environmental preservation and protection. The Council of Great Lakes Industries has developed a self assessment matrix that can be used as a guide and measure of environmental excellence. This matrix is part of a Baldridge-type quality environmental management award that

will be implemented by the Council of Great Lakes Governors.

For many decades, government has been in the business of setting environmental standards with the mission of protecting health and environment. These standards may be modified, consistent with the body of knowledge and good science that supports standard-setting. As our understanding of our environment has progressed, tools such as risk assessment and management have been developed, which are also important elements of environmental management.

Within the past few years, governments have also begun to recognize the effectiveness of voluntary solutions. U.S. EPA Administrator William Reilly has expressed satisfaction with the voluntary 33/50 reduction program for selected Toxics Release Inventory chemicals. Jean Charest, Canadian Federal Minister of Environment, and Ruth Grier, Ontario Minister of the Environment, have responded favorably to industry involvement and leadership in the New Directions Group.

None of these initiatives would be possible without sustained will, cooperative action, and the application of significant resources. While there are no easy solutions, many of the options available to us are being pursued with energy. However, many other compelling issues face us, such as energy, exotic species, natural habitat, education, and health care. Given the tradeoffs in managing broad sets of issues in a climate of shrinking resources, we expect that this process and our choices will continue to be difficult. *Only if the public policy development process becomes a truly consensus one will we be able to allocate our limited resources in a way that is consistent with the greatest good of society.*

Project Coordinator: Walter Hoagman
Copy Editor: Martha Walter
Designer: Millie Flory
Water Quality Committee: Christine Pennisi, Walter Hoagman, Martha Walter, Cindy Hagley, Mike McLean, Jennifer Pulz, Maran Brainard, Frank Lichtkoppler, Harvey Hoven.
Chair, Great Lakes Sea Grant Network Marine Advisory Service: Al Miller

For More Information
For additional copies of this publication or additional information, contact the following Network Water Quality Committee member in your state.

Illinois/Indiana Sea Grant Program
Christine Pennisi
Area Advisor, Marine Extension
2320 W. Peterson Avenue
Chicago, IL 60659
312/761-5099

Michigan Sea Grant College Program
Walter Hoagman
District Extension Sea Grant Agent
P.O. Box 599
Tawas City, MI 48764
517/362-3449

Minnesota Sea Grant College Program
Cindy Hagley
Great Lakes Environmental Quality Educator
208 Washburn Hall
University of Minnesota-Duluth
Duluth, MN 55812
218/726-8713

New York Sea Grant
Jennifer Pultz
Extension Specialist
Cooperative Extension Center
21 S. Grove Street
East Aurora, NY 14052-2398
716/652-7874

Ohio Sea Grant College Program
Maran Brainard
Communicator
The Ohio State University
1314 Kinnear Rd.
Columbus, OH 43212-1194
614/292-8949

University of Wisconsin Sea Grant Institute
Harvey Hoven
Field Agent
University of Wisconsin-Superior
143 Sundquist Hall
Superior, WI 54880-9985
715/394-8472

For quantity orders, contact:
Michigan Sea Grant Communications
University of Michigan
2200 Bonisteel Blvd.
Ann Arbor, MI 48109-2099
313/764-1138