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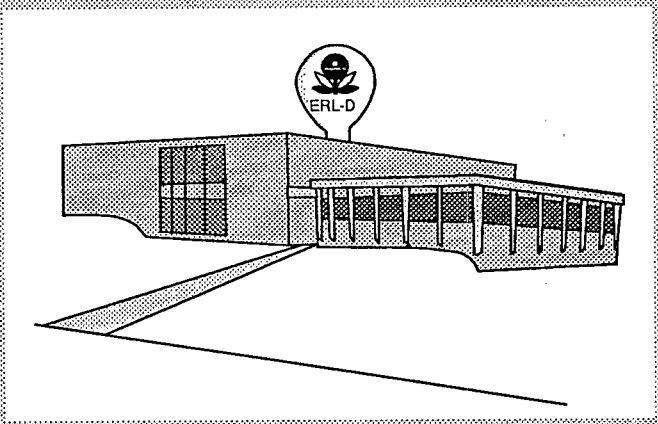
March 1992

ERL-Duluth

Spotlight on Research 1991



U.S. Environmental Protection Agency
Office of Research and Development
Environmental Research Laboratory-Duluth
6201 Congdon Boulevard
Duluth, Minnesota 55804

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March 1992

ERL-DULUTH

SPOTLIGHT ON RESEARCH 1991

Compiled by

Strategic Communication Council

Participating Members:
Robert Drummond
Gary Glass
Evelyn Hunt
Roger LePage, AScI
Anne Pilli, CSC
Barbara Sheedy, AScI
Diane Spehar, AScI

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DIRECTOR'S PERSPECTIVE

The Environmental Research Laboratory at Duluth (ERL-D) conducts research to advance our fundamental understanding of aquatic toxicology and freshwater ecology. Its mission is to develop the science needed by EPA in creating environmental policies for use of freshwater resources.

This laboratory has been generating research data to help prevent or solve water pollution problems since its inception in 1967. The staff has produced over 800 peer-reviewed scientific papers and technical reports. These data have been used to establish water quality criteria and advisories, and to develop predictive models to help prevent adverse effects in our freshwater ecosystems.

Over time, the problems have become more complex and there is greater urgency for answers based on scientific findings. Research managers and technical specialists need to be informed and kept up-to-date on both new findings and the problems currently under investigation. This repository of information highlights many of our research activities. Organizational structure and contacts according to area of expertise are also listed.

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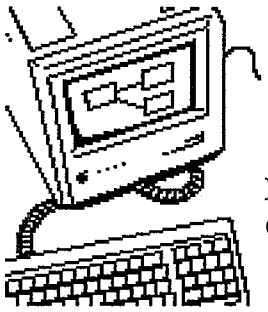
Assessment Tools for the Evaluation of Risk (ASTER)

ASTER was developed by ERL-D to assist regulators in performing ecological risk assessments. ASTER is an integration of the AQUIRE (**AQ**Uatic toxicity **I**nformation **RE**trieval) toxic effects database and the QSAR (**Q**uantitative **S**tructure **A**ctivity **R**elationships) system, a structure activity-based expert system. ASTER is designed to provide high quality data for discrete chemicals when available in the associated databases and QSAR-based estimates when data is lacking. ASTER is currently available to governmental agencies through the U.S. EPA National Computing Center. Training is available and consists of a brief overview and hands-on computer access to the ASTER system.



For more information please contact Christine Russom, FTS 780-5709.

Biotechnology

One of our goals is to develop single species test protocols. This year we completed twelve separate protocols for exposing fish and invertebrates to a zoospore producing fungus, *Lagenidium giganteum*. The zoospores of this fungus attach, bore through the cuticle and kill mosquitos by growing within the body cavity. Each protocol is in a standard format of numbered paragraphs and designed to 'stand alone' in their use.

The protocols contain information to conduct a successful exposure including examples of data sheets and timetables. The procedures were based on actual tests with *Lagenidium* and those data are included in each set.

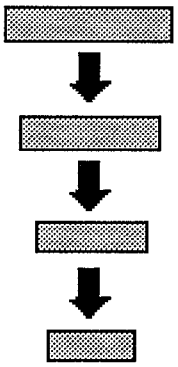
Contrary to our earlier work with a spore-based bacterial insecticide, non-target animals were affected by the fungi. We found that effect concentrations (LC50) on non-target zooplankton were about 25 times higher than those for the targeted mosquito.

For more information contact
Dick Anderson, FTS 780-5616

Contaminated Sediments Research - Quality Criteria

Guidelines for deriving Sediment Quality Criteria (SQC) are being examined to validate the ability of predictive EPT (equilibrium partitioning theory) relationships to protect benthic communities. Tissue residue/toxicity relationships are being studied to establish cause and effect tissue concentrations to aid in the verification of SQC and the development of food chain models.

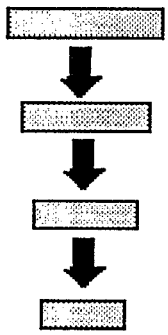
To perform reliable assessments of contaminated sediments for regulatory/remediation activities it is necessary to have standard methods such as bioaccumulation protocols and toxicity tests. ERL-D is developing test methods for contaminated sediments using three species: the amphipod, *Hyalella azteca*, the chironomid, *Chironomus tentans*, and the oligochaete, *Lumbriculus variegatus*. Some of the reasons for choosing these species include: a) ecological relevance, b) ability to assess acute and chronic toxicity endpoints, and c) ease of culturing and handling. ERL-D also is developing toxicity identification evaluation procedures for sediments to pinpoint contaminants responsible for toxicity in samples that theoretically, could contain thousands of different chemicals.



For more information please contact
Gary Ankley, FTS 780-5603.

Contaminated Sediments Research - Remediation

Mineral processing techniques developed by the mining industry for the concentration of iron ores, nonferrous ores, and industrial minerals are being applied to develop a viable treatment flow sheet for the remediation of contaminated sediments in the Great Lakes. The ultimate objective is to reduce the cost of remediation by decreasing the volume of clastic material that would require rigorous treatment such as encapsulation, incineration, or permanent impoundment.

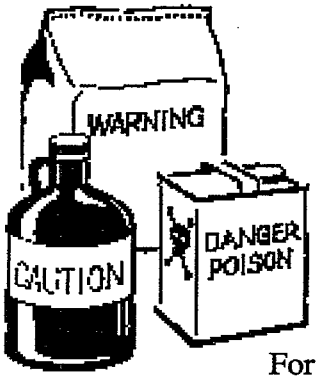


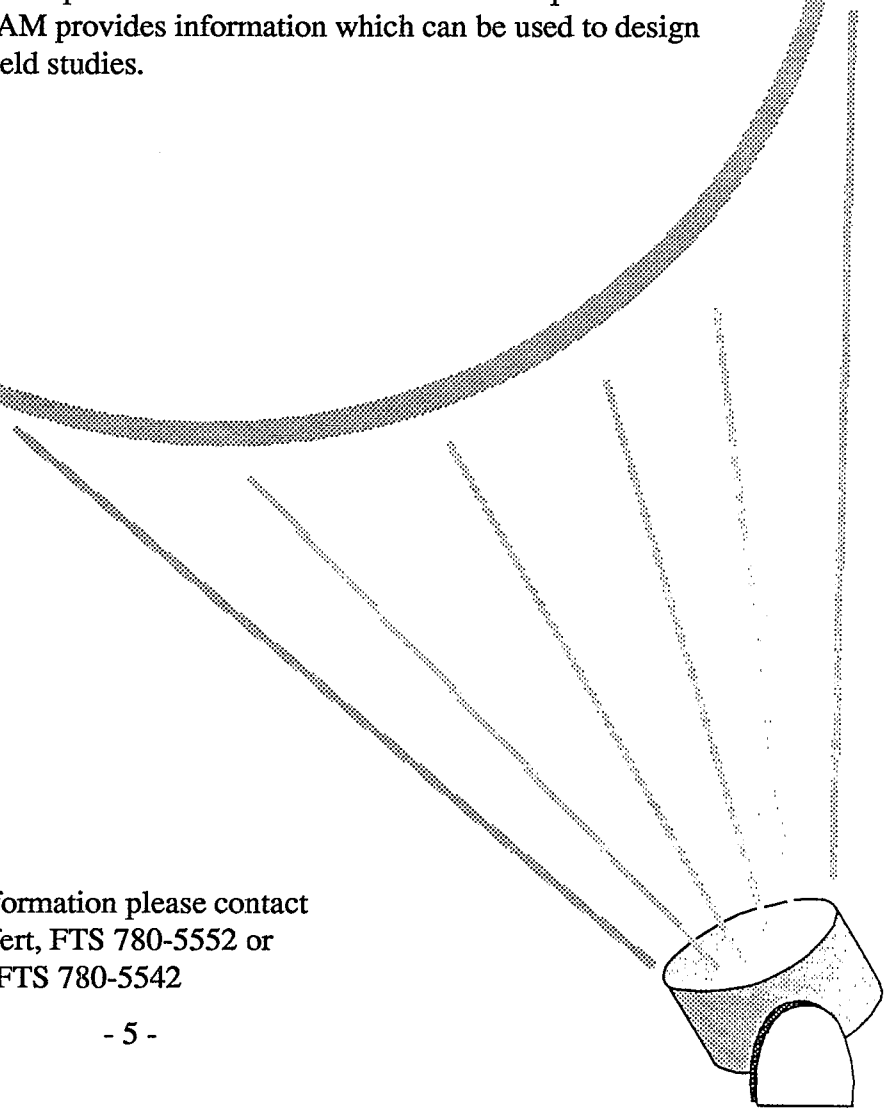
For more information please contact Douglas Kuehl, FTS 780-5511.

Ecosystem Response

We have recently developed and refined the littoral enclosure design and protocol for testing the effects of pesticides and other toxic compounds in natural aquatic ecosystems. Littoral enclosures are a mesocosm system designed to provide ecosystem effects information for use in the pesticide registration process.

Littoral enclosures are also being used to provide statistically valid ecosystem effects data for the development and testing of the Littoral Enclosure Risk Assessment Model (LERAM). The LERAM, developed from the Comprehensive Aquatic System Model (CASM), has predicted the effects observed in studies of littoral ecosystems exposed to different pesticide concentrations, and has provided risk assessments for each exposure level. In addition, LERAM provides information which can be used to design and evaluate field studies.





For more information please contact
Richard Siefert, FTS 780-5552 or
Frank Stay, FTS 780-5542

Environmental Monitoring & Assessment Program (EMAP)

The EMAP-Great Lakes Program goals are to estimate status and trends of ecological conditions of Great Lakes with known confidence, to monitor indicators of pollutant exposure and habitat conditions, to seek associations with ecological conditions, to evaluate long-term effectiveness of management actions, and to provide periodic statistical summaries and interpretive reports.

For more information please contact
Steven Hedtke, FTS 780-5610.

Global Climate

Our long- term objective is to predict the nature, degree, and significance of global climate change effects on freshwater fisheries. Initial research activities are focused on developing models for translating meteorological conditions associated with a doubling of CO_2 levels in the atmosphere into changed water quality conditions and fisheries resources. A procedure for estimating regional effects of climate change on water temperature, thermal structure, dissolved oxygen, and fishes has been developed.

Effects of acid rain on aquatic biota of a warmwater lake community to alternate year reductions in pH are being studied. Effects on all major biotic components, system processes, and water quality conditions are being examined through both extensive field monitoring, ancillary lab and *in situ* experiments. Results will be used in the development of models to predict acid deposition impacts.

Since precipitation was determined to be the major source of mercury, sites were selected to establish regional mercury deposition patterns on a state-wide scale in Minnesota. All of these sites (except Duluth) were chosen to be co-located with other acid precipitation sampling efforts (major ions) for comparison purposes. This knowledge could lead to an understanding of mercury sources to the atmosphere as well as indicating zones of high deposition requiring more attention, particularly from the standpoint of fish consumption advisories.

For more information please contact John Eaton, FTS 780-5557.

Great Lakes Research - Overview

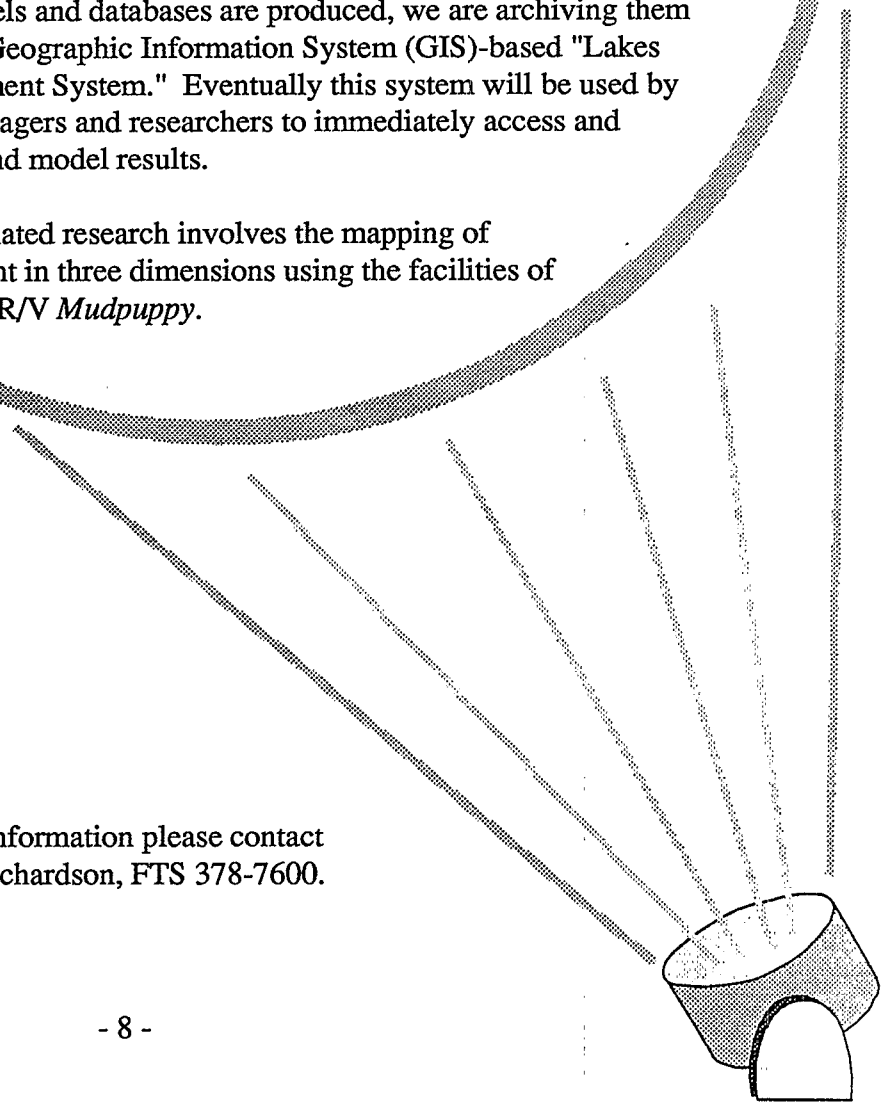
Our research efforts in and around the Great Lakes are varied and extensive. We are developing models that relate the sources and quantities of chemicals to the lakes to concentrations in water, sediment, and biota. Model predictions are then used to determine the effectiveness of alternative control strategies. The primary site for this research has been Green Bay. However, we are also developing preliminary models for Lake Ontario and Lake Michigan. Eventually we will have planning level models completed for all the lakes and even a model that connects the lakes.

The planning models by their nature possess much uncertainty because of the lack of specific process rate information and data. Plans are underway to conduct research to better understand physical, chemical, and biological process rates and to improve model relability.

As various models and databases are produced, we are archiving them for application in a Geographic Information System (GIS)-based "Lakes Analysis Management System." Eventually this system will be used by Great Lakes managers and researchers to immediately access and display data and model results.

Related research involves the mapping of sediment in three dimensions using the facilities of the R/V *Mudpuppy*.

For more information please contact
William Richardson, FTS 378-7600.



Great Lakes Research - Chemical Effects

Distribution of contaminants in Green Bay phytoplankton and zooplankton is under investigation. Analysis of phytoplankton and zooplankton samples indicated that the spatial distribution of two persistent organic contaminants, polychlorinated biphenyls (PCBs) and dieldrin, were distinctly different in Green Bay. PCB concentrations were high in the lower Fox River and exhibited a decreasing gradient to outer Green Bay; conversely, dieldrin exhibited an increasing pattern toward the outer bay. These patterns were observed for both phytoplankton and zooplankton for all seasons. These findings suggest different management and remedial strategies for the two contaminants, as dieldrin may be an historical contaminant.

For more information please contact
Russell Kreis, Jr., FTS 378-7615.

Great Lakes Research - Mathematical Models

The development of mass balance models of water quality has been a principal focus of the Great Lakes Research Program. The models synthesize scientific understanding of processes affecting transport, distribution, and fate of contaminants in aquatic systems. Predictions of a mass balance model for polychlorinated biphenyls (PCBs) in Saginaw Bay, Lake Huron, have been verified using data collected ten years after the model's development. The collected data show PCB concentrations declining by 80% in the water column and by 40% in the sediment over the period 1979-1989. This corresponds to a period of time in which PCB loadings to the bay were dramatically reduced. Model predictions for the water column agreed well with the data; however, the decline in sediment PCB concentrations was overpredicted. This deficiency has been overcome by the development of special sediment traps. The post-audit of the Saginaw Bay PCB model indicates the potential utility of mass balance models to predict long-term transition in toxic chemical concentrations in response to loading reductions.

For more information please contact
Douglas Endicott, FTS 378-7613.

Introduced Species

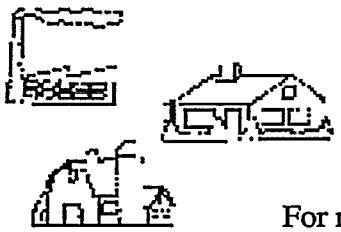
In response to the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990, with funding under the Clean Water Act, EPA is conducting and supporting research on introduced species through ERL-D. This research is focused on understanding how the attributes of successful invaders and vulnerable ecosystems interact to produce ecosystem effects. Successful invaders undergoing study at ERL-D include the zebra mussel (*Dreissena polymorpha*) and a fish species, the ruffe (*Gynmocephalus cernua*), which currently is found only in Western Lake Superior, near Duluth, MN, and Thunder Bay, Ontario. Vulnerable ecosystems being studied or considered include the Great Lakes and rivers and streams throughout the continental United States. Ecosystem effects studied include effects on nutrient cycling and eutrophication, contaminant transfer and cycling, trophic relations and habitat or biodiversity degradation.

For more information please contact
J. David Yount, FTS 780-5752.

Nonpoint Source Characterization

We have initiated a new project to determine the impact of agrichemicals on aquatic life. This project will fulfill certain objectives of EPA's Midwest Agrichemical Surface/Subsurface Transport and Effects Research (MASTER) Plan that outlines research needs for the Walnut Creek Watershed located near Ames, Iowa and the western corn belt ecoregion.

The U.S. Geological Survey and U.S. Department of Agriculture Management Systems Evaluation Areas (MESA) Program has emphasized research on the transport and fate of selected agrichemicals and effects on water. However, the ecotoxicological effects associated with varying farming systems and agrichemical loadings have not been addressed to date. The general goals of the proposed research at ERL-D will be to develop fate and ecotoxicological cause-and-effect information for typical classes of agriculture chemicals found in the surface waters of the midwest corn belt. This information should assist in developing diagnostic procedures and predictive techniques to describe their impacts on the well-being of aquatic life and to assess the environmental benefits of different ecosystem restorative techniques or alternate farm management systems.



For more information please contact
A. Ron Carlson, FTS 780-5523.

Point-Source Discharges / Effluent Characterization

A combined effort between ERL-D and the Office of Wastewater Enforcement and Compliance (OWEC) has resulted in a finalized version of EPA's guidance for "Assessment and Control of Bioconcentratable Contaminants in Surface Waters." This guidance presents procedures for identifying, assessing, and controlling chemicals which cause chemical residues in fish and shellfish by bioconcentration and/or bioaccumulation processes.

To predict the aquatic toxicity of hazardous waste constituents, models are being developed that are applicable to diverse exposure conditions such as routes of exposure, bioavailability, and fluctuating concentrations as well as procedures to predict toxicity of diverse hazardous waste constituents and diverse aquatic organisms.

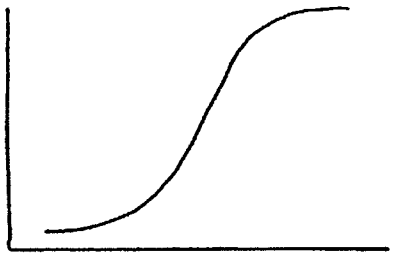
Another aspect of the effluent studies includes development of a scientific basis to identify the cause of toxicity in industrial and municipal effluents and development of toxicity test methods to incorporate effluent toxicity limits in the National Pollutant Discharge Elimination System (NPDES) permit process.

For more information please contact Lawrence Burkhard, FTS 780-5554.

Risk Assessment - Carcinogenicity

A small fish toxicity model is under development to validate the use of small aquarium fish, such as the medaka, as models for assessing health and environmental hazards posed by synthetic chemicals to provide low-cost, biologically-based *in vivo* models for risk assessments.

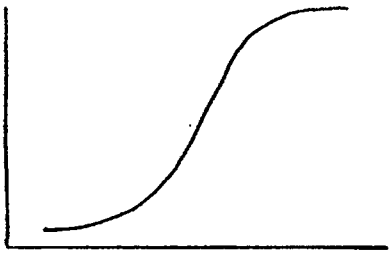
A carcinogenicity bioassay has been used to examine the effects of TCDD at low levels on the development of tumors in various tissues. An *in vivo* carcinogenicity bioassay is also being developed using sediments known to be contaminated.



For more information please contact
Rodney Johnson, FTS 780-5731.

Risk Assessment - Gill Exchange Model

Knowledge of the accumulation of organic chemicals by fish can be important in risk assessments. It provides necessary exposure information for assessing risks to wildlife and humans consuming the fish. A mathematical model for gill exchange was developed based on the fundamental processes regulating exchange - flows of water and blood to the exchange surface, diffusion of chemical between the flows, and the speciation of the chemical within the blood and water. The model was able to predict, almost always within a factor of two, the uptake and elimination rates for sets of chemicals with a wide range of hydrophobicity for both large and small fish.

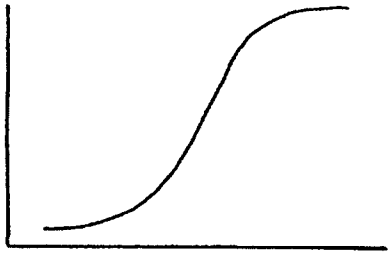


For more information please contact
Russell Erickson, FTS 780-5534.

Risk Assessment - Predictive Toxicology

Efforts at ERL-D have been initiated to address a variety of new research and application issues associated with use of predictive toxicology models in ecological risk assessments. In the field of environmental toxicology quantitative structure activity relationships (QSARs) have developed as scientifically defensible tools for predicting toxic effects of chemicals when little or no toxicological data are available. In the past, application of these models has typically been on a chemical-by-chemical basis.

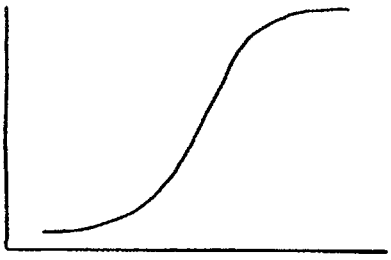
Recently, however, there has been an increasing interest in using these models to rapidly screen, rank, and assess large lists of environmental pollutants. This new phase of QSAR application is reflected by the accelerating need in the Office of Pesticides and Toxic Substances to assess existing chemicals and a variety of listing/delisting activities associated with the new Clean Air Act Amendments and Superfund activities. Efforts are now under way to develop new software applications to insure that QSAR technology can be readily applied to these expanding activities.



For more information please contact
Steven Bradbury, FTS 780-5527.

Risk Assessment - Special Marine Studies

ERL-D is recognized as a leader in fish toxicology, and the monitoring and modeling of pollutants in the Great Lakes. Recently a major research program has been established to study the effects of environmental pollutants upon the survival of marine mammals. Analytical procedures and rigorous quality assurance criteria, based upon mass spectroscopy techniques, have been developed for these studies. The goal of this work is to attempt to assess the role of environmental contaminants in the deaths of marine mammals during the recent mass mortality event which took place along the U.S. Atlantic coast and in the Gulf of Mexico.



For more information please contact
Douglas Kuehl, FTS 780-5511.

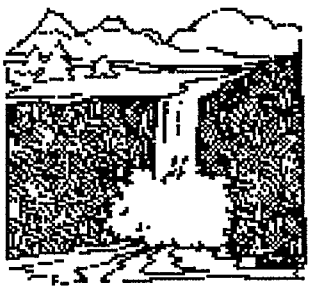
Water Quality Criteria

Water quality criteria are derived to provide a sound risk assessment approach for developing state standards. Both laboratory and field studies are conducted to develop chemical specific freshwater and marine criteria as part of EPA's toxics control strategy. Database analyses are used to evaluate the integrity of minimum data sets and to define research needs to improve the scientific underpinnings of criteria. Research on such specific issues as chemical bioavailability, effects of fluctuating exposures, effects of chemical mixtures, and lab-to-field extrapolations is conducted to address exposure scenarios for use in conducting appropriate risk assessments of aquatic ecosystems.

For more information please contact
Robert Spehar, FTS 780-5564.

Watersheds

Integrated watershed assessment techniques are being developed to provide a framework for assessing integrity in terms of water quality trends, land use and habitat features, and their impact on biological community structure and function. ERL-D has begun cooperative studies with the States of Minnesota and Michigan to assess the physical (habitat), chemical (surface water and sediment quality), and biological (benthic) community characteristics in two watersheds dominated by agricultural activities - the Minnesota and Saginaw River Basins. Observations to date indicate that much of the present-day problems from agriculture stem from nonpoint sediment and nutrient inputs. Information gathered from these two studies will be incorporated with other river basin data to develop diagnostic criteria to characterize watershed health. This information can then be used by state regulators for watershed goal-setting in terms of present and future uses and in planning remediation or clean-up activities.



For more information please contact
John Arthur, FTS 780-5565.

Wetlands

The overall goal of the wetland research project is to provide the information needed to develop and evaluate management strategies for protecting the ecological integrity of wetlands. A number of studies in several types of wetlands are underway, or about to begin, on the effects of environmental stressors such as chemical pollutants and physical disturbances, on wetlands, and the functions wetlands perform in the landscape.

Field mesocosms are used to determine the response of wetland processes and biota to controlled ranges of chemical concentrations or conditions associated with a specific stressor. Empirical field studies are used to compare "real world" wetland conditions and functions among small groups of wetlands along a gradient of environmental stressors. Studies to take place in the next five years include the responses of prairie pothole wetlands to excess sedimentation, the effects of management practices and nonpoint source pollution on bottomland hardwood forests, and the effects of storm water on urban wetlands.

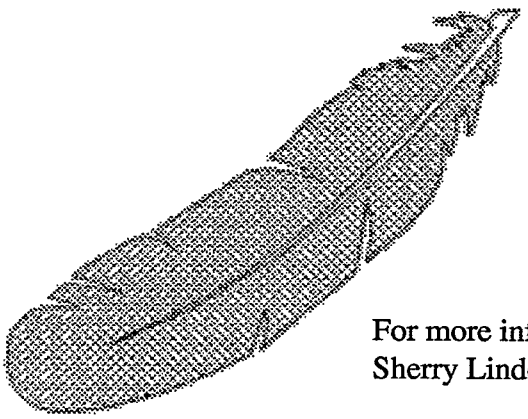
For more information please contact
William Sanville, FTS 780-5723.

American Indian Program

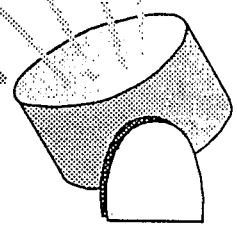
Over the past three years ERL-D's Human Resources Office, the Fond du Lac Indian Reservation, and the Center of American Indian and Minority Health have established a positive working relationship. As a result of this cooperative effort, several programs are in place and planned which benefit American Indian students.

ERL-D's cooperative education program with the Ojibway School targets kindergarten through senior high school students. The objective of this program is to expose American Indian elementary students to science, thereby increasing their interests. Internships for high school students and K-12 teachers are available to foster interest in science, math, and bio-medical careers. Students and teachers complete research projects over a four-week period each summer. ERL-D hosts a program for undergraduate science and bio-medical students. This program, through the Fond du Lac Reservation's Ni-Shou Gabawag grant, allows students to work with research teams for ten hours per week during the school year and full-time during breaks and summer vacations.

In the future, ERL-D welcomes the opportunity to support existing programs as well as develop a pre-collegiate program with the Fond du Lac Community College. This community college is one of 27 tribal colleges within the United States. Through continued participation in these programs, ERL-D anticipates producing a small, steady stream of American Indian scientists in five years.



For more information please contact Sherry Linder, FTS 780-5543.



Community Involvement

The people at ERL-D are involved in many projects that affect their lives and those of the community. For example, R.E.A.P. (Recycle Everything and Anything Project) was established in 1988 to provide a center for recyclable items at ERL-D and to reduce the waste stream from the lab to the landfill. To date, over 25 tons of recyclable glass, aluminum cans, tin cans, and white paper have been gathered by R.E.A.P. volunteers.

Another effort at ERL-D involves the preservation of the natural beauty of the area surrounding the facility. Set on the shore of Lake Superior, the lab's grounds are beautified by a group called C.H.E.A.P. (Committee Handling Environmental Aesthetics Project). This group has transplanted trees and shrubs, and added bird houses to the property.

Volunteers at ERL-D maintain a section of a trail called the Lake Superior Hiking Trail, which will extend 250 miles from Duluth to Canada. One can imagine that maintaining a trail is some work and a lot of fun.

For the Duluth area community, ERL-D periodically holds an "open house." Most of the open houses take place during anniversary celebrations or special events such as Earth Day. The lab usually hosts between 1,000 and 5,000 visitors.

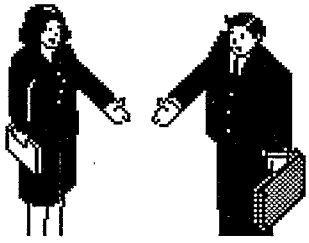
For more information please contact
Robert Drummond, FTS 780-5733.

Cooperative Agreements

Cooperative agreements are a result of the Federal Grant and Cooperative Agreement Act of 1977 which established government-wide criteria for distinguishing between federal procurement and assistance relationships.

ERL-D has had approximately 50 cooperative agreements on-going at one time during each of the past fifteen years. We anticipate that many more cooperative agreements will be awarded next year with an even greater emphasis being placed on competition. Many new areas of research have recently been added to our program and many more are expected to begin this year. Among these are the MASTER Program, exotic species (zebra mussel), EMAP, sediments, wetlands, mass balance, and dioxin. Seventy-five percent of the new funds are expected to go to universities off-site. The total project costs of on-going multi-year cooperative agreements during FY91 for ERL-D was $18,422,244.

Generally, the advertisements for competitive awards for cooperative agreements are solicited in the Commerce Business Daily. Any eligible organization wishing to be on the ERL-D mailing list for competitive cooperative agreements may contact Arlene Shelhon (218) 720-5540.



For more information please contact
Arlene Shelhon, FTS 780-5540.

International Exchange

In 1991 approximately 25 scientists from many countries of the world visited ERL-D. These men and women spent days or weeks interacting with ERL-D scientists. Some of the homelands represented were Russia, Bulgaria, China, Denmark, France, and Korea.

ERL-D scientists traveled world-wide to share their expertise with scientists in Thailand, Russia, Great Britain, Denmark, Holland, Belgium, and Canada.

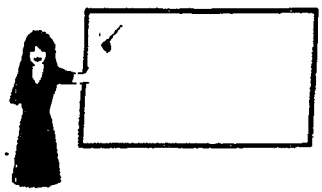
We at ERL-D are proud to be part of the world-wide scientific community, and we expect this interaction to continue and to accelerate in the coming years.

For more information please contact
Evelyn Hunt, FTS 780-5509.

Research Seminars

ERL-D scientists and staff members gather regularly to listen to seminars presented by their colleagues and other scientists from the United States, Canada, and other countries. Scientists share their accomplishments in their areas of interest and expertise. Local and area researchers from other institutions also attend these interesting and illuminating lectures.

In addition, scientists at ERL-D share their expertise by presenting poster sessions and giving formal papers at symposia such as the Society of Environmental Toxicology and Chemistry (SETAC) and the American Chemical Society.



For more information please contact
Evelyn Hunt, FTS 780-5509.

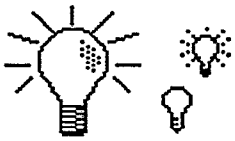
Science and Environmental Education

Science education for area youth is very important to the people at ERL-D. Scientists from ERL-D participate in programs directed at exploring careers in math, science, health, and technology. Others serve as judges, mentors, or special committee members at science fairs.

We are actively promoting environmental education among area elementary students and teachers. The lab hosts area teachers at aquatics education workshops and we visit area schools using a traveling display to give children "hands-on" experience in aquatic biology and chemistry. An Environmental Stewardship Fund, a private fund, was formed at ERL-D. The goal is to instill and promote environmental stewardship in all facets of our society through environmental education.

Each year, scientists from ERL-D co-sponsor a research poster session with the University of Minnesota Chapter of Sigma Xi. The Stay-In-School Program allows students in high school and college to be actively involved in laboratory and field research, to publish scientific research papers, and to work in administrative areas.

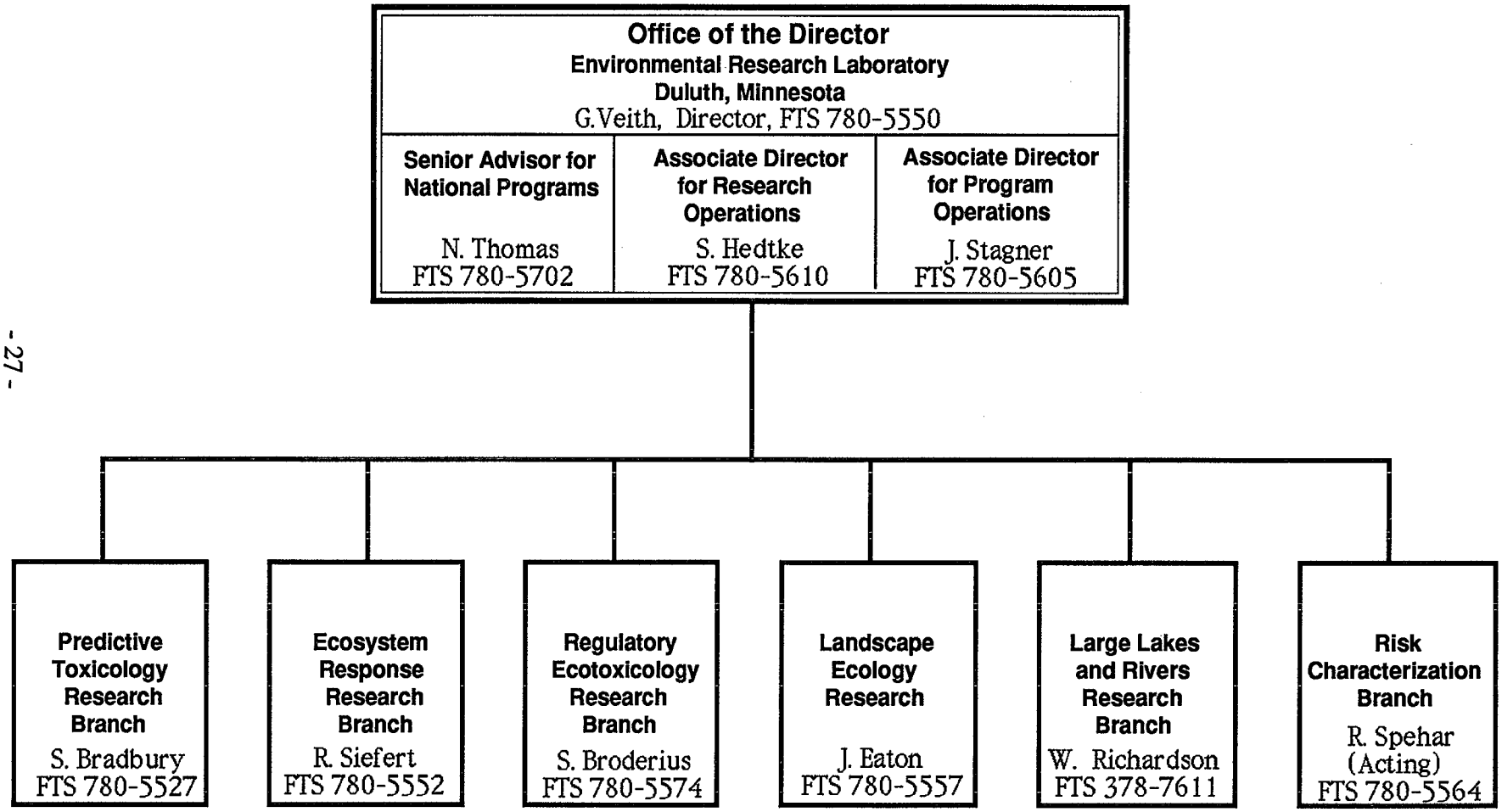
More than 500 persons are given the opportunity to learn more about ERL-D's research each year through in-house tours.



For more information please contact
Robert Drummond, FTS 780-5733.

ENVIRONMENTAL RESEARCH LABORATORY--DULUTH, MINNESOTA

The mission of the Environmental Research Laboratory at Duluth is the development of technology of known uncertainty for predicting and assessing the effects of pollutants and polluting activities on freshwater ecological resources.



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