12/1/2005

The Water Quality Research Program

Introduction

It is no surprise that water quality is so important to our society. Water is essential for life. Humans consist mostly of water. We refer to Earth as the water planet. We often refer to water as the universal solvent, and the water which surrounds contains various levels of compounds, that when they reach a certain threshold, can be considered pollutants. The importance of clean water is also reflected in EPA's top two goals which are to protect air and water quality.

In order to meet our clean water goal, we have developed rules and regulations; setting criteria and standards to safeguard ourselves from water of poor quality. However, adverse effect thresholds diverge greatly depending upon what organism is being exposed, as well as how frequently or how greatly it is exposed. When we seek to extend regulatory controls to protect the organisms in our water environment, so that they can contribute to the ecological diversity and services of the environment, we ask at what cost; both in terms of financial resources for their protection and relative to the likely impacts on society from their loss. ORD's Water Quality Research Program helps provide the scientific foundation for answering these questions.

Inherent to our approach is a focus on a problem-driven water quality research program conducted in parallel to other research programs such as the ecological program which represents core research that seeks to better understand how ecosystem processes function. Problem-driven research is derived to a great extent from client input, while the outcomes of core ecosystems core research involves ways to quantify meaningful attributes, particularly relative to a variety of environmental conditions. In this manner, the development of classification approaches that relate ecology and land uses to water quality can lead to the creation of better tools and better management options for restoring and protection water resources both regionally and nationally.

One of the challenges in evaluating and improving water quality is the fact that there are so many different factors affecting water quality. Water quality is affected by air quality, pesticides and toxics, endocrine disrupting compounds, and mercury; each of which has a corresponding ORD research program. Likewise, water quality is inescapably linked to other research programs such as human health, drinking water, ecology, land, economics and decision-making and global climate change. This leaves us with the difficult task of accurately and clearly describing the water quality research program as compared to a myriad of ways it could be defined and managed.

Program Vision

The ORD National Program for Water Quality is committed to meeting EPA's water quality goals by conducting high quality, credible, leading-edge, mission relevant research. Our programs are designed to:

1. Produce watershed-applicable tools by researching the underlying science, initiating integrative studies, and forming collaborative partnerships to provide methods to develop

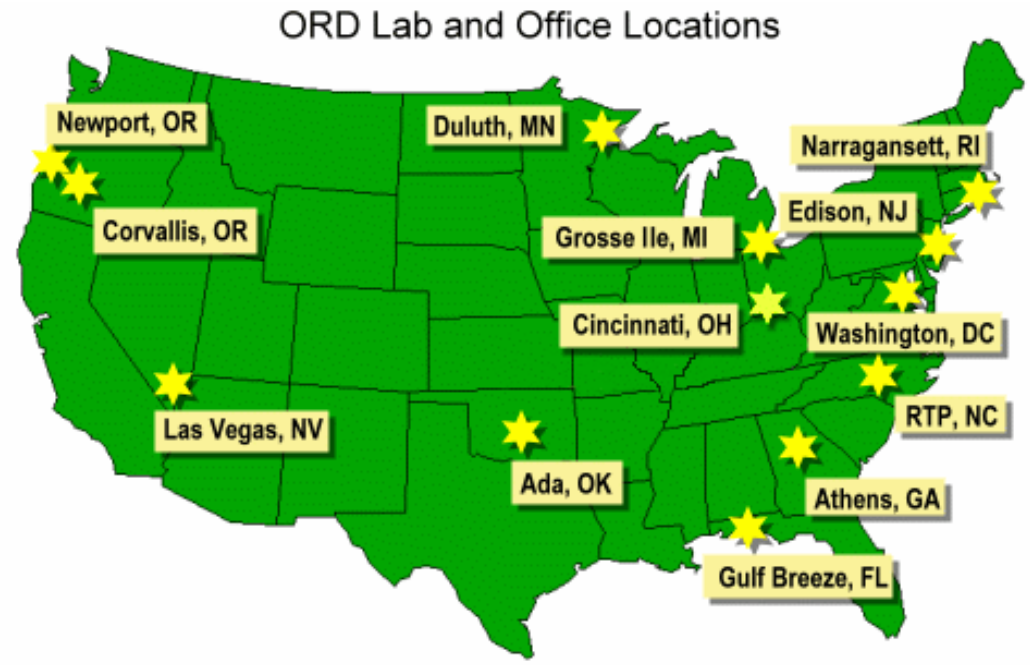
and apply criteria for habitat alteration, nutrients, pathogens, sediments and toxic chemicals;

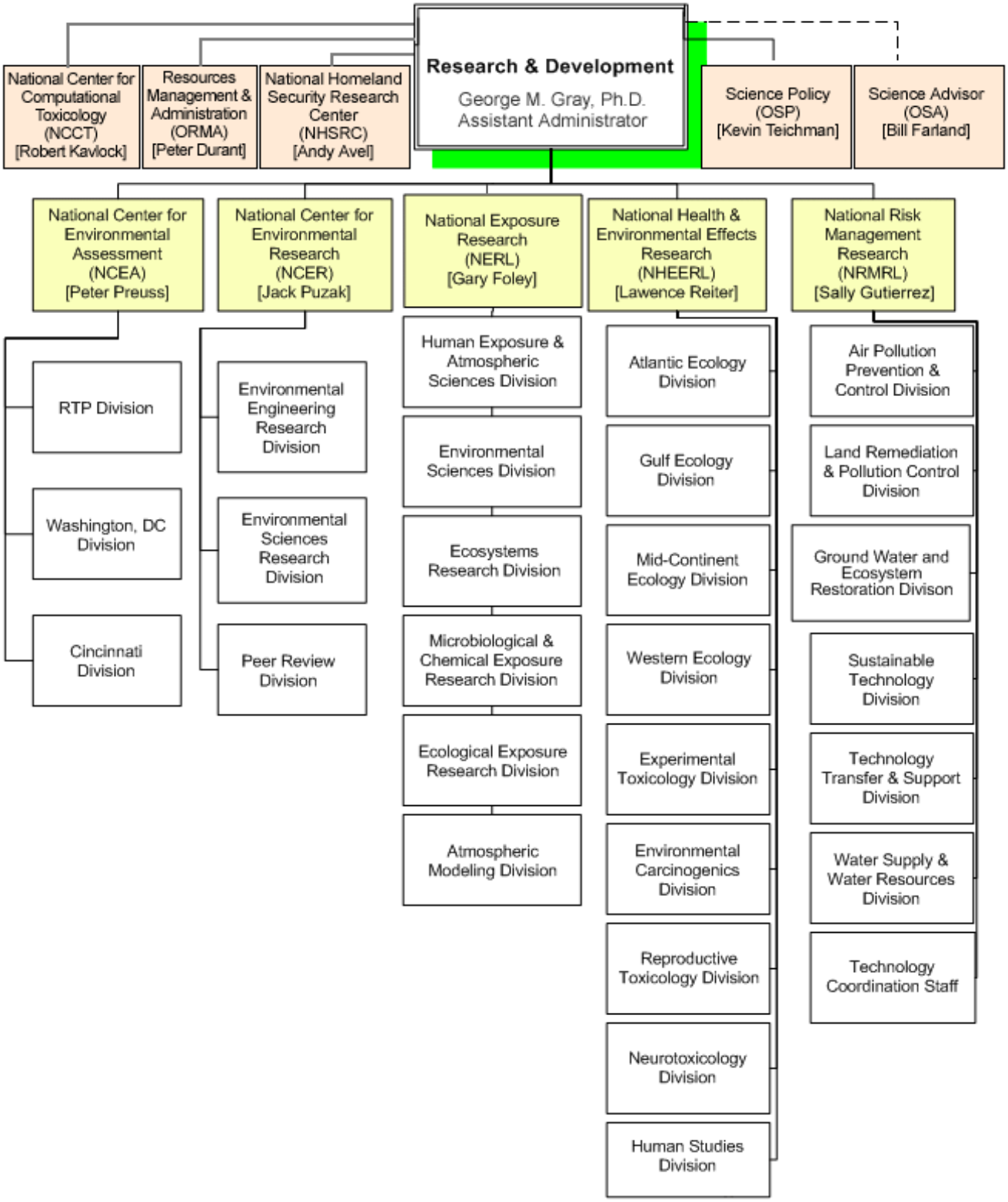
2. Assess and diagnose causes and sources of water body impairment; and
3. Demonstrate tools to restore, protect and forecast benefits of attaining uses for high priority subjects that present high risk and/or high uncertainty.

To do this we work with our customers to identify and produce timely research products for use in achieving safe and clean water. Specific areas of focus are: the increased use of biological indices; improving our understanding of landscape and watershed scale processes; conducting watershed scale hypothesis-driven research; using uncertainty analysis in modeling and decision-making; and providing approaches to reduce exposures and decrease human health risks from water and biosolids contaminants.

Organizational Structure

The human resources needed to perform water quality research and to achieve our goals are dispersed among laboratories and centers located across the U.S. The locations are illustrated in the following graphic. The ORD organization chart (last updated 11/1/05) is also shown.





ORD Organization Chart (11/1/05)

ORD's Mission is to:

- Perform research and development to identify, understand, and solve current and future environmental problems.
- Provide responsive technical support to EPA's mission.
- Integrate the work of ORD's scientific partners (other agencies, nations, private sector organizations, and academia).
- Provide leadership in addressing emerging environmental issues and in advancing the science and technology of risk assessment and risk management.

Our research program is organized around the "risk paradigm," an important Agency organizing principle. The risk paradigm consists of two interrelated phases, risk assessment and risk management. Risk Assessment is the process used to evaluate the degree and probability of harm to human health and the environment from such stressors as pollution or habitat loss. The risk assessment process, as proposed by the National Academy of Sciences (NAS) in 1983, consists of:

- Exposure Assessment - describing the populations or ecosystems exposed to stressors and the magnitude, duration, and spatial extent exposure,
- Hazard Identification - identifying adverse effects (e.g., short-term illness, cancer) that may occur from exposure to environmental stressors,
- Dose-Response Assessment - determining the toxicity or potency of stressors, and
- Risk Characterization - using the data collected in the first three steps to estimate and describe the effects of human or ecological exposure to stressors.

Risk Management entails determining whether and how risks should be managed or reduced. It is based on the results of the risk assessment as well as other factors (e.g., public health, social, and economic factors). Risk management options include pollution prevention or control technologies to reduce or eliminate the pollutant or other stressor on the environment. The environmental or public health impacts resulting from risk management decisions must then be monitored so that any necessary adjustments can be made.

In order to provide better integration of research across this risk paradigm, ORD has established National Program Directors (NPDs) in a number of subject areas. The NPD for Water Quality has the responsibility for planning water quality research across the EPA laboratories and centers, working with our clients to determine research needs and priorities.

The Water Quality Research Program Goals

The primary client for the Water Quality MYP is the U.S. EPA's Office of Water. The research described in the Water Quality MYP is intended to support OW in meeting their goals and the objectives of the Clean Water Act and other legislation.

EPA's multi-year plan for water quality research establishes four long-term goals (LTGs), three of which represent research to be conducted in support of clean and safe water. The fourth LTG goal, which focuses on exposures to and health risks presented by biosolids, is reflected under

the Agency's Goal 3; Preserve and Restore the Land. Within the scope of the water quality MYP, EPA's LTGs are to:

1. Provide the approaches and methods to develop and apply criteria for habitat alteration, nutrients, suspended and bedded sediments, pathogens and toxic chemicals that will support designated uses for aquatic systems.
2. Provide the tools to assess and diagnose the causes and pollutant sources of impairment in aquatic systems.
3. Provide the tools to restore and protect impaired aquatic systems and to forecast the ecological, economic, and human health benefits of alternative approaches to attain water quality standards.
4. Provide the approaches, methods and tools to assess the exposures and reduce the human health risks from biosolids contaminants for use by the Office of Water, States and others in updating biosolids guidance and regulations.

LTG 4 goal deals with biosolids issues. Because these materials are often transported significant distances they are not really bound to their watershed of origin, but the concerns for human health and environmental effects can be.

By design, the LTGs and the research planned are intended to enhance the science and engineering content of EPA, Regions, State and local water quality program actions. The MYP achieves this by relating back to the Strategic plan objectives of improving water on a watershed basis, protecting coastal and ocean waters, and enhancing science and research. In this manner, the Water Quality MYP is the vehicle for identifying and conducting the fundamental and applied water quality science needs of the Agency.

The Watershed approach was adopted as a major focus for the MYP structure because of the many influences watersheds have on water quality. Watersheds are often the focus of efforts to manage water use and for pollutant reduction programs. Traditionally, watershed managers deal with pollutant discharges or sources in order to protect water resources such as river segments or wetlands. However, the reduction of contaminants from single sources is often not sufficient to adequately protect the aquatic environment from the impacts of multiple stressors that contribute to overall decline within a watershed. Therefore, the tie-in of LTG 2 (involving the tools to assess and diagnose the causes of impairment) and LTG3 (tools to restore and protect impaired systems) to the watershed approach is evident. LTG 1 (approaches and methods to develop and apply criteria) is necessary to support designated uses. As EPA continues to move toward the use of biocriteria and bioassessment data, this research also fits within the watershed paradigm, but pays particular attention to stressors that the Agency has cited as causing water body impairment: embedded and suspended sediment, nutrients, and pathogens.

Key Science Questions

Key science questions have been developed for each LTG to guide the development of research plans. The key science questions identified under each LTG are addressed in separate presentations.

Assessing Progress

In a comprehensive evaluation of science and research at EPA, the National Research Council recommended that the agency substantially increase its efforts to explain the significance of its research products and to assist clients inside and outside the agency in applying them. For EPA's environmental research programs, periodic retrospective analysis at intervals of four or five years is needed to characterize research progress, identify when clients are applying research to strengthen environmental decisions, and evaluate client feedback about the research. Conducting program evaluation at this interval enables the assessment of research progress, the scientific quality and decision-making value of the research, and whether research progress has resulted in short-term outcomes for specific clients. Two key review processes for the Water Quality Research Program and the Board of Scientific Counselors (BOSC) and the Office of Management and Budget's Program Assessment Rating Tool (PART).

<u>BOSC</u>

ORD is absolutely committed to independent expert evaluation. The review provided by the Board of Scientific Councilors serves to evaluate program progress; a necessary and vital step essential to the success of the program. Panel recommendations and observations will provide valuable information that will help ORD to:

- plan, implement, and strengthen its research programs,
- compare a program with programs designed to achieve similar outcomes in other parts of EPA and in other federal agencies,
- make research investment decisions over the next five years,
- prepare EPA's performance and accountability reports to Congress under the Government Performance and Results Act, and
- respond to evaluations of federal research such as OMB's PART.

<u>PART</u>

Federal agencies must demonstrate how their programs achieve outcomes relevant to national priorities, mission, and strategic goals. This objective is emphasized in the Government Performance and Results Act (enacted by the U.S. Congress in 1993) and the Office of the President. The Government Performance and Results Act (GPRA) requires federal research managers to extend their focus to the outcomes that result from investments in research programs. Building on this focus, the Office of Management and Budget (OMB) and the White House Office of Science and Technology Policy (OSTP) collaborated to develop a Program Assessment Rating Tool (PART) that links program performance, progress to achieve outcomes, and budget decision-making.

In PART guidance for federal research, OMB requires that long-term goals for research programs be expressed as outcomes that can be accomplished in a 5-10 year time-frame and that contribute to the federal agency's mission and GPRA strategic goals. Further, the research program's intended results, or outcomes, are defined as external to the program and of direct importance to agency mission and strategic goals. At EPA, research programs contribute to outcomes when specific clients use an improved scientific foundation and apply key research

contributions to strengthen environmental decisions or regulations. These decisions and resulting actions (e.g., the reduction of contaminant emissions or the restoration of ecosystems) ultimately contribute to improved environmental quality and health. EPA's Water Quality Research Program is expected to be scheduled for a PART review in 2006.

Future directions
Following the BOSC review, but concurrently with the PART review, the process for updating the WQ MYP will begin. As part of this update our intent is to receive broad input, involve customers in the priority setting process, and keep the research prioritization process transparent. Stakeholder input will be crucial. Participation from EPA Program and Regional Offices and Federal agencies will be sought. The goal is to obtain technical and science inputs from a wide selection of stakeholders so that ORD can work with its major clients to develop prioritization and ranking criteria for the purpose of setting priorities and timelines, and for the planning of collaborative efforts. During this process, we expect to focus our discussions in order to define relevant and useful research products and measures of appropriate outcomes.

Water Quality and other Research Program Priorities
Although the research described in the Water Quality MYP is intended to support OW in meeting their goals and the objectives of the Clean Water Act and other legislation, ORD also envisions the Water Quality research program as the application and demonstration vehicle for the relevant science programs described under its goal to provide Healthy Communities and Ecosystems. Accordingly, research conducted to meet the strategic plan goal of providing Clean and Safe Water must be highly coordinated with the core ecosystems research.

How the Water Quality MYP relates to Core research conducted under the Healthy Communities and Ecosystems strategic goal
To understand the relationship between the Water Quality research program and the Ecosystems program, it is first necessary to describe the Ecosystems research goals. The objective of EPA's ecological research program is to strengthen the scientific foundation that is essential to protect, sustain, and restore the health of our nation's ecosystems by developing, demonstrating, and transferring scientifically valid frameworks, tools, indicators, and guidelines for decision-makers and scientists in specific federal, state, and local organizations. To accomplish this objective, EPA's ecological research program includes a mixture of basic and applied research that is organized around four research topics:

1. *Ecosystems Conditions Research.* Research on this topic is designed to improve water quality monitoring and water monitoring networks to keep water clean, safe and secure by developing statistical monitoring frameworks and designs and appropriate ecological indicators to determine the status and trends of ecological resources by States and Tribes. Priorities for Conditions Research include the following:
   - Develop ecological indicators to monitor status and trends of ecological resources;
   - Develop statistical monitoring frameworks for high priority aquatic resources;
   - Develop integrated monitoring and listing approaches;

- Identify major stressors associated with impairment in high priority aquatic resources; and
- Develop probabilistic models to determine threshold of biological impairment in targeted impairment.

2. *Ecosystems Diagnosis Research*. Research is designed to develop methods and models to understand links between human activities, natural dynamics, ecological stressors and ecosystem condition. Priorities for Diagnosis Research include developing methods and models to:
   - Identify causes of degraded and impaired conditions identified with monitoring and assessment approaches;
   - Link the presence of environmental stressors and ecological impairment; and
   - Assist managers with diagnosing and managing environmental stressors.

3. *Ecosystems Forecasting Research.* Research is designed to apply methods and models to predict multi-stressor effects on ecological resources to assess vulnerability and manage sustainability. Priorities for Forecasting Research include developing methods and models to:
   - Characterize ecosystems processes and properties;
   - Forecast human activities and natural processes associated with change;
   - Extrapolate across spatial and temporal scales
   - Characterize uncertainties and variability in sources of environmental stressors;
   - Develop strategic approaches to predict ecological benefits of management alternatives at different ecological scales; and
   - Develop protocols for conducting predictive community-level risk assessments.

4. *Ecosystems Restoration and Management Research.* Research is designed to provide scientifically defensible methods to protect and restore ecosystem conditions. Priorities for Restoration and Management Research include the following:
   - Improved understanding of the physical, biological and chemical processes critical to achieving ecosystem restoration and management goals,
   - Applied field research to evaluate the effectiveness of restoration and management activities or interventions implemented to improve the environment,
   - Assessment and evaluation of the benefits and value of restoration and management activities, and
   - Development of tools for the application of findings by watershed managers and restoration practitioners.

The EPA has the critical and complex mission of protecting human health and safeguarding the environment. Today, decision-makers recognize that changes in ecosystem structure and function result from multi-media contaminants and stressors that originate from both local and geographically distant sources. Many mechanisms by which contaminants and stressors alter ecosystems are poorly understood, as are the immediate and long-term consequences of these alterations. For example, significant uncertainties exist about the quality and condition of our

nation's waters and aquatic ecosystems. Currently, the States and EPA lack water quality data for more than half of our nation's estuaries, lakes, rivers, and streams. Data to assess the most significant source of impairment to water quality–non-point source pollution–exists for less than ten percent of the States.

Without improved scientific guidelines and tools, decision-makers can not assess or predict the impact of degraded water quality and air quality on the health of our nation's rivers, wetlands, forests, estuaries, or aquatic ecosystems. These uncertainties limit EPA's ability to implement Clean Water Act requirements to evaluate ecological risks in establishing Total Maximum Daily Loads (TMDLs) and in issuing National Pollutant Discharge and Elimination System (NPDES) permits.

Similarly, significant gaps exist in our understanding about the adverse impacts of atmospheric pollution and deposition on ecosystems. These gaps persist despite statutory mandates in the Clean Air Act to reduce deposition of nitrates, total nitrogen, sulfates, and total sulfur from the atmosphere; prevent significant deterioration to ecosystems; and assess the effects of deposition on the condition of our nation's most sensitive ecosystems. Since deposition is the major pathway for pollutants from the atmosphere to the biosphere, these knowledge gaps also increase the uncertainty about impacts to aquatic resources and ecosystems, especially for contaminants such as mercury.

How other MYPs relate to the Water Quality MYP

The ***Drinking Water*** MYP shares common research interests with the Water Quality program, specifically relative to source water protection. The Safe Drinking Water Act Amendments of 1996 direct EPA to conduct research to strengthen the scientific foundation for standards that limit public exposure to drinking water contaminants. The Amendments contain specific requirements for research on waterborne pathogens, such as Cryptosporidium and Norwalk virus; and other harmful substances in drinking water. Many of the protozoan parasites and viruses have been shown to survive wastewater treatment processes, and therefore effluent discharges could affect downstream source water quality. However, interests are not limited to microbes and toxic compounds, but also include the discharge of nutrients that may lead to algal blooms. Thus areas of overlapping interest include understanding causes and controlling hazardous algal blooms; developing improved pathogen enumeration methods, infectivity and viability assays; and developing source tracking tools.

Endocrine Disrupting Compounds may have a variety of sources, one of which includes humans and wastewater effluents. To support its regulatory mandates, EPA's research seeks to improve our scientific understanding of the exposures, effects, and management of endocrine disruptor chemicals and to determine the extent of the impact they may have on humans, wildlife, and the environment. The Agency has established three long-term goals for its research on endocrine disruptors. Within the scope of this MYP, EPA will:

- Provide a better understanding of the science underlying the effects, exposure, assessment, and management of endocrine disruptors.
- Determine the extent of the impact of endocrine disruptors on humans, wildlife, and the environment.
- Support EPA's screening and testing program.

Since wastewater effluents are a conveying medium to receiving waters, the occurrence, treatment, and environmental impacts of these compounds are of great interest to the water quality program. Whereas the responsibility for developing assays lies elsewhere, the methods and procedures developed need to be applied to demonstrate impacts and/or ways to improve water quality.

Mercury in fish tissues is a major public environmental issue. A 1997 EPA Mercury Study Report to Congress discussed the magnitude of mercury emissions in the United States, and concluded that a plausible link exists between human activities that release mercury from industrial and combustion sources in the United States and methyl mercury concentrations in humans and wildlife. Regulatory mandates require EPA to address these risks. The Agency is developing risk management research for managing emissions from coal-fired utilities (critical information for rule-making) and non-combustion sources of mercury; risk management research for fate and transport of mercury to fish; regionally-based ecological assessments of the effects of methyl mercury on birds; assessment of methyl mercury in human populations; and risk communication methods and tools. EPA has established two long-term goals for mercury research.

- To reduce and prevent release of mercury into the environment.
- To understand the transport and fate of mercury from release to the receptor and its effects on the receptor.

This work on fate and transport is key to protecting water quality as it must first be determined how mercury is transported and transformed in water bodies and wetlands.

The Global Change Research Act of 1990 established the U.S. ***Global Change Research Program*** to coordinate a comprehensive research program on global change. This is an inter-Agency effort, with EPA bearing responsibility to assess the consequences of global change on human health, ecosystems, and social well-being. Research examines future global change scenarios and the influence of climate, land use, and will include assessments of air quality, water quality, ecosystem health, and human health. EPA's research plan for global climate change lays out five long-term goals; two of which relate to water quality.

- Build the capacity to assess and respond to global change impacts on fresh water and coastal ecosystems.
- Determine the possible impacts of global change on water quantity and quality and the consequences for aquatic ecosystems and drinking water and wastewater systems. Develop adaptation strategies to increase the resilience of those systems.

Environmental policy is designed to change behaviors that cause environmental problems. ***Economics and Decision Sciences*** research is being undertaken to increase our understanding of these behaviors. In addition, this research will inform state and federal environmental agencies on how best and most cost-effectively to accomplish three overarching responsibilities:

1. Anticipating, identifying, and setting priorities for managing environmental problems to protect ecological and human health;

2. Developing policies to address the selected environmental priorities; and
3. Implementing the policies to achieve better environmental outcomes.

Under its multi-year plan for economics and decision sciences, EPA has established long-term goals for economics and decision sciences research that focus on changing behaviors that cause environmental problems; developing tools to assess the highest priority issues based on public preferences; and developing implementation strategies that accurately account for behavioral responses to government initiatives and interventions.

Over the last decade, the Agency has increasingly focused on pollution prevention when addressing high-risk human health and environmental problems using a preventive approach that requires: (1) innovative design and production techniques that minimize or eliminate adverse environmental impact; (2) holistic approaches that make the most of our air, water, and land resources; and (3) fundamental changes in the ways that goods and services are created and delivered to consumers. EPA has established five long-term goals for ***Pollution Prevention*** and new technologies research. These goals focus on the development of tools, technologies, and sustainable environmental systems approaches and on continuing to prevent and control pollution by targeting sources and sectors that pose the greatest risks to human health and the environment. Several of these goals are to:

1. Develop new and advanced theories and methods of environmental system analysis, along with decision support tools based on those methods that can be applied both within and beyond the industrial sector (e.g., municipal, agriculture, transportation, energy).
2. Provide appropriate and credible performance information about new, commercial-ready environmental technology that influences users to purchase effective environmental technology in the US and abroad.
3. Assemble and deliver to EPA Regions, the Office of Water, and state and local governments a watershed-scale strategy for sustainable environmental systems based on computer based tools and a written manual of suggested management practices to reduce risks to human health and the ecology using combined economics, hydrologic, physical and ecological, land use, legal, and technological methods.