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Environmental Protection
Agency

Washington, DC 20460

Science and Research at the
U.S. Environmental Protection Agency

EPA Progress Report 2011

Office of Research and Development






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Happy 2011 everyone! Anyone made any science-related new year's resolutions?

Follow our blog, "It All Starts with Science" at: blog.epa.gov/science/

EPA awards $7 Million to study effects of pollution exposures and social stressors on communities http://bit.ly/hB8IvT

EPA Research chief Anastas about to take the stage at ICOSSE in Tucson to talk sustainability

"Our current reality needs to change. The leadership of today needs to challenge the status quo if we are to [illegible]"

"I am done with the false choice between environmental protection and economic growth," We can and will have both - Anastas quotes EPA Admin

Attending Science Online 2011 **#scio11** in RTP this week? Sign up for our tour & meet EPA researchers http://bit.ly/epDAgf

EPA's Dr Jackson gives sneak peak into collaborative prjt on value that natures provides us- our life support system **#scio11**

EPA ecologist Betsy Smith sharing how scientists are helping provide tools /models for proactive **#green #eco** decision making **#scio11**

Popping in to see senior analytical chemist John Turlington's lab on EPA **#scio11** tour

Now learning abt homeland security research for decontamination on EPA **#scio11** tour http://bit.ly/hdsJsj

EPA's Lemieux shares structure of the decon testing chamber, we use a proxy for spores, that behave the same, but not dangerous **#scio11**

RT @imascientist Looking at how to decontaminate after biological attack. There's a cool test chamber w airlock and everything! **#scio11 #EPA**

EPA's Dr. Shah explains to **#scio11** tour that in virtual liver project they are looking at liver cancer as it changes proteins in cells

EPA's **#scio11** tour has ended, but have your own virtual tour of EPA's Research Triangle Park Campus http://bit.ly/eWNF4e

RT @lisapjackson Today I visited EPA labs in Cincinnati w/SBA Administrator Mills to announce a collaboration to clean up our water http://budurl.com/dsqa

Public utilities + researchers + innovative businesses, Cincinnati's Water Techn Innovation Cluster protects health http://bit.ly/gWm30t

Can Highways Contribute to Asthma? EPA scientists & partners team up to examine the link: http://bit.ly/fi5Z2A

Apply for Computational Toxicology EPA grant: Develop high-throughput assays to assess reproductive/developmental tox http://bit.[illegible]

Interested in biofuels impact on the environment? EPA's draft report & info on how to comment: http://bit.ly/ijnukq

"EPA Science: How's Attitude?" in today's **#sciwed** blog. The attitude? Determinedly optimistic! http://bit.ly/dGwzJl

[illegible] an exposure-response analysis tool for scientists http://bit.ly/fbk5iB

EPA Submits Draft Hydraulic Fracturing Study Plan to Independent Scientists for Review http://bit.ly/dKjBBL

EPA's NexGen program holding public meeting in DC nxt week to discuss latest advances in risk assessment http://bit.ly/dMO10c

Valentine's Day & air pollution (both can take ur breath away - the 2nd not in a good way) EPA's air research: http://bit.ly/94f2Ct

Shout out to everyone attending 2011 International Public Science Events Conference & **#AAASmtg** in DC. We'll be there! http://bit.ly/fQO0TR

Protecting Genetically-Modified Corn Crops w/ Proactive, High-Tech Monitoring in EPA's Science Matters http://bit.ly/gT2gur

Measuring **#climate** change & land use impacts on water quality/ecosystems. Read/give input on EPA's draft report http://bit.ly/icwMxw

Bolster the science of oil spills, apply for EPA research grant environmental impact & mitigation of oil spills http://bit.ly/gqsc9P

A Family's Support Goes Far for a Passionate Woman Scientist today's **#sciwed** blog celebrating women's history month http://bit.ly/elUPoG

In DC? Check out the Science Advisory Board meeting tomorrow & Friday - topics include EPA's 2012 research budget http://bit.ly/hGZKu2

At **#SOT2011**? Join EPA's Dr Hal Zenick 10-11am at EPA's booth 1341 talking about effects of contaminants & environmental stressors.

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EPA United States Environmental Protection Agency

Research and Development at the U.S. EPA

About this Report

No other research organization in the world has the depth and breadth of science and engineering expertise represented by EPA's workforce.

Agency research is conducted by hundreds of staff scientists and engineers in laboratories and research facilities at 13 locations around the country. They are joined by a network of collaborators and partners from across the scientific community, including grantees and fellows supported by EPA's Science to Achieve Results (STAR) extramural research program. In addition, EPA is one of 11 federal agencies that participate in the Small Business Innovative Research (SBIR) program, enacted in 1982 to strengthen the role of small businesses in federal research and development, create jobs, and promote technological innovation.

This report is designed to provide highlights of the results and impacts of that collective effort that were accomplished in 2011. Highlights were contributed from each of the Agency's 13 labs, research centers and offices to provide an overview of research results and to illustrate some of the specific impacts that are important to partners of the Agency's Office of Research and Development. It is these partners who rely on EPA science to make decisions and take action to protect human health and the environment.

While this report is organized by research programs and partnerships, it is important to note that Agency scientists and engineers work collaboratively to produce an overall research program that is highly integrated and transdisciplinary.

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"Science must be the backbone for EPA programs. The public health and environmental laws that Congress has enacted depend on rigorous adherence to the best available science."

--Lisa P. Jackson
Administrator, U.S. Environmental Protection Agency

A message from Lek Kadeli
Acting Assistant Administrator
EPA Office of Research and Development

Science to Support Our Mission

EPA's Office of Research and Development (ORD) plays a central role in the research and engineering efforts that are central to the Agency. Our integrated scientific investigations, conducted across a broad spectrum of disciplines, provide the firm, scientific foundation that supports the Agency's mission to safeguard human health and protect the environment. ORD also plays a critical role in catalyzing innovation to provide enhanced solutions to these same problems.

For more than 40 years, the results of that work have provided timely, accessible, and usable tools and information to our partners across the Agency and throughout the nation. Our research results and technological solutions have led to longer life spans, safer communities, and cleaner air and water for all Americans.

That critically important work continues today, but in an era of increasingly complex environmental challenges, and at a time when every federal agency must demand itself to work as efficiently as possible on behalf of the American people.

As exemplified by this 2011 Annual Report from EPA's Office of Research and Development, EPA's community of scientists and engineers have embraced those challenges.

In 2011, to improve effectiveness and efficiency, the Office embarked on a major effort to strategically align its diverse research portfolio around the central and unifying concept of sustainability. Through six highly integrated Research Programs—**Air, Climate, and Energy; Sustainable and Healthy Communities; Safe and Sustainable Water Resources; Chemical Safety for Sustainability; Human Health Risk Assessment;** and **Homeland Security Research**—science and engineering solutions were delivered to protect human health and the environment.

While laying the groundwork to strategically align EPA's research programs in ways that simultaneously advance sustainability and realize efficiencies acros our organization, Agency scientists, engineers, and their partners continued to deliver sound, impactful research results throughout 2011.

Just a few highlight from the many the science achievements that are presenting in this report are:

- A final study plan to help the nation better understand the potential impacts of the stimulation technique known as hydraulic fracturing on drinking water resources.
- Advancing the Community Mulitscale Air

Quality (CMAQ) model used across the world to better understand the complex dynamics of air pollution in order to protect local communities.

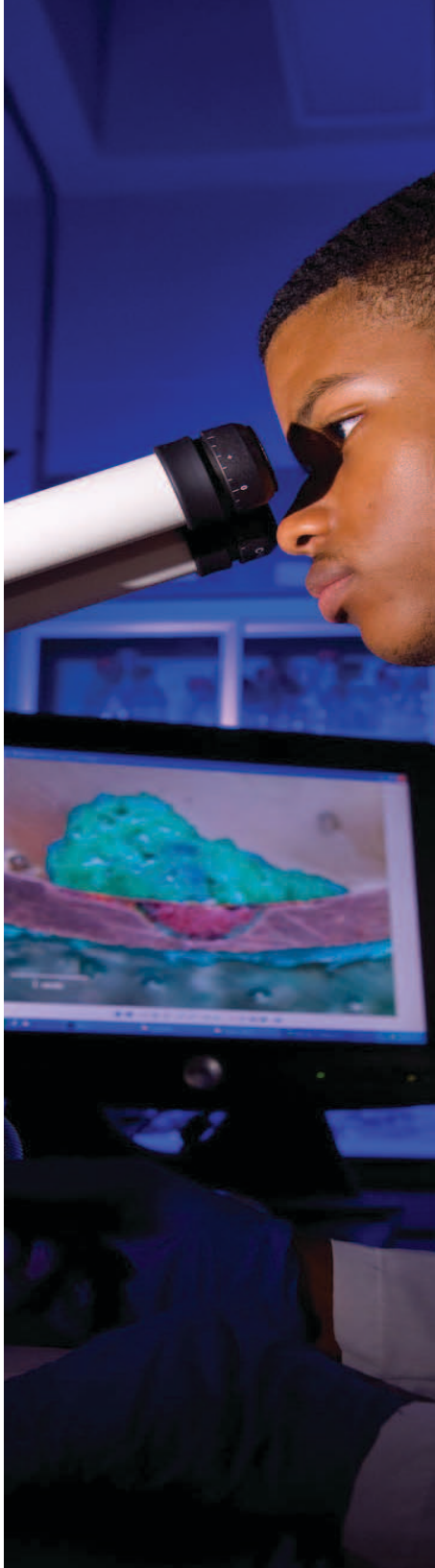
- Leading the way to revolutionize toxicity testing through the use of innovative technologies such as computational toxicology, automated, high-throughput assays—and robots.
- Supporting EPA's critically important work to protect human health through the completion and advancement of Integrated Science Assessments and the Agency's widely-used Integrated Risk Information System.
- The launch of the Water Innovation Technology Cluster, an EPA-supported public-private partnership designed to bring innovative water quality technologies to market, leading to clean water and green jobs.
- Cultivating relationships with EPA regional and program offices to better understand needs at the community level, and deliver products that help them move toward a more sustainable future. Such efforts include a National Atlas for Sustainability, efforts to quantify sustainability, and a research program measuring the "ecosystem services" of the nation's coral reefs.
- Funding the nation's top scientists, engineers and other innovators through EPA grant and award programs, such as the Science to Achieve Results Program. In 2011, EPA funded 137 graduate fellowships, 80 research grants, and 37 Small Business Innovation Research awards.
- Leading the Bio-Response Operational Testing and Evaluation Project, a research partnership uniting federal agencies in the Homeland Security arena to better prepare the nation to respond to and recover from the release of biological agents such as anthrax.

Each and every achievement outlined in this report carries with it a story of success and commitment made by a team of researchers. Each team, in turn, is made up of individual scientists and engineers—dedicated researchers who have devoted their careers to advancing EPA's mission to protect human health and the environment. Whether an Agency scientist or engineer, or one of the nation's top innovators supported through an EPA grants or award, they are all part of a continuum of science achievement that now stretches over four decades, and has led to a cleaner, healthier, and more prosperous nation. It is only through their continued commitment that we will be able to achieve a sustainable future.

Thank you,

Lek Kadeli
Acting Assistant Administrator
EPA Office of Research and Development

This report is dedicated to Paul T. Anastas for his visionary leadership serving as the Assistant Administrator for EPA's Office of Research and Development (ORD) from 2009 to 2011, and to the ORD scientists and engineers, and their partners, for turning that vision into reality.



Air, Climate, and Energy

American communities face serious health and environmental challenges from air pollution and the growing effects of climate change, both of which are linked intricately with current and future energy options. Improving air quality, reducing greenhouse gas (GHG) emissions and developing adaptation strategies to address climate change are central to the EPA's mission to protect public health and the environment.

The Agency's Air, Climate, and Energy research examines the interplay between air pollution, climate change and the dynamic energy landscape to develop innovative and sustainable solutions for improving air quality and addressing climate change. These air pollution research efforts support policies with far-reaching health benefits across the nation.

This section highlights some of the top research results EPA researchers and their partners have achieved in 2011 in the areas of Air, Climate, and Energy. It illustrates specific impacts that are important to partners of the Agency's Office of Research and Development. The highlights presented were contributed by EPA's research labs, centers, and offices located around the country, and were performed by Agency scientists and engineers, as well as their partners, grantees, fellows, and collaborators from across the scientific community.

NASA's 117-foot, four-engine turboprop P-3B research aircraft takes flight to collect air. *Image courtesy of NASA.*

Ready for Takeoff: Monitoring Air Pollution from the Sky

EPA scientists and partners from the National Air and Space Administration (NASA) took to the skies in July 2011 to advance air pollution monitoring and help protect public health in urban areas.

The flights were part of a five-year collaborative project known as "DISCOVER-AQ"—for **D**eriving **I**nformation on **S**urface Conditions from **CO**lumn and **VER**tically Resolved Observations Relevant to **A**ir **Q**uality.

During the study, researchers made a series of flights aboard NASA aircraft equipped with scientific instruments to measure gaseous and particulate pollution. While in flight, they took a series of measurements that were carefully choreographed with simultaneous efforts from both satellites above, and ground-based monitoring stations below the planes.

Together, the measurements were designed to shed light on how satellites can be used to monitor and understand pollutant concentrations and distributions near the earth's surface, where the information can inform local communities and be used to protect public health.

During the July, 2011 DISCOVER-AQ data collection segment, two NASA airplanes flew in unison over urban areas and major interstate highways between Washington, DC and Baltimore, MD, with additional flight time over small towns and Chesapeake Bay. One plane, flying at 26,000 feet, employed laser technology to detect patterns of particulate pollution, and remote-sensing technology to sample a column of air for key gases. The other plane took samples at two different altitudes, sampling air at 1,000 feet, and then above ground-based air quality monitors in spirals from 1,000 to 5,000 feet.

The overall purpose of the missions was to sample pollutants in columns of air in a "vertical profile." Later, researchers examined the profile to determine how the pollution measurements collected from the ground stations compared to the air column measurements collected in flight.

Research results are expected to provide a greater understanding of how the existing air monitoring network, funded by EPA and run by states and local agencies, could be improved through the use of satellite observations. With improved ability to monitor pollution from satellites, scientists could make better air quality forecasts, more accurately determine sources of pollutants in the air, and more closely determine fluctuations in emissions levels.

EPA and NASA researchers expect to release initial study results in early 2012.

For more information on DISCOVER-AQ, visit http://discover-aq.larc.nasa.gov

Research aircraft flow over this ground-based air monitoring station in Beltsville, Maryland.

Breathing Easier with Newest CMAQ Model

In 2011, EPA released a new version of the groundbreaking and widely-used Community Multiscale Air Quality modeling system.

Versions of the state-of-the-science modeling system, known as "CMAQ," have been used by the Agency and states for more than a decade to design emission control strategies to protect public health from the harmful effects of air pollution. At the state level, the CMAQ system shapes how regulators implement solutions to meet National Ambient Air Quality Standards (NAAQS), which have far-reaching human health benefits across the nation. In addition, the National Weather Service has been using the model for years to produce daily U.S. forecasts for ozone and air quality.

The release of CMAQ version 5.0 introduced additional tools for studying air quality and its impacts on climate change. Taking advantage of improved computing power and recent developments in air chemistry and atmospheric science, CMAQ 5.0 combines three individual modules—meteorology, emissions, and chemical transport. Instead of running the models in sequence, as in previous versions, the meteorology and air chemistry-transport models in CMAQ 5.0 now operate together and interact in feedback loops on the fly, providing more accurate forecasts that reflect interactions between pollution and weather.

With CMAQ 5.0, scientists can model air quality at the level of individual towns and cities throughout the entire Northern hemisphere. The framework combines advances in physical, chemical, mathematical, and computational sciences. These new capabilities enable scientists to study the global movement of air pollution and how it affects air quality and climate change.

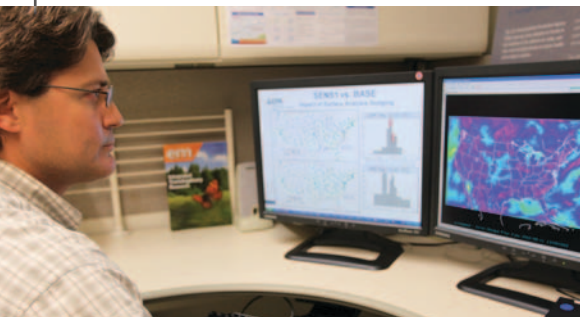
On a hemispheric scale, scientists apply CMAQ 5.0 to account more accurately for "background pollution" originating from distant locations. This upgrade allows policymakers to understand and use the data to balance local and national air policy standards, and integrate them with international solutions.

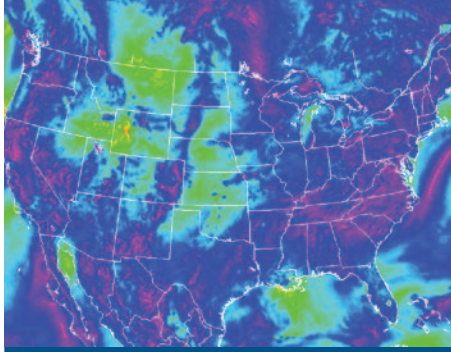
To help spread the word about CMAQ's capabilities, EPA worked with the University of North Carolina at Chapel Hill to create the Community Modeling and Analysis System (CMAS), a model development center for air-quality modelers and researchers around the world. EPA uses CMAS to distribute new versions of CMAQ, to facilitate CMAQ training, and to cultivate collaboration.

CMAQ's impacts reach far beyond just the United States, as it is used in more than 50 countries and by thousands of individuals. For example, officials in the United Kingdom use the model to produce daily air quality forecasts and to develop national air quality policies. To expand such international efforts, in 2011 EPA experts helped train Indian researchers about CMAQ, part of a National Science Foundation-funded project to exchange information and enhance the capability of partner researchers.

Air-quality scientists and policy makers can use CMAQ 5.0 as a modeling tool for a wide variety of innovative and collaborative applications. EPA air and climate scientists now can apply CMAQ technology to cutting-edge research questions, to support health studies advancing the link between air pollution and adverse health effects, and to increase the abilities of domestic and international regulators to create better and more informed policies for the protection of human health and the environment.

EPA scientist examens data generated by the Community Multiscale Air Quality model.





EPA's Community Multiscale Air Quality modeling system uses real or potential weather conditions and atmospheric chemistry to make air quality projections.

Emissions Testing for Clean Cookstoves

Emissions from the average "indoor" fire widely used throughout the developing world—the heating source and stove for about half the world's population—leads directly or indirectly to millions of cases of respiratory illness and nearly two million premature deaths each year, primarily in women and young children. In a 2002 report, the World Health Organization listed indoor smoke from solid fuels used in such stoves, typically wood, dung, and coal, as among the top 10 risks to human health.

Together with the U.S. Department of State and several other federal government and private sector partners, the Agency supports the U.N. Foundation's Global Alliance for Clean Cookstoves (GACC), a public-private alliance that addresses the high prevalence of toxic smoke exposures worldwide from indoor fires and inefficient cookstoves. In addition, EPA researchers have been working with the Partnership for Clean Indoor Air (PCIA) to reduce smoke exposure resulting from household cooking and heating practices across the world.

In 2011, EPA researchers conducted the most extensive round of cookstove testing to date. Expanding on earlier work, they tested 44 combinations of stoves, fuels, and operating conditions for fuel efficiency and for pollutant emissions, which negatively affect human health and the global climate.

EPA's objectives in conducting the cookstove studies include:

- Determining if certain cookstoves are more fuel efficient and emit fewer pollutants compared to traditional "three-stone fire" systems (three stones placed around a fire to hold up a pot); and
- Providing useful information on cookstove performance and emissions to PCIA partners and others who supply stove technology to developing countries.

Research results indicate that some stoves currently in use (e.g., natural-draft stoves using high-moisture fuel) offer increased fuel efficiency and lower pollutant emissions, as compared to traditional cooking methods. In addition, stoves made from lighter and less dense materials tended to reduce cooking times, thereby increasing fuel efficiency and lowering emissions.

EPA and GACC partners are now evaluating the results of the tests to identify the most promising stoves for field trials, and to improve testing methods.

With increasing greenhouse gas emissions, smoke from stoves in the developing world has escalated from a local issue to a worldwide one. Reduction of carbon dioxide and black carbon emissions from cooking fires represents a fast and inexpensive approach to mitigating global climate change and improving health.

EPA engineer inspects a cookstove design.

Emissions Testing for Clean Cookstoves *Cont'd.*

In 2012, EPA plans to conduct a more comprehensive, solid-fuel cookstove study; researchers will test newer stove designs and measure a higher number of air pollutants.

Where there's Smoke: Peat Fires and Emergency Room Visits

A June, 2008 lightning strike in rural coastal North Carolina ignited a wildfire that scorched over 40,000 acres of land and a smoldering peat fire that was not declared out until some seven months later, in January of 2009.

The conflagration also sparked the opportunity for EPA clean air scientists to examine the respiratory and cardiovascular health effects of the population living in the rural NC counties exposed to plumes of often low-hanging smoke typical of peat fires.

Using satellite imagery, the investigators identified counties most severely affected by the smoke pollution. Researchers then collected Emergency Room (ER) records from the affected counties and those nearby for comparison.

Results of the EPA study revealed, for the first time, an association between smoke from peat fires and an increased number of ER visits for symptoms of heart failure. They also show a significant increase in respiratory effects (asthma, pneumonia and acute chronic bronchitis) in the high-smoke areas. In addition, the research team discovered that certain groups of people—older adults and those with pre-existing lung and heart problems, for example—were more susceptible to the adverse affects of wildfire smoke.

The study findings could lead to further research on weather modeling and wind patterns for the prediction of wildfire smoke plume locations in advance of extreme smoke exposure. This type of technology would allow community officials to warn susceptible populations of hazardous air conditions, thus limiting exposure and decreasing adverse health problems and ER visits. The research provides health officials and the local population with important information about the local air quality in the face of peat fires, and promises to have real impact in helping inform actions to protect public health.

Peat fire in rural North Carolina emits thick, low-lying smoke. *Images courtesy of U.S. Fish and Wildlife Service.*

Biodiesel fuel.

Turning Waste into Fuel

EPA scientists took on the challenge of identifying new uses for waste glycerol, an abundant byproduct of the biodiesel production industry, which is growing in many and varied applications. For example, more and more specially-adapted engines in cars, trucks and tractors are relying on biodiesel as the primary fuel source. In addition, some restaurants use biodiesel as a cooking resource. During the biodiesel production process, waste glycerol results from the transesterification of triglycerides and is thus increasing with biodiesel production. Glycerol is used frequently in commercial and industrial applications and is considered a relatively valuable product. However, the current glycerol surplus has caused the bottom to fall out of the market. Alternative glycerol markets are needed to improve both the economics of the biodiesel production process and the disposal and recycling processes for this new waste stream.

EPA is researching several new applications for waste glycerol in an effort to make the byproduct more useable and to reduce harmful effects associated with current disposal practices. The researchers evaluated glycerol using many chemical and operational tests. They determined that glycerol's low energy density, high viscosity or thickness, and high auto-ignition temperature properties make it an unsuitable alternative for a vehicle fuel. In addition, the composition of waste glycerol changes dramatically depending on the biodiesel feedstock (e.g., vegetable oils or rendered animal fats, which must be processed before burning in engines), the catalyst used, and the degree of post-reaction cleanup (i.e., the length of time required for the chemical reaction to occur).

To evaluate glycerol as a boiler fuel, EPA worked with North Carolina State University (NCSU) researchers to develop a commercial-scale boiler system that uses glycerol waste as fuel. To create realistic conditions under which to conduct the tests, the team scaled-up the system to commercial levels. The scientists and engineers tested environmental impacts by measuring performance, emissions and other process characteristics. The team monitored nitrogen oxides, total hydrocarbons and particulate matter (PM) for two grades of crude glycerol. Next, they compared their findings to data from other common fuels used in similar applications, such as No. 2 fuel oil and propane.

EPA and NCSU researchers determined that a specially designed burner known as a "refractory" burner combusts glycerol effectively, but results in high PM emissions due to the presence of residual catalytic material. Since EPA carefully regulates PM emissions, these high levels of PM emissions present an issue that will need to be addressed before crude glycerol can be burned routinely in boilers at power plants and other industrial facilities.

Although the EPA/NCSU team determined that glycerol is not an ideal fuel source for many boiler systems, they discovered that the waste glycerol resulting from burning biodiesel may be useful in certain boiler systems. For example, systems configured to produce steam and co-generate electricity may be able to use the glycerol byproduct efficiently. This solution reduces harmful, costly and process-intensive disposal impacts. In addition, reduces or eliminates transportation costs and displaces the need for some fossil fuels in certain boiler units.

These results represent important first steps to gaining an understanding of how glycerol could and could not be used as an alternative fuel. The findings illuminate practical and appropriate uses for waste glycerol as a boiler fuel in specific applications. In addition, this study examines key stages in the life cycle of biodiesel usage and the re-use

Turning Waste into Fuel *Cont'd.*

of waste and fuel sources. EPA places strong emphasis on life cycle assessments in its ongoing research endeavors. These assessments are instrumental to key sectors (e.g., energy) for identifying the opportunities and barriers inherent to various environmentally-sustainable actions.

Air, Climate, and Energy

2011 Accomplishments – In Brief

Specifying Emissions with New Database

EPA's unique database, SPECIATE, houses valuable data on the array of air pollutants emitted from manufacturing and other air pollution sources.

State and local agencies and the air quality modeling community use the SPECIATE database to prepare and enhance emission inventories and to understand the composition of chemicals known as total organic compounds (TOC) and PM emissions. This ensures that air pollution control programs target the appropriate sources.

In 2011, Agency clean air researchers released the enhanced SPECIATE Version 4.3, which includes an additional 405 specifically identified ("speciated") chemical profiles, bringing the total number to 5,592 chemicals.

Researchers designed SPECIATE 4.3 to:

(1) create speciated emission inventories for regional haze, particulate matter (PM), greenhouse gases and air quality modeling;
(2) estimate toxic air pollutant emissions from PM and organic gas primary emissions; and
(3) verify profiles derived from ambient measurements.

The updated version includes new profiles for road vehicles, marine vessels, ethanol fuel production, and several stationary sources, including the pulp and paper industry.

The SPECIATE Version 4.3 database provides additional support to multiple science centers and enables increased data accuracy for air pollution control efforts.

Supporting the National Climate Assessment

EPA is one of 13 federal partners in the U.S. Global Change Research Program (USGCRP), which coordinates and integrates federal research on global environmental changes. Every four years, the National Climate Assessment (NCA) is conducted under the auspices of the USGCRP, and a synthesis report is presented to the President and Congress as required by the Global Change Research Act of 1990. EPA is leading NCA workshops, serving on the Interagency NCA Working Group, and authoring scientific and technical inputs for the 2013 Report.

EPA researchers led two workshops in December 2010 and January 2011 on monitoring changes in the physical climate system and on evaluating the impacts of

Air, Climate, and Energy

2011 Accomplishments – In Brief, Cont'd.

climate change on ecosystems and socio-economic systems. The first workshop report, *Ecosystem Responses to Climate Change: Selecting Indicators and Integrating Observational Networks*, outlines a process for selecting indicators that represent the impacts of climate change on the nation's ecosystems. The report also identifies opportunities for collaboration and coordination among existing and potential future observational networks.

A second workshop report, *Valuation Techniques and Metrics for Climate Change Impacts, Adaptation, and Mitigation Options*, provides a snapshot of the capabilities, readiness, and applicability of methods for assigning monetary value to climate impacts and adaptation. EPA also collaborated on a third workshop and report titled, *Uses of Vulnerability Assessments in the National Climate Assessment*.

NEXUS: Along the Road

Can living near a highway make children more susceptible to asthma attacks? During 2011, EPA scientists, together with partners from the University of Michigan, began the second major data collection phase of a study designed to answer that question.

Study scientists are conducting the Near Roadways Exposure to Urban Air Pollutants Study ("**NEXUS**" for short), a comprehensive asthma trigger study. Using data from more than 60 children living in Detroit who suffer from asthma, they are looking at the mixture of pollutants that originate from Detroit-area highway traffic and how that pollution affects children with asthma. Data collected from air near major highways, as well as in homes and schools, will shed more light on the mixture of air pollutants that affect asthma and overall health.

Study results will provide community decision-makers with valuable information on how best to design school environments and residential areas to protect children from the effects of roadway-related pollution.

Air, Climate, and Energy

2011 Accomplishments – In Brief, Cont'd.

Supporting EPA Research Partners

EPA awards research grants and awards in a diversity of environmental science and engineering disciplines—including work in *Air, Climate, and Energy* research—through its Science to Achieve Results (STAR) program and the Small Business Innovation Research program (SBIR). The STAR program engages the nation's best scientists and engineers in targeted research that complements EPA's own outstanding intramural research program.

Grants are awarded through a competitive solicitation process and independent peer review.

The Agency also periodically establishes research centers to achieve long-term research goals. For example, in 2010 the Agency announced more than a $31 million, five-year grant to establish four Clean Air Research Centers (CLARC) to focus on the health effects of exposure to particulate matter (PM), ozone, and other air pollutants, both singly and in multipollutant atmospheres.

Accomplishments of EPA partners in the areas of Air, Climate, and Energy for 2011 include the following highlights.

EPA-supported Institute Advances Clean Air Science

With significant EPA support, the Health Effects Institute (HEI)—a nonprofit corporation chartered in 1980 as an independent research organization to provide high-quality, impartial, and relevant science on the health effects of air pollution—continued to tackle important and fundamental issues for air quality science.

Typically, HEI receives half of its core funds from the Environmental Protection Agency and half from the worldwide motor vehicle industry.

Research results included a review of ultrafine particle health and environmental effects, a new ozone program, international climate and air quality work, significant findings on the health effects of diesel particles and allergic inflammation and neurotoxicity effects, and a new solicitation on research assessing the health impacts of actions taken to control air pollution. In addition, HEI continued an

Air, Climate, and Energy

2011 Accomplishments – In Brief, Cont'd.

important collaboration on the National Particle Component Toxicity Initiative (NPACT), and made significant progress on the Advanced Collaborative Emissions Study (ACES).

HEI continued its distinguished record of delivering reports important to EPA efforts to protect human health from the adverse effects of air pollution. For example, in 2011, the Institute released studies on: air pollution "hot spots" (high concentration areas); concentrations of air toxics in motor-vehicle-dominated environments; the future of vehicle fuels and technologies and their related health benefits and challenges; and links between diesel exhaust and airway inflammation.

EPA-supported MESA Air Study Advances Health-air Pollution Link

The EPA-supported Multi-Ethnic Study of Atherosclerosis and Air Pollution (MESA) is designed to examine the relationship between air pollution exposures and the progression of cardiovascular disease over time. The unprecedented, ten-year study involves thousands of participants, representing diverse areas across the United States.

The central scientific hypothesis for the study is that long-term exposure to fine particles, or Particulate Matter (PM), in air pollution is associated with a more rapid progression of coronary atherosclerosis (hardening of the arteries) and an increased risk of coronary events, such as heart attacks.

To test this hypothesis, a host of air pollution and participant health measures are being collected and analyzed. Along with measuring particulate matter (PM) concentrations and variability at the neighborhood, home and individual levels, the MESA Air Pollution Study is using data from the national PM2.5 monitoring system.

Study researchers are integrating such environmental data into computer models to estimate long-term PM exposure for all study participants. The cardiovascular health of each participant is also being tracked, with a subgroup of 3600 participating in additional medical evaluations for subclinical, asymptomatic progression of atherosclerosis.

In 2011, MESA researchers continued this critically important work, advancing new methods for estimating air pollution exposure and providing innovative modeling techniques to fuse data obtained from air quality monitoring at the community level to health impacts at the personal level.

Air, Climate, and Energy

2011 Accomplishments – In Brief, Cont'd.

STAR Climate Change Research

The core purpose of the EPA's Global Change Research Program is to provide stakeholders and policymakers with the scientific information, analysis tools and techniques they need to effectively respond to risks posed by global change. One important area of study is exploring how aquatic resources, such as wetlands and coastal areas, will be impacted by climate change. (For more about that work, also see the stories below under the "Interdisciplinary Research" heading.)

To advance those efforts, the Agency supports top scientists through its Science to Achieve Results (STAR) grant program.

Significant 2011 findings by EPA STAR grantees included new understandings of the impact of storms and flooding, identifying likely causes of amphibian declines, how Chinook salmon runs in California are likely to decline, and new modeling tools for managing agricultural resources. Examples of those accomplishments include:

Climate Change, Land Use, and Declining Amphibian Populations

An EPA-supported study conducted by a researcher at the University of South Florida explored the link between climate change, land use, and the spread of pathogens in amphibians and other "ecothermic" (commonly known as "cold-blooded") hosts.

Findings from the research include: pathogen introductions, coupled with climate change, are the likely explanation driving worldwide extinctions of amphibians; changes in temperature variability associated with climate change might be just as significant to disease emergence as temperature changes; and, out of 240 predictors, the presence of the herbicide atrazine was the best predictor for the abundance of parasitic larval trematodes in the declining northern leopard frog (*Rana pipiens*).

California Salmon Runs and Climate Change

An EPA-funded researcher at the University of California-Davis found that more aggressive steps will be necessary to prevent population declines, and even extinctions, in spring-run Chinook salmon (*Oncorhynchus tshawytscha*) in California.

In the research, climate data coupled with watershed hydrology and salmon population dynamics models predict increased salmon mortality and population decline in the coming decades.

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Climate and Emissions Changes Impact Water Quality

EPA-funded researchers at the University of Maryland worked to understand the impacts of global climate and air pollution emission changes from today through 2050 on U.S. water quality, focusing on the nitrogen cycle.

The researchers applied state-of-the-art, integrating modeling systems that included a global climate-chemical transport component with a climate-hydrology-air quality-water quality component for North America. The grantees currently have a paper in press on the hydrological budget and crop yield predictions in the Upper Mississippi Basin.

Coastal Habitat in the Pacific Northwest

EPA-supported researchers at Western Washington University created a model and modeling technique with the potential to help coastal communities quantify the impacts of sea level rise on seagrass habitat and related ecosystem services.

The researchers created a spatially explicit, relative elevation model for Padila Bay, WA. A publication based on initial results indicated that the unique geomorphology of the Padila Bay region made it possible for sea level rise to create new habitat faster than it was destroyed, and suggests important clues for other coastal areas faced with planning adaptation strategies to mitigate the impacts of global change.

Interdisciplinary Research

Exploring the links between climate change and aquatic resources

As outlined above in STAR Climate Change Research, the core purpose of the EPA's Global Change Research Program is to provide stakeholders and policymakers with the scientific information, analysis tools and techniques they need to effectively respond to risks posed by global change. One important area of that study is exploring how aquatic resources,

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such as wetlands and coastal areas, will be impacted by climate change.

Highlights of EPA research advancing what is known about climate change and aquatic resources follow below.

Vulnerability Assessments Support Climate Ready Estuaries Program

Estuaries are places where freshwater from a river mixes with salt water from the ocean. Considered "nurseries of the sea," these unique environments support thousands of species of wildlife and perform valuable ecological services such as filtering sediments and pollution from water. Estuaries also contribute economically to the population by providing ideal sites for tourism, fisheries, and recreational activities.

Estuarine ecosystems are particularly vulnerable to climate-related changes in precipitation, water flow, and sea level rise. The National Estuary Program (NEP) is a network of voluntary community-based programs that safeguards the health of important coastal ecosystems across the country. As part of EPA's Climate Ready Estuaries Program, researchers conducted pilot assessments in collaboration with two NEP partners, the San Francisco Estuary Partnership (SFEP) and the Massachusetts Bays Program (MBP) to consider how salt marsh and mudflat ecosystems may be affected by changes in climate drivers such as temperature, precipitation, and storms.

A new methodology based on an expert elicitation exercise in a workshop setting was used in this study. In February 2012 EPA issued a final report describing the results of this workshop. The report, *Vulnerability Assessments in Support of the Climate Ready Estuaries Program: A Novel Approach Using Expert Judgment* was released in two volumes: *Volume I: Results for the San Francisco Estuary Partnership* and *Volume II: Results for the Massachusetts Bays Program*.

Expert elicitations were held for both the SFEP and MBP projects. An expert elicitation is a process using expert judgment to inform decision-making when certain conditions exist. These include situations in which uncertainties are large, empirical data may not yet be available, more than one conceptual model can explain available data, and/or technical judgments are required to assess assumptions.

Conducted during a two-day workshop, the SFEP and MBP expert elicitations guided the experts through a series of questions regarding each aspect of the salt marsh or mudflat system. The experts developed ecosystem models to characterize: relationships among key physical and ecological variables that regulate ecosystem processes; relative sensitivities of these relationships under current and future climate change scenarios; degree of confidence in these relationship predictions; and implications for management. Conclusions then were drawn from the data derived from the experts' judgments about climate change effects. This is the first time expert elicitation has been applied to ecosystems, and the reported results lead to valuable implications for coastal area management.

In an era of shrinking budgets coupled with increasingly complex decision-making needs, managing natural resources in the face of climate change is a challenge. In light of this, the Climate Ready Estuary Program's assessment method took advantage of existing scientific expertise to help identify reliable adaptation strategies, weigh difficult trade-offs, and justify management action, all in a timely

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and efficient manner.

Based on the reported results of the workshop, estuary managers can identify where major shifts in the system are likely to occur under future climate conditions and how management strategies can be adjusted in response. Information from these assessments will support climate change adaptation planning efforts by the SFEP, the MBP, other NEPs and managers of other climate-sensitive ecosystems.

The 20 Watersheds Project: Exploring Stream Water and Climate Change

Recognizing that the impacts and risks associated with climate change will vary regionally, EPA conducts research to identify where the greatest vulnerabilities lie and to develop response options for a wide range of plausible climate futures.

With a focus on water flow and nutrient and sediment levels, EPA researchers began an effort to fill knowledge gaps in the sensitivity of U.S. streams to potential climate change. The effort combines existing tools (e.g., climate, land-use and watershed models) and data to look at these scientific issues.

A recent study models twenty large U.S. watersheds looking at stream water quality. The watersheds range across the country and were chosen based on regional variability in land-use practices, climate conditions and watershed systems, as well as to overlap with other EPA projects and the availability of existing data.

Scientists are exploring watershed modeling results that cover a broad range of sensitivity tests for a variety of climate change scenarios. The early results of this "20 watersheds project," display key methods, sensitivities and uncertainties that are part of these watershed models. For example, scientists found that climate models are very sensitive to changes when taken from large-scale assessments and "downscaled" for smaller, regional assessments. Research is also focused on the interaction between climate change and other environmental factors such as urbanization and changes in carbon dioxide levels.

The results of this research will provide key information about adapting to new

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conditions. A paper describing this study titled, *Investigating the Sensitivity of U.S. Streamflow and Water Quality to Climate Change: The U.S. EPA Global Change Research Program's "20 Watersheds" Project*, was published in July, 2011.

Climate and Watershed Assessment Tools BASINS and WEPP

The average global temperature has increased 1.4°F during the last century, one of the indicators that the climate is changing. Potential effects of climate change include increased risk of flooding and drought, changes in the quality and seasonal timing of water runoff, loss of aquatic habitat and harm to ecosystems.

Recently, EPA and its partners crafted Climate Assessment Tools (CATs) that work with the Agency Office of Water's Better Assessment Science Integrating point and Nonpoint Sources climate assessment tool (BASINS), and USDA's Water Erosion Prediction Project climate assessment tool (WEPP). These tools support the study of scenario-based assessments where scientists examine environmental situations as they play themselves out into the future. Using existing modeling systems as the platform for the CATs enhances the usefulness and credibility of analytic results, helping decision-makers understand the potential effects of future climate change on watershed systems.

A 2011 draft report, BASINS and WEPP Climate Assessment Tools: Case Study Guide to Applications, was released in the fall of 2011 and presents six case studies that use scenarios to evaluate future climate change, land use and management. Each case study presents a real or plausible climate change effect in a specific location and shows how BASINS or WEPP can be used to better understand the local impacts of global climate change. The scientific approach supported by these tools—scenario analysis—can inform system behavior, identify vulnerabilities and evaluate management responses.

Workshops Develop a Climate Change Monitoring Network

In response to evidence that climate change and related impacts are affecting aquatic ecosystems, EPA began to monitor the effects of climate change on streams. The Agency organized two workshops to formulate monitoring goals and to collect input from state and regional officials involved in building biomonitoring data. The workshops were held in conjunction with other science meetings (New England Association of Environmental Biologists and North American Benthological Society) and were attended by state biologists from New England, New York, EPA Region 1 and the U.S. Geological Survey (USGS).

The monitoring network will rely upon data gathered by the states, EPA, USGS and other organizations. The resulting datasets will inform vulnerability assessments of Northeastern streams. In addition, local partners will benefit from more information on potential indicators of climate-related effects in these ecosystems.

Aquatic Ecosystems, Water Quality and Global Change

The Intergovernmental Panel on Climate Change defines vulnerability as: "The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes." In order to efficiently manage water resources and systems in the coming years, vulnerabilities of such systems to climate change must be recognized and better understood.

The EPA report *Aquatic Ecosystems, Water*

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Quality, and Global Change: Challenges of Conducting Multi-stressor Global Change Vulnerability Assessments maps key indicators of watershed vulnerabilities nationwide. Released in August 2011, the report investigates the best practices and challenges associated with identifying indicators of relative watershed vulnerability to external stresses such as climate and land-use change across the United States.

EPA scientists mined scholarly journals to identify and analyze more than 600 indicators of water quality and aquatic ecosystems. Examples of indicators include water chemical and nutrient levels, the presence of animal and plant species, local land use, and more. Datasets from EPA, other federal agencies and other organizations were also used to assess ecosystems and human system resilience in the face of global change and other current stresses.

The report forms a building block for future work on global change vulnerability assessments. The impacts of global change will result from often-complex interactions between current stressors reducing overall resilience at the same time that broader global climate change comes into play. The work described in this report can contribute to connecting the needs of water quality and aquatic ecosystem managers to the capabilities of global change researchers.

Climate Change Vulnerability Assessments of Water Utilities

A new EPA report, *Climate Change Vulnerability Assessments: Four Case Studies of Water Utility Practices*, focuses on water resource decision-making as a complex process and concludes that the impact of climate change on decision-making poses challenges. The report illustrates the types of analyses, models and climate change information being developed and used by selected utilities to proactively understand and adapt to national climate risks.

The utilities featured in this report are East Bay Municipal Utility District (Contra Costa and Alameda Counties, CA); New York City Department of Environmental Protection (New York, NY); Seattle Public Utilities (Seattle, WA); and Spartanburg Water (Spartanburg, SC). EPA researchers developed case studies using published information about each utility and interviews with utility staff.

The approaches taken by each utility to assess their vulnerability to climate change ranged from environmental modeling and scenario analysis to reviews of available studies. The case studies illustrate that different approaches reflect specific local needs and conditions, existing vulnerabilities, local partnerships and available information. For example, the New York City Department of Environmental Protection recognizes the risk of increased flooding and sewer system overflows while the focus of East Bay Municipal Utility District is on decreasing annual precipitation and increasing demand for water resources. This report provides useful examples for utility managers, resource planners, climate scientists and others seeking recommendations on vulnerability issues.

Helping States Assess Aquatic Resources for a Changing Climate

In 2011, EPA researchers released for peer review a draft report, *Implications of Climate Change for State Bioassessment Programs and Approaches to Account for Effects*, along with the companion *Freshwater Biological Traits Database*.

Together, the draft report and database

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present information designed to help the Agency's Office of Water and other partners to be better prepared to monitor water quality and aquatic resources in the face of a changing climate.

Because environmental agencies, tribes, and others rely on established data collection practices and biomonitoring techniques to assess water quality and aquatic resources, it is important for them to consider how traditional assessment practices might be affected by climate change. The report presents science on how biological indicators may be used to detect climate change effects, and encourages state bioassessment programs to document changes at key sites.

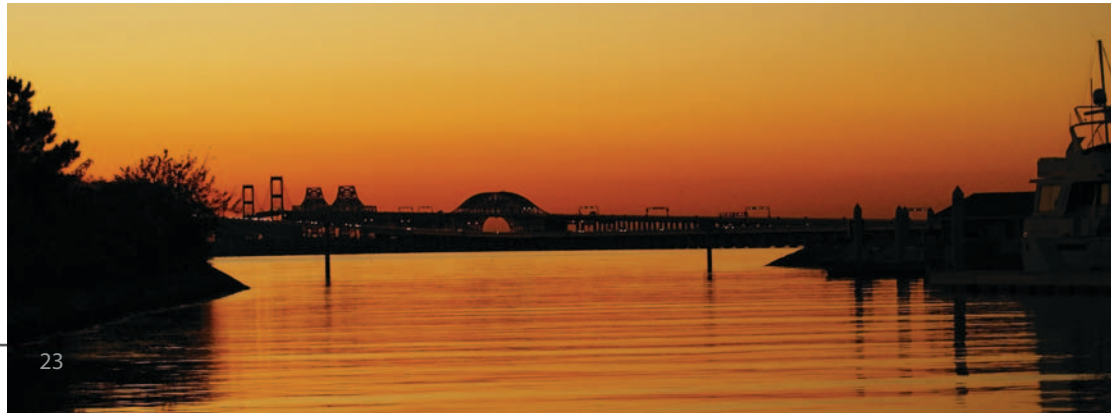
The Freshwater Biological Traits Database contains traits such as morphology, life history, resource acquisition preference, mobility and tolerance for more than 3,000 North American species. To increase transparency, the database is accessible online.

Assessing Climate-Relevant Decisions: Application in Chesapeake Bay

Climate change is a global phenomenon that is affecting natural and human systems in all parts of the world. Some of the decisions and actions taken to manage these systems are likely to be affected by climate change and may likewise affect the vulnerability of the managed resource or ecosystem to climate change. Maintaining or improving the health of resources requires not only understanding the magnitude of potential impacts, but also understanding the effects of climate change on specific practices and their performance.

EPA's 2010 report, *A Method to Assess Climate-Relevant Decisions: Application in the Chesapeake Bay (External Review Draft)*, describes an approach to inventory and analyze management decisions in order to produce useful information targeted toward effective adaptation to climate change. The Chesapeake Bay was chosen for the pilot study because decision making occurs at several levels (e.g., state, multi-state, EPA, other federal agencies), management is concerned with both water quality and aquatic ecosystem decisions, and decisions that affect actions implemented on the ground are readily identifiable.

After selecting the Chesapeake Bay as an exemplary study area, EPA researchers (1) compiled a list of key decisions under consideration; (2) developed criteria for evaluating the climate-relevance of those decisions; (3) applied the criteria to determine decisions potentially sensitive to climate change; (4) solicited expert judgment regarding those selections; and (5) tested alternative schemes for prioritizing decisions most in need of decision support. This study revealed that it provides useful information on adaptation measures for local decision makers and direction for fruitful research endeavors that will further improve our provision of information.



Chesapeake Bay.

Chemical Safety for Sustainability

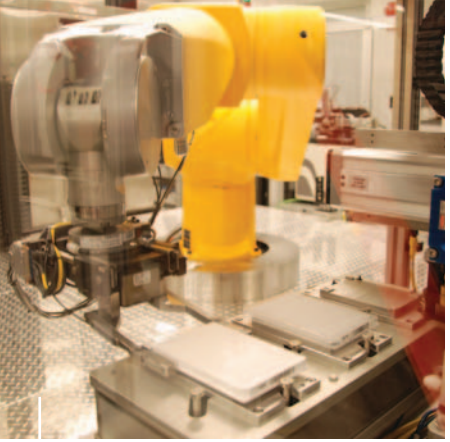
Chemical safety is a high priority for EPA. Moving toward a safer and more sustainable environment requires designing and manufacturing new and existing chemicals in cleaner, less toxic ways.

With tens of thousands of chemicals currently in use and hundreds more introduced each year, EPA's Chemical Safety for Sustainability research aims to develop information, methods and tools to make better informed, more timely decisions about these chemicals.

Many chemicals have not been thoroughly assessed for potential risks to human health and the environment, and the impacts of use over a chemical's life cycle (from design to production to disposal) are not well understood. EPA research is focused on meeting these challenges using innovative approaches, maintaining a life-cycle perspective, and embracing the principles of green chemistry – the design of chemical products and processes that reduce or eliminate the generation of hazardous substances.

Chemical Safety for Sustainability includes research in computational toxicology, nanotechnology, green chemical design, pesticides, industrial chemicals, endocrine-disrupting chemicals and human health risks.

This section highlights some of the top research results EPA researchers and their partners achieved in 2011 advancing Chemical Safety for Sustainability. It illustrates specific impacts that are important to partners of the Agency's Office of Research and Development. The highlights presented were contributed by EPA's research labs, centers, and offices located around the country, and were performed by Agency scientists and engineers, as well as their partners, grantees, fellows, and collaborators from across the scientific community.



Tox21: EPA and partner researchers are using a robotic system to test thousands of chemicals.

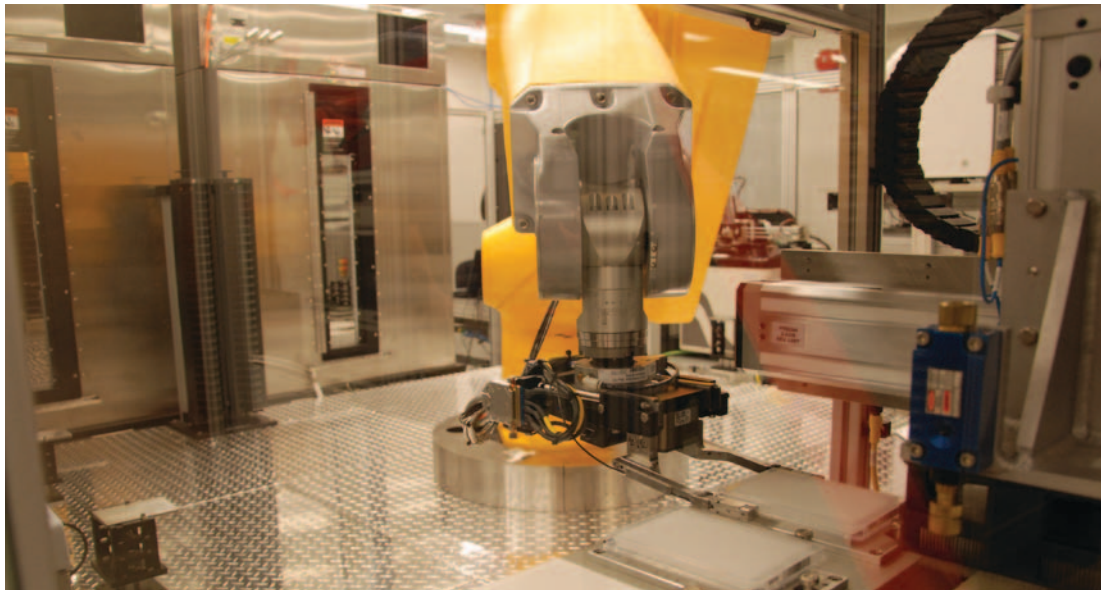
The Future of Toxicity Testing is Now

In March 2011, EPA leaders gathered with their colleagues from the National Institute of Environmental Health Sciences of the National Institutes of Health, the U.S. Food and Drug Administration (FDA), and elsewhere to unveil a new high-speed robot screening system that will test 10,000 different chemicals for potential toxicity. The celebration marked the beginning of a new phase of an ongoing collaboration—Tox21—that is working to protect people's health by improving how chemicals are tested in this country.

That's where the robots come in.

The robot system, which is located at the National Institutes of Health Chemical Genomics Center (NCGC) in Gaithersburg, MD, was purchased as part of the Tox21 collaboration established in 2008. Tox21 merges existing resources, including research, funding and testing tools, to develop ways to more effectively predict how chemicals will affect human health and the environment.

The mechanized, robot-driven testing system greatly reduces the need for lab animals in toxicity testing, working instead with 3-by-5-inch test plates that are moved precisely through a series of steps by giant, and constantly moving robot arms. Each plate contains 1,536 small wells that



can hold various living animal cells—typically skin, liver, or brain cells of rats or humans—and a sample of a particular chemical to be screened. The robot uses a pin tool to dispense a precise amount of a chemical being tested into each well.

Researchers have developed software that flags signs of biological activity in the exposed cells, so they can interpret the results and then identify chemicals that warrant further screening or study. Just because a chemical shows a reaction with an isolated cell (skin, liver, etc.) does not necessarily mean that it will have the same effect when interacting with a living person. To address this, a team of EPA researchers are developing algorithms that predict whether a person's organs and body as a whole will react to chemical exposure the same way their individual cells did in the preliminary tests.

Tox21's new robot system significantly reduces the cost and duration of chemical testing, which will allow EPA to better identify potentially harmful chemicals and serve its core mission to safeguard human health and the environment. It also allows the FDA to better analyze unexpected toxicity, opening the door for better drug development.

Advancing the Science of Chemical Risk

Everyday activities, actions as simple as biting into an apple, house cleaning, or walking across a carpet, may expose people to a host of chemicals through a variety of pathways. The air we breathe, the food and water we consume, and the surfaces we touch are all the homes of natural and synthetic chemicals, which enter our bodies through skin, mouth, and lungs.

In most cases, there is not one single source for any given chemical that may be found in our bodies. This makes determining how (and how much of) certain chemicals enter our bodies a challenge for health assessors and others. To address this challenge, EPA scientists are using sophisticated computer models and methods to develop an innovative set of tools that can be used to estimate total exposures and risks from chemicals people encounter in their daily lives.

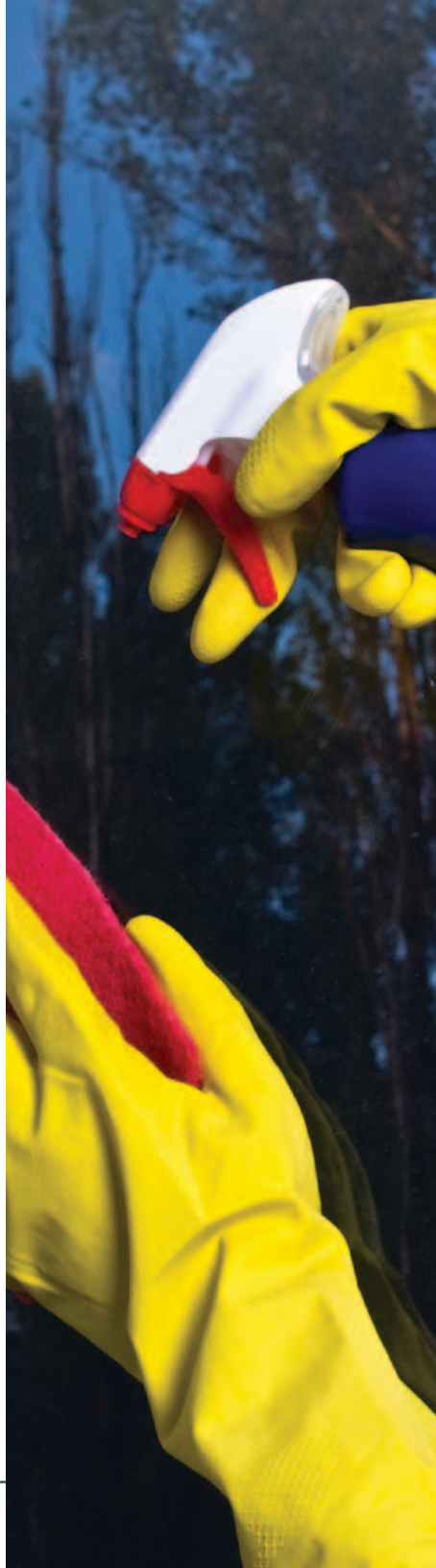
EPA's Stochastic Human Exposure and Dose Simulation (SHEDS) model can be used to estimate the range of total chemical exposures in a population from different exposure pathways (inhalation, skin contact, dietary and non-dietary ingestion) over different time periods. The estimates are calculated using available data, such as dietary consumption surveys; human activity data drawn from EPA's Consolidated Human Activities Database (CHAD); and observed chemical levels in food, water, air, and on surfaces like floors and counters. The data on chemical concentrations and exposure factors used as inputs for SHEDS are based on measurements collected in EPA field studies and published literature values.

The story of how chemicals enter the human body doesn't end there, however. The exposure estimates that SHEDS generates are now being used as inputs for another kind of model – a physiologically based pharmacokinetic (or PBPK) model, which predicts how chemicals move through and concentrate in human tissues and body fluids.

Using PBPK models, scientists can take the estimates of chemical exposures across multiple pathways generated by SHEDS, and examine how exposed chemicals will distribute to internal organs and tissues in the body, and determine how long the chemicals will take to be naturally processed and eliminated from the body.

Together, these two models provide scientists with a much more accurate picture of the risk certain chemicals pose to human health—a picture they've been able to confirm by extensive comparisons against real-world data, such as duplicate diet and biometric data collected by the U.S. Centers for Disease Control and Prevention in the National Health and Nutrition Examination Survey (NHANES), which collects biomarker data from 5,000 people each year. When EPA researchers have compared the SHEDS-PBPK exposure and dose estimates with the physical NHANES data, they've found that the model's predictions line up very closely with the observations in the survey.

SHEDS has already been used in developing EPA's regulatory guidance on organophosphate and carbamate pesticides, and chromated copper arsenate, a chemical wood preservative



EPA scientists are developing models to estimate total exposures from everyday activities.

Advancing the Science of Chemical Risk *Cont'd.*

once used on children's playground equipment. Now, EPA researchers are using the coupled SHEDS-PBPK models to examine a relatively new class of chemical pesticides called pyrethroids to determine whether they pose any risk to human health and the environment.

EPA scientists are continuing to refine the SHEDS and PBPK models used in these studies, adding functions and testing them against real-world data. For policy makers, these models will serve as invaluable tools in making decisions meant to protect human health and the environment from the risk of exposure to harmful chemicals.

Thinking Small: Investigating Nanotechnology

A single nanometer is one-billionth of a meter. Nanotechnolgy, it follows, is the science, engineering, and technology conducted at the nanoscale, manipulating and using compounds from about 1 to 100 nanometers in size. Such materials often have unique and desirable commercial properties.

Nanoparticle use has entered the consumer and industrial sectors and its use is expected to increase significantly in the near-future. But along with the promise and potential of nanotechnology is the need to ensure new products, processes, and technologies are developed in ways that don't pose risks to the environment and human health.

EPA researchers recently examined the manufacture and use of a range of nano-materials that are components of other products. These experts also studied the effect of nanocomponents on the four main components of the life cycle of resulting products: (1) material selection; (2) manufacture; (3) application; and (4) disposal/recycling. Because some health effects and risks associated with components used on this small scale may emerge only during discrete life-cycle phases, it is important for scientists to identify and interpret these risks.

EPA researchers are providing new methods that can be used by manufacturers and scientists to characterize the size, concentration, and chemical composition of nano-based products. Researchers are using data generated with these methods to develop models for predicting how these materials are released from plastic composites, coatings, and textiles and how they react once they are released in the air, water, or soil. These data can be used to assess the potential hazard of such materials.

In September 2011, EPA published *Guidance to Facilitate Decisions for Sustainable Nanotechnology*, a document providing assistance for assessing the sustainability of nano-scale products. The document delivers up-to-date information about nanoproducts to help develop a decision-support framework, and to guide sound risk management efforts for workers, engineers, consumers, and the public.

Researchers will update subsequent releases of the report to help stakeholders and to advance sustainable nanotechnology.

Thinking Small: Investigating Nanotechnology *Cont'd.*

Exploring nanoparticle impacts on vehicle emissions

One nanotechnology that a team of EPA researchers are investigating is the fate and effect of nanometer-sized cerium particles used as fuel additives, particularly as they relate to air quality. The researchers are examining the difference between ordinary diesel emissions and those from diesel mixed with nano-cerium additives to better understand how adding nano-cerium to fuel changes the composition of diesel exhaust.

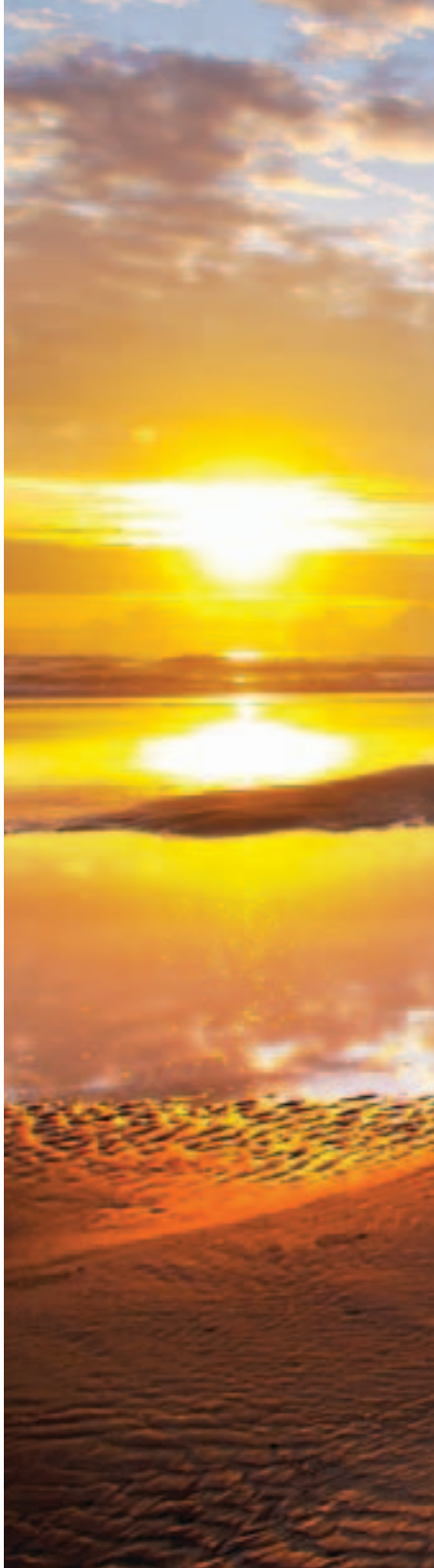
EPA scientists are also conducting atmospheric modeling research to estimate how cerium-induced emissions would change air quality if a portion, or all, U.S. diesel vehicles used nano-cerium fuel additives. Study results are expected in 2012.

Effects of Nanomaterials in Natural Environments

EPA researchers are also investigating whether nanomaterials might have harmful effects on ecological systems and non-human species. One outcome of the work is the finding that certain types of nano-scale titanium dioxide, a material currently used in many consumer products, were found to become very toxic to small aquatic organisms in the presence of sunlight (when tested in specific laboratory conditions).

While non-toxic in laboratory settings, the addition of sunlight increases the toxicity of the material by a factor of 100 to 10,000, depending on the species tested. The phenomenon, called "phototoxicity," occurs at levels of natural sunlight that can be expected to occur under natural settings. EPA researchers have also developed rapid chemical assays that are highly predictive of these effects on whole organisms and are currently investigating these processes in terrestrial and marine systems.

An additional area of focus in that realm is the toxicity and food chain transfer of single wall carbon nanotubes (a fibrous nanomaterial) in marine environments. The effort has demonstrated that these materials are relatively non-toxic to the tested marine species, and cannot be transferred along the marine food chain, from prey to predator. A key additional key outcome of this work has been the development of methods for extracting single wall carbon nanotubes from sediments and organisms and for their analysis using near-infrared technology.



Chemical Safety for Sustainability

2011 Accomplishments – In Brief

Determining the Cumulative Risk of Pyrethroid Insecticides

Chrysanthemum flowers produce a natural pesticide called pyrethrum. Pyrethroid insecticides are a similar product but can be found in both natural and man-made forms. Only a handful of the more than 1,000 varieties of pyrethroid insecticides are used in the United States. These pyrethroids are found in products to control insects like household sprays, pet sprays and shampoos. Use of these insecticides has increased throughout the past decade, and usage of phosphate-based pesticides—which are toxic to humans—has been declining.

To test the danger of pyrethroid insecticides to humans, EPA researchers collaborated with the EPA Office of Pesticide Programs to complete a cumulative risk assessment. This assessment looks at pyrethroids and their exposures in order to sum up the human health risks of these chemicals. The assessment produced data for 14 pyrethroid insecticides using both test tube experiments and living models. Additionally, EPA researchers generated data that showed the effects of exposure to multiple pyrethroid insecticides simultaneously, as can occur in the real world. Multiple exposures are important to assess because the effects of individual chemicals can become significantly more alarming when combined with other chemicals.

EPA published the cumulative risk assessment of pyrethroid insecticides in November 2011. It indicates that many of the current uses for these insecticides do not pose risks for children or adults. Additionally, the assessment concludes that other uses of these insecticides can be registered, since their cumulative risks raised no red flags. This assessment is considered highly conservative (that is, it overestimates exposure) because it assumes that all people will be exposed to the highest possible levels of pesticide residue, an event unlikely to occur in real life. Even with this conservative exposure methodology, the estimated risks to adults and children are well below EPA's level of concern.

Making Sense of Biomonitoring Data for Understanding Human Exposures to Chemicals

When it comes to assessing the health of humans and the environment, more scientific information (data) is always welcome. This is especially true regarding chemical exposures. However, handling and making use of large amounts of data can prove difficult.

In the recent past, many more government agencies and other organizations have been reporting human biomonitoring data. Human biomonitoring refers to the process of studying the outcomes of chemical exposures on small amounts of biological samples like human tissues. Once data are received, the next hurdle is how to handle this increased amount of scientific information.

The National Research Council (NRC) of the National Academy of Sciences identified gaps and uncertainties in EPA's ability to use and analyze these human biomonitoring data in EPA risk assessments and management decisions. To remedy this situation, the NRC concluded that peer-reviewed approaches are necessary.

In response, EPA researchers have created a biomonitoring framework to guide future human exposure research by developing tools and methods that help interpret the abundance of data.

Chemical Safety for Sustainability

2011 Accomplishments – In Brief, Cont'd.

The framework describes novel tools, emerging technologies and biomonitoring advances to ultimately improve research and decision making. Additionally, the framework provides information about the types and quality of available data to support EPA decisions. This will assist public health surveillance efforts and EPA's ability to focus on areas of particular concern.

This framework has been published and used by EPA's Chemical Safety for Sustainability research program. The knowledge gained from developing and using this framework will help fill the gaps that the NRC noted, support EPA assessments and educate the public about the accumulation of chemicals in their bodies.

Leveraging Modern Methods: EPA's ToxCast Program

Many new chemicals are introduced into the market each year, adding to the thousands already in production and use. Testing the potential toxicity of each new chemical that people may be exposed to presents challenges. To help, EPA launched the ToxCast™ program in 2007.

EPA's ToxCast™ is a multi-year effort to develop a timely, cost-effective approach for prioritizing the thousands of chemicals that may need further toxicity testing. Through the program, Agency researchers are developing and using advanced science tools to better understand how processes within the human body are impacted by exposure to chemicals, and working to determine which exposures are most likely to lead to adverse health effects.

ToxCast™ is testing more than 2,000 chemicals under various classifications, including active pesticide ingredients, inert pesticide ingredients, consumer products (such as chemicals in food, cosmetics, sunscreens and sweeteners), pharmaceuticals, antimicrobial agents, and "green," environmentally-friendly chemicals.

During 2011, EPA scientists completed Phase I of ToxCast's new medium-throughput test methods for developmental neurotoxicity. These same chemicals were also used to test for developmental toxicity in a novel zebra fish assay.

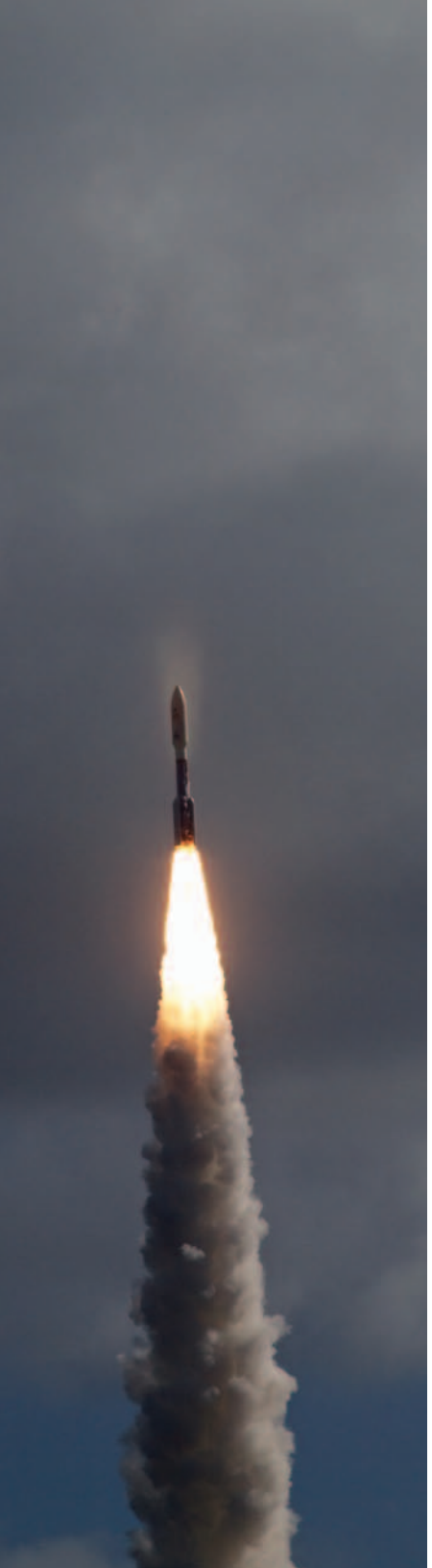
Through the work of EPA researchers, 13 peer-reviewed scientific articles presenting ToxCast research results were published in 2011, including *PLoS ONE, Chemical Research in Toxicology,* and *Toxicological Sciences.*

Perchlorate Exposure Associated With Indirect Indicators of Thyroid Problems

Perchlorate is a chemical that occurs both naturally and through manufacturing. Manufacturers use it to make rocket fuel, fireworks, flares and explosives, and it can also be present in bleach and in some fertilizers.

Scientists have found low levels of perchlorate in drinking and groundwater in most states. This contaminant may have harmful effects on the thyroid gland, a part of the body essential to the production of hormones needed for normal growth and development. A recent EPA study looked at the association between perchlorate in urine samples and biological signs of thyroid hormone disruption.

To do this, Agency scientists used 2001 and 2002 data from the National Health and Nutrition Examination Survey (NHANES). NHANES assesses the health and nutritional status of adults and children in the United States by combining interviews and physical examinations of 5,000 residents every year.



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This study presents an innovative approach to using biological signs of thyroid dysfunction among both men and women to test for low-level, significant exposure to perchlorate. EPA researchers linked certain biological signs of thyroid function to findings of perchorlate in urine. The results of this study were published in December, 2011 in a paper titled, *Association Between Perchlorate and Indirect Indicators of Thyroid Dysfunction in NHANES 2001-2002, a Cross-Sectional, Hypothesis-Generating Study*.

Improving Access to Analysis with ExpoCastDB

In 2011, EPA scientists released a database of chemical exposure studies known as ExpoCast DB. ExpoCastDB consolidates human exposure data from studies that have included the collection of chemical measurements from homes and childcare centers. Data include the amounts of chemicals found in food, drinking water, air, dust, indoor surfaces and urine. ExpoCastDB users can obtain summary statistics of exposure data and download datasets. EPA scientists will continue to add internal and external chemical exposure data and advanced user interface features to ExpoCastDB.

The tool is available to both researchers and the public and can be found online at: http://actor.epa.gov/actor/faces/ExpoCastDB/Home.jsp.

Characterizing Aquatic Exposures to Real-world Chemical Mixtures

EPA scientists have developed and applied innovative methods for rapidly characterizing the impact of real-world exposures to mixtures of endocrine disrupting chemicals, pesticides, and other emerging chemicals of concern for aquatic species (fish).

The methods developed can be used as a biomonitoring tool for identifying chemical exposures from potentially contaminated waters, and to demonstrate the effectiveness of actions taken to reduce such exposures. The validated methods will provide partners and stakeholders, including EPA Regions, the National

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Enforcement Investigations Center, the Great Lakes National Program and EPA's Office of Water, with a way to rapidly identify source waters that may result in unsafe exposures for both aquatic species and people.

Leadership in Life Cycle Assessments and Data Availability

EPA plays a leading role in government-wide discussions on the adoption of life cycle assessments (LCAs). An LCA examines the total potential environmental impacts associated with a product from its creation to its disposal.

This process of studying a product's complete life cycle requires an examination of the raw materials used and the way materials are produced. Factors such as the product's use, reuse and maintenance are also incorporated into an LCA. The LCA process is data intensive, expensive and time-consuming. Thus, EPA researchers have tried to make completed LCA data more readily available to industries and the public.

On a national level, EPA supports advancement of the Life Cycle Inventory Database, an LCA database for products within the United States. On an international level, EPA works with the United Nations Environment Programme and the Society of Environmental Toxicology and Chemistry to improve the way information is shared across databases around the world. Other EPA international work increases the credibility of existing LCA data, generates additional data, enhances data accessibility and complements other data-related initiatives.

Additionally, EPA scientists are participating in a multi-agency effort to create a data "commons" platform for easy public access to federal LCA data. This effort includes collaboration with the U.S. Department of Agriculture, National Renewable Energy Laboratory, National Institute of Standards and Technology and the U.S. Department of Veterans Affairs. One important objective is the creation of a "digital commons" to link federal LCA data with that of the private sector. Such connections could have a significant impact on the resources available to promote sustainable products.

Life Cycle Analysis of Lithium-ion Batteries

The primary goal of many of EPA's LCA studies is to help companies make environmentally-friendly choices about which materials they use and how they manufacture products. These studies can also identify areas that might benefit from better energy efficiency. One such study involves the lithium-ion (Li-ion) battery system used today in many hybrid cars.

The automobile industry's production of alternative vehicles (for example, electric, hybrid electric and plug-in hybrid electric) has grown substantially in recent years. Growth in this sector supports the Obama Administration's goal of reducing U.S. dependence on oil.

Lead is the primary metal used for

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batteries found in conventional cars and trucks. Most hybrid car batteries, on the other hand, are made of either nickel-metal hydride or lithium-ion (Li-ion), both of which are more environmentally friendly than lead-based batteries. Li-ion is generally considered the least toxic of the battery options; however, the environmental impacts of the production, usage and disposal of Li-ion batteries are largely unknown.

In conjunction with EPA's Office of Chemical Safety and Pollution Prevention, EPA researchers conducted a study on the life cycle of the Li-ion battery energy system in vehicles. The study estimates the environmental impact of the Li-ion battery by examining each step of its "life," from the collection of the raw materials to the production of the battery to its final disposal. Researchers are currently preparing a report on the Li-ion battery study.

Greening the Government and Advancing Sustainability

EPA scientists are leading the way in federal efforts to "go green." Going green will allow the government to run more efficiently while supporting environmental goals.

Working towards a green goal, EPA scientists support the Agency's Sustainable Products Network (SPN) effort. The SPN promotes EPA's leadership in green and sustainable product development and procurement for use by other agencies. EPA encourages the adoption of SPN's set of environmental standards for certain products and services.

Additionally, EPA researchers continue to work with the General Services Administration (GSA) on purchasing environmentally-friendly products. This partnership also helps calculate the environmental impacts related to federal spending. On "America Recycles Day," EPA and GSA worked together to highlight the benefits of recycling electronics, or "e-Cycling," and promote sustainability and green solutions.

For sustainable and green solutions to make an impact, the sustainability claims of commercial products must be consistent. EPA scientists and engineers are working with the Office of Resource Conservation and Recovery to ensure accurate claims about the sustainable life cycle of "green" products, including claims about a product's carbon footprint. EPA researchers from the Sustainable Technologies Division co-led a study on the rules for such claims.

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Characterizing Perfluorinated Chemicals in Water

EPA scientists have developed and applied analytical methods for characterizing the concentration of perfluorinated chemicals in surface and well water samples. Perfluorinated chemicals (PFCs) are manmade chemicals used in a wide range of commercial and consumer products (e.g., textiles, electronics, stain-protective coatings). EPA analytical methods have been used in a series of field studies to generate high quality environmental data.

EPA's Office of Water considered the results when establishing the provisional health advisory guidelines for drinking water for two common PFCs (perfluorooctane sulfonate and perfluorooctanoic acid). The methods are being used by EPA Regional Offices to monitor surface and drinking water supplies to ensure exposures to these PFCs from public drinking water supplies are safe.

Cell Culture-based Tests Open Up New Field of 'Metabolomics'

Testing the effect of chemicals on the metabolic processes of living cells can be time-consuming and expensive. This is especially true when multiple chemicals are evaluated at the same time. EPA scientists have sidestepped these issues by developing a more efficient method for assessing chemical risks. This innovative method is a novel type of cell culture-based research called metabolomics.

Chemical processes that occur within cells leave behind unique chemical "fingerprints." Metabolomics is the study of these metabolic fingerprints and the cellular processes that produce them. The fingerprints can be studied to understand changes that are occurring within cells that have been exposed to a specific chemical. To test chemical toxicity, cells are grown in a well-controlled environment. Highly automated processing reduces costs, the use of animals and time.

Following the exposure of cells to a chemical, researchers perform nuclear magnetic resonance spectroscopy (NMR) and mass spectrometry (MS) on the biofluids from the cell cultures. NMR and MS will indicate any changes to the normal composition of cellular metabolites. EPA scientists have reduced the time for these processing steps by more than 10-fold compared to traditional methods. The changes in cellular metabolites caused by chemical(s) exposure can now be obtained rapidly. Further analysis can provide knowledge about the exact nature of the toxicity produced by chemical(s) exposures.

EPA researcher shown here with nuclear magnetic resonance equipment used in metabolomics research.

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Computerized System for Pesticides

EPA scientists have developed a computerized system to support the rapid evaluation of pesticide applications submitted to the Agency for registration or re-registration. The system includes a search engine and associated database of chemical metabolic maps and supporting data for a large number of currently registered pesticides.

When a pesticide application is submitted, Agency risk assessors can efficiently evaluate the chemical against other similar registered compounds and efficiently determine the potential for the new chemical, its metabolites, and remnants left after its degradation, to result in harm to humans or the environment. The system provides risk assessors with data and knowledge for the rapid, inexpensive, and reliable prioritization of chemicals and supports EPA's efforts to reduce the requirements for expensive animal testing.

Supporting EPA Research Partners

EPA awards research grants and awards in a diversity of environmental science and engineering disciplines—including work in Chemical Safety for Sustainability—through its Science to Achieve Results (STAR) program. The Agency is also one of 11 federal agencies that participate in the Small Business Innovation Research (SBIR) Program established by the Small Business Innovation Development Act of 1982.

Together, these programs engage the nation's best scientists, engineers, and innovative small businesses in targeted research that complements EPA's own outstanding intramural research program.

Accomplishments of EPA partners in the areas of Chemical Safety for Sustainability for 2011 include the following highlights.

Cutting-Edge Science on Human Liver Response to Toxic Chemicals

The human liver is like a waste treatment plant for the body, playing a key role in removing harmful chemicals. However, if a chemical is toxic to the liver, it can affect how the body responds to other chemicals.

To advance innovative research in the area of chemical toxicity testing and the human liver, EPA awarded nearly $3 million to researchers from four academic institutions: Virginia Polytechnic Institute and State University (VA Tech), The University of North Carolina at Chapel Hill (UNC), Indiana University Bloomington (IU), and The Hamner Institutes for Health Sciences based in North Carolina.

Every year, manufacturers introduce hundreds of new chemicals into the marketplace, adding to the tens of thousands that are already in use. Understanding how chemicals might be toxic to the liver is critical to public health. Traditionally, chemical toxicity studies are conducted using animal testing which is expensive, time-consuming, and

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controversial. To ease the burden of animal testing, scientists at the four institutions are working to create new methods and tools to expand current understanding of the effects of certain chemicals on the liver.

Researchers at VA Tech hope to engineer a 3-dimensional tissue that will mimic liver behavior. By exposing this liver model to known toxicants, scientists will use genetic work and computational modeling to understand the biological effects on the liver due to each chemical and combinations of chemicals.

The Hamner Institutes will create a multicellular model of a human liver lobe to study the effects of a highly toxic environmental contaminant, 2,3,7,8-tetrachlorodibenzo-p-dioxin.

IU researchers propose to craft tools and standards to help researchers share information about liver model characteristics and toxicology.

Scientists from UNC will gather and organize a biological and chemical information database that relates to liver toxicity. With this information, they plan to develop predictive models for chemical impacts on the liver.

Prenatal Exposure to Pesticides Linked to IQ Deficits

Three independent investigations supported by the EPA-funded Children's Environmental Health Research Centers reached similar conclusions associating prenatal exposure to organophosphate (OP) pesticides with IQ deficits in school-age children.

All three investigations found some evidence of an association between OP exposures in utero and negative impacts on intelligence and mental development at around seven years of age, including memory, processing speed, verbal comprehension, perceptual reasoning, and full scale IQ.

The three studies were conducted at the University of California, Berkeley, School of Public Health; the Mailman School of Public Health at Columbia University; and Mount Sinai School of Medicine. All involved cohorts of women enrolled during pregnancy.

The Berkeley and Mount Sinai investigators measured OP pesticide metabolites in the pregnant women's urine, while the Columbia investigators measured the OP pesticide chlorpyrifos in umbilical cord blood. Intelligence tests were administered to children of these mothers between ages 6 and 9 years at Mount Sinai and at age 7 years at Berkeley and Columbia.

Although the study findings are not directly comparable, all three investigations found evidence linking prenatal OP pesticide exposures with adverse effects on cognitive function that continued into early childhood.

Organophosphate pesticides have been associated with brain and nervous system damage in animal and human studies. In 2010 the U.S. EPA registered more than 30 organophosphate pesticides, including several for home garden use. Chlorpyrifos, which figures prominently in two of the three EHP studies, is widely used in agriculture as well as in household ant and

EPA is advancing the understanding of how chemicals might be toxic to the human liver.

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roach baits in child-resistant packaging, although all other home uses of this pesticide were phased out after 2000 due to concerns about neurotoxicity in humans.

(Also see *Children's Environmental Health and Disease Prevention Research Centers*, page 62.)

Study Improves Understanding of Arsenic in Food

A study advancing the understanding of the dietary sources of human exposure to arsenic has just been published in the Proceedings of the National Academy of Sciences (PNAS) by a team of scientists from the EPA/NIEHS Children's Environmental Health and Disease Prevention Research Center at Dartmouth College (Dartmouth Children's Center).

The study measured the arsenic levels in the urine from about 230 pregnant women living in New Hampshire, and found that the level was significantly higher for women who had eaten rice within 2 days of the testing than those that had not eaten rice. The level of naturally occurring arsenic in well water in the area where the study is being conducted is higher than in many other parts of the U.S. Although EPA standards set limits for arsenic levels in drinking water, concerns about arsenic exposure are now extending beyond water to foods such as the rice plant, which can take up arsenic from the environment where it is grown. Researchers are investigating whether the combined level of arsenic from both water and food could affect the health of the developing fetus and young children.

The authors note that their findings highlight the potential need to monitor arsenic content in food and reinforce the concern that some private well water in some areas of New Hampshire may be a potential source of arsenic exposure. While this study reveals the potential for exposure to arsenic from rice, additional research is needed to determine if there are actual health impacts from this type of exposure and ultimately any health risks, if found, would then need to be weighed against the nutritional benefits of rice consumption.

This study confirms research conducted by EPA scientists in 2009 that found that some fruits, fruit juices, rice, beer, flour, corn and wheat can be dietary sources of arsenic. The 2009 study used computer

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models to develop population-level estimates of exposure to arsenic from food. The study found estimated arsenic exposures from diet to be approximately one-fifth the level set by EPA to protect consumers from the effects of long-term exposure to arsenic in tap water.

The Dartmouth Children's Center is jointly funded by the U.S. Environmental Protection Agency and the National Institute for Environmental Health Sciences. The goal of the Children's Center is to better understand the combined impact of arsenic both in drinking water and food on children's health and to support community and public awareness to minimize those health risks and reduce environmental threats to children's health.

(Also see *Children's Environmental Health and Disease Prevention Research Centers*, page 62.)

Human Health Risk Assessment

Every day, the U.S. Environmental Protection Agency (EPA) must make decisions about environmental pollutants that impact human health and the environment. There are currently more than 80,000 chemicals in commerce, and more are introduced each year. Only a small fraction of these chemicals have been adequately assessed for potential risk, often because of limits in existing data, tools, and resources.

EPA's Human Health Risk Assessment research helps address this problem by providing state-of-the-science products in support of risk assessment, such as independently peer reviewed human health assessments for individual chemicals and chemical mixtures; integrated science assessments for criteria air pollutants; rapid risk assessments and technical support to meet partner and stakeholder needs; and tools to modernize human health risk assessment.

The products of this research are used by local, state, national and international authorities to guide waste site cleanups, protect the air, set exposure limits for drinking water, and determine the potential risk to public health from exposures to multiple environmental contaminants. EPA and its partners help drive the evolution of the science of risk assessment through original research, consultation with experts and by accepting new challenges. These include developing community risk assessment tools and tailoring risk assessments to support key decisions.

This section presents highlights of EPA research activities and achievements in 2011 in the area of human health risk assessment.

Human Health Risk Assessment

Truck Loads of Science? Gathering the Best Air Science

Years ago a member of EPA's Science Advisory Board was asked in a Congressional hearing if EPA could provide Congress with the data it relied on in its recent plan to regulate particulate matter in air. He answered that this was possible, but you would have to back an 18 wheel truck up to the Longworth House Office Building to do it.

EPA evaluates and integrates evidence, often many thousands of studies, from across scientific disciplines—atmospheric sciences, dosimetry, exposure, toxicology, controlled human exposure, epidemiology and ecology—to provide the scientific basis for decisions to retain or revise the National Ambient Air Quality Standards (NAAQS) for "criteria" air pollutants. EPA calls them "criteria" pollutants because the Agency uses criteria based on human health and environmental effects to set acceptable levels.

There are six criteria air pollutants:

1. Ozone,
2. Particulate matter,
3. Carbon monoxide,
4. Sulfur dioxide,
5. Nitrogen oxides, and
6. Lead

Numerous and diverse industrial, commercial, residential and traffic sources release these pollutants into the air. They are considered harmful to public health and the environment when their concentration exceeds an acceptable level, referred to as the standard level. It is EPA's job to re-evaluate the standards for these pollutants every five years. EPA then works with the states to take steps to comply with the standards to protect public health.

In the past, EPA's scientific reviews for each criteria pollutant ran to thousands of pages. Today, the Agency summarizes and synthesizes the most policy-relevant science in Integrated Science Assessments (ISAs) for the criteria pollutants. All ISA documents are vetted through a rigorous peer review process. This process includes two reviews by the Clean Air Scientific Advisory Council (CASAC) and an opportunity for public review and comment.

During the past year the Agency made significant progress in generating and reviewing ISAs. The Agency released the first draft of the ISA for Lead (Pb) in May 2011, and it was reviewed at a CASAC peer review meeting in July. The Agency also released the first draft of the ISA for Ozone in March 2011, and it was peer reviewed at a meeting of the CASAC in May 2011. For both pollutants, second

Truck Loads of Science? Gathering the Best Air Science *Cont'd.*

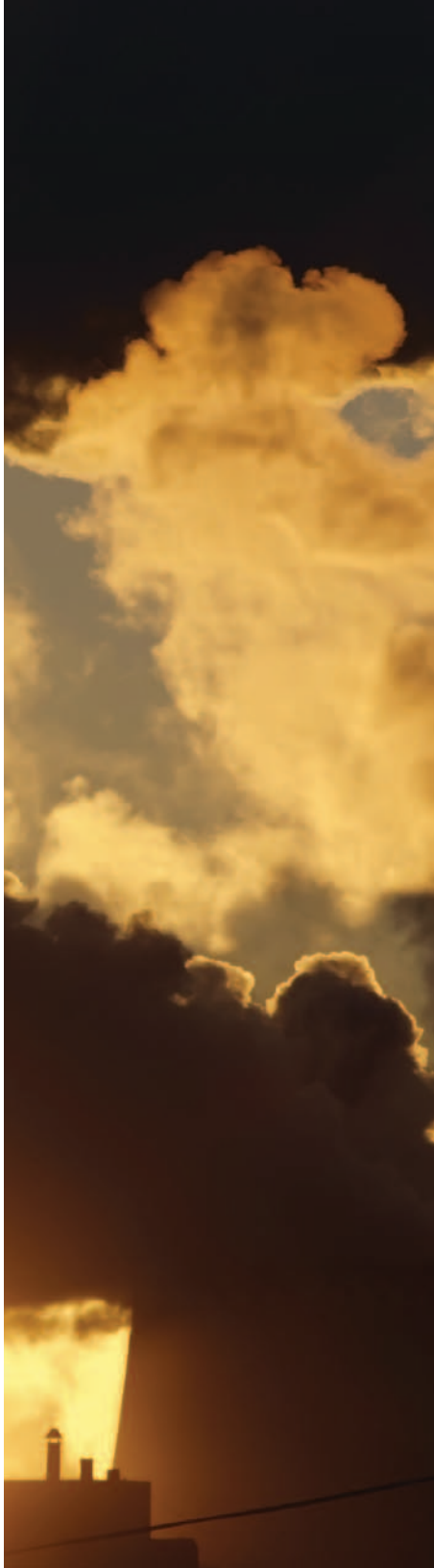
draft ISAs were prepared for release in 2012, incorporating revisions to respond to public and peer review comments.

Because people are not exposed to only one pollutant at a time, but rather a complex mixture of pollutants, the scientific and regulatory communities are studying how to evaluate the health and environmental impacts of exposure to mixtures of air pollutants. This is a challenging problem. In 2011, EPA convened a multipollutant science and risk analysis workshop to explore this topic, and to identify challenges and opportunities in developing a Multipollutant Science Assessment (MSA). EPA is now working to develop a framework for an MSA as a companion assessment to the ISAs whereby the health effects of exposure to a mixture of pollutants, principally the criteria air pollutants, may be systematically evaluated.

Setting air quality standards for the criteria pollutants has far-reaching health and economic benefits across the nation. By setting scientifically sound standards, EPA hopes to reduce mortality, hospitalizations, missed workdays, asthma episodes and other serious health effects. Across the federal government, economists and other experts consistently have found that EPA's air quality standards have resulted in the greatest benefit to public health of any policies developed by any government agency.

Integrated Science Assessments (ISAs)

Criteria Pollutant (Human Health and Ecological Effects)	Status of ISA
Lead (neurodevelopmental effects; effects on aquatic and terrestrial ecosystems)	Underway – 1st draft May 2011; second draft February 2012
Ozone (respiratory effects; reduced plant growth and visible foliar injury)	Underway – 1st draft March 2011; second draft September 2011
Carbon Monoxide (cardiovascular effects)	Completed in January 2010.



A Global Resource Improves: The IRIS Process and Assessments

EPA plays an important role in providing timely, high-quality and accessible human health risk information on environmental contaminants that may endanger the health of the American public. Central to this aspect of EPA's mission is the Integrated Risk Information System, commonly called the IRIS Program.

This program provides health effects information on chemicals to which the public may be exposed from releases to air, water, and land and through the use and disposal of products. IRIS assessments provide a critical part of the scientific foundation for EPA decisions to protect public health across EPA's programs and regions under an array of environmental laws. These documents provide federal, state, local and other policy makers with the latest scientific information to make decisions about cleanup and other actions to protect people's health. IRIS assessments provide information on a chemical's potential for causing adverse health effects along with information about the relationship between the dose of the substance and the biological response. Government and private entities combine IRIS values with information about exposure to characterize the public health risks of chemical substances. EPA and others use this information, along with relevant considerations such as statutory and legal requirements, economic and social factors, risk management options, and public health and cost/benefit information to make decisions about chemicals in the environment. Therefore, IRIS assessments provide a critical part of the science to support risk management decisions to protect public health, but they are not a complete risk assessment or a regulatory level.

IRIS contains information on more than 560 chemicals, and the program continues to grow. Over the past few years, EPA has taken several actions to improve the IRIS Program. For example, in May 2009, EPA announced a new IRIS process designed to streamline and strengthen the assessment development process while ensuring the highest level of scientific quality, integrity, transparency, and timeliness. This new process reduced the number of steps in the assessment development process from 14 to 7 and improved transparency by clearly documenting and explaining changes in EPA's scientific judgments during the assessment development process and making comments from other federal agencies and White House offices publicly available. Since the new process was instituted and as of the writing of this report, EPA has completed 24 IRIS assessments.

In April 2011, the National Research Council (NRC) made suggestions to improve the development of draft IRIS assessments. EPA welcomes those suggestions and is fully implementing them consistent with the NRC's Roadmap for Revision, which viewed the full implementation of their recommendations as a multi-year process. Consistent with the NRC recommendations, draft assessments released in fiscal year 2012 will be shorter and more concise, clear, systematic, and visual. In addition, these assessments will use a new document structure, including an executive summary presenting major conclusions, a preamble describing methods used to develop the assessment, distinct sections on hazard identification and dose response, and more tables and figures to present data.

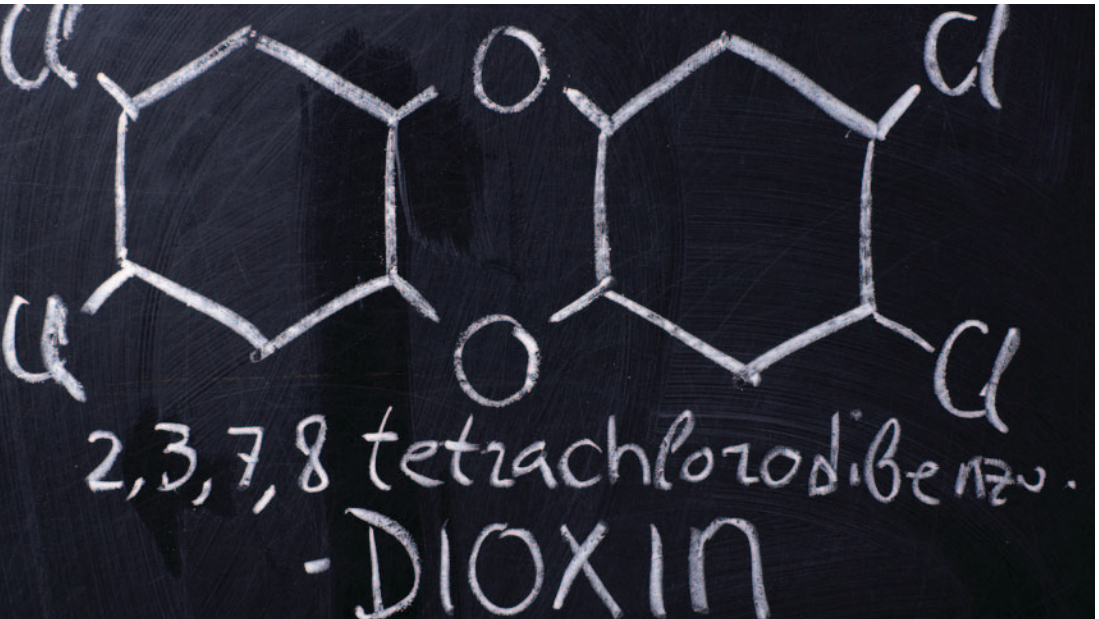
In 2011, EPA released four final IRIS assessments, including the long-awaited assessment for trichloroethylene (TCE).

A Global Resource Improves: The IRIS Process and Assessments *Cont'd.*

TCE is a widely used industrial solvent commonly found at Superfund sites across the country. In the assessment, EPA concluded that TCE causes cancer in humans and also poses a non-cancer health hazard to the central nervous system, kidney, liver, immune system, male reproductive organs and the developing fetus' cardiac system.

In 2011, EPA also made tremendous progress toward completing its assessment of dioxin, receiving a favorable review by the Agency's Science Advisory Board in August 2011 and advancing the noncancer portion of the assessment to the final steps of the assessment development process. Dioxins refer to a family of toxic chemicals that share a similar chemical structure and induce harm through a similar mechanism. One specific dioxin, 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), is best known for being the active ingredient in Agent Orange, a widely used herbicide in the Vietnam War. TCDD has long been associated with a range of adverse developmental and cancer-causing health effects in humans, including disruption of the hormone system and multiple tumors. While the manufacture of TCDD stopped in the 1970s, dioxins remain in the environment due to their longevity and the ongoing contributions as a by-product of incineration processes. The levels of dioxins in the environment have been falling over time thanks to a number of federal and state regulations and cleanup actions.

EPA strives to continually improve the IRIS Program while developing scientifically rigorous chemical health assessments. IRIS assessments are held to the highest Agency standards, and the process for developing an IRIS assessment includes rigorous independent external peer review, internal review by EPA scientists, public review and comment, and opportunities for review by other federal agencies. These standards are among the best in the federal government and the scientific community.



EPA Human Health Risk Assessments

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EPA Improves Exposure Factors Handbook for Broader Use

A thorough assessment of a person's exposure to toxic chemicals is important to determine how to limit or avoid exposures to dangerous pollutants. Exposure factors are estimates that are related to human behavior patterns and characteristics that help determine the level of a person's contact with a chemical. In 2011, EPA released a revision of the 1997 Exposure Factors Handbook reference tool and also released a companion highlights document.

The purpose of the handbook is to: (1) summarize data on human behaviors and physiology that affect exposure to environmental pollutants; and (2) recommend values to use for these factors. To complete that goal, the handbook gives information and reviews statistical data on various physiological and behavioral factors that are often used in assessing exposure to environmental chemicals. Recommended values are given for the general population and for various parts of the population who may have characteristics different from the general population, such as children and the elderly.

The main audience for the handbook is exposure and risk assessors who need data on standard factors to determine people's exposure to toxic chemicals. Steps for doing an exposure assessment include: (1) figuring out the source of the environmental contamination and the media (air, water, etc.) that moves the pollutant; (2) determining the contaminant concentration; (3) determining the ways people can be exposed to the toxicant; (4) determining the things people do that change their amount of exposure, such as time, frequency and duration of exposure; and (5) identifying the people exposed. Exposure factors to assess include: drinking water intake; soil intake; rates from breathing; skin factors, including skin area and soil attachment and penetration factors; intake of specific food groups (e.g., fruits and vegetables, fish, meats, dairy products, grain products and homegrown foods); total food intake; breast milk intake; human activity factors; consumer product use; and residential characteristics.

The data presented in the *Exposure Factors Handbook* have been combined from various sources, including government reports and information presented in scientific journals. Studies included in the handbook were chosen because they were seen as useful and fitting for estimating exposure factors based on the following considerations: (1) soundness (adequacy of approach and a small or defined bias); (2) applicability and usefulness (focus on the exposure factor of interest, representativeness of the population, currency of the information and adequacy of the data collection time span); (3) clarity and completeness (accessibility, reproducibility and quality assurance); (4) variability and uncertainty (variability in people and uncertainty in the results); and (5) evaluation and review (level of peer review and number and agreement of studies). EPA assigns confidence ratings of low, medium or high to each recommended value based on those considerations. The ratings are not supposed to be uncertainty analyses; rather, they should be seen as suggestions that EPA programs or individual exposure and risk assessors can think about and change as needed based on their own evaluation of a given risk assessment situation. The *Exposure Factors Handbook* is the Agency's main source of exposure factor information, and is used by exposure and risk assessors within and

EPA Human Health Risk Assessments

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outside the Agency as a reference tool. EPA strives to include in the Handbook full discussions of the issues that assessors should think about in deciding how to use the exposure factors and recommendations.

Health and Environmental Research Online (HERO) Database

If you have ever wondered what science EPA uses in its assessments, then the Health and Environmental Research Online (HERO) database is the place for you. EPA is dramatically increasing the transparency of and public accessibility to scientific information identified, evaluated and used in EPA assessments. Introduced in 2009, the HERO database is used by EPA to develop rigorous and transparent risk assessments and to share information with the public.

What is HERO? HERO is a database of the scientific studies considered and used in EPA assessments. It represents a transformational approach in using the world's scientific literature in the risk assessment process. HERO is a comprehensive system to identify, compile, characterize, analyze, synthesize and prioritize scientific studies used in health assessments. HERO is an evergreen database, meaning that new studies are added continuously so that scientists can always keep up with new research. References, including peer-reviewed papers, technical bulletins, conference proceedings and other sources, are sorted, classified and made available through HERO.

HERO includes more than 300,000 scientific papers from peer-reviewed work used by a variety of EPA and outside experts in creating Integrated Science Assessments (ISAs), Integrated Risk Information System assessments, and other research and assessment documents. For example, in the ISAs for Lead and Ozone currently in development, there are hyperlinks to bibliographic information in HERO for each reference cited. Also, HERO web pages for the pollutants provide information on the references considered and included in the assessments.

In addition to supporting Agency researchers, HERO gives the public an easy way to search and analyze the scientific literature underlying health and environmental risk assessments that are used to support EPA decision making. The HERO website provides tools and data to help the public and other stakeholders identify important research. Every American has the right to know what data underly key regulatory decisions and, as such, HERO is an important contribution to open government directives.

Improvements and Innovations in Dose Response Assessment

Chemical health assessments are a key component of the science underlying environmental decisions at EPA, and it is critical that they are based on the best available science. In 2011, EPA made several improvements to three tools used to develop chemical health assessments, such as Integrated Risk Information System (IRIS) assessments. These innovations will improve the scientific foundation of the Agency's chemical health assessments.

Multistage Weibull Time-to-Tumor Model: This model estimates the time it takes for tumors to form after a person is exposed to different doses of a cancer-causing chemical. The tool is an important component of chemical risk assessment for cancer causing agents since scientists know that there is a latency period for

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developing cancer that varies according to the size of the chemical dose and potency of the chemical. The model predicts two types of results from exposure to cancer-causing agents: death from cancer and the development of cancerous lesions (which applies to non-lethal types of cancer).

CatReg: CatReg is an important statistical tool that helps scientists use data from multiple studies when estimating doses associated with extra risk. EPA researchers can use CatReg to analyze toxicity data after they are assigned to severity categories for effects (e.g., no effect, adverse effect, severe effect). CatReg calculates the probabilities of the different severity categories over different exposure conditions. CatReg can be used to analyze data from multiple endpoints within a single study or a combination of similar studies. This important tool helps EPA make better use of a wide range of toxicity data in IRIS and other chemical health assessments.

Updates to Benchmark Dose Software: When investigators test the carcinogenicity of a chemical in animal experiments, it often causes more than one type of cancer. The National Research Council suggested that EPA develop a

model that accounts for these results. The model would assume that even though more than one type of cancer could develop from exposure, the risk of developing one type of cancer is independent from all the others. More than a decade ago, EPA released its first version of Benchmark Dose Software (BMDS). A benchmark dose (BMD) is an estimate of the dose or concentration that can be expected to produce a change in the rate at which a chemical causes harm. An example is how much chemical exposure it would take to cause a 10 percent increase in a particular type of cancer compared to unexposed test animals. The 2011 update to the BMDS calculates composite risk values for multiple tumor types, allowing EPA to evaluate the health risks from exposure to carcinogens in a more realistic way.

Provisional Peer Reviewed Toxicity Values Help Protect Health

There are currently more than a thousand hazardous waste sites in the United States. Often, these sites are contaminated with multiple chemicals. EPA's Superfund program conducts risk assessments to determine how threatening a hazardous waste site is to human health and the environment. Risk assessors seek to determine a safe level for each potentially dangerous contaminant present. For

EPA Human Health Risk Assessments

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humans, this is a level at which adverse health effects are unlikely and the probability of cancer is very small. In order to conduct a robust human health risk assessment at a hazardous waste site, EPA needs information on the hazard and dose-response of the chemicals present, as well as other scientific information like the nature and extent of human exposure to the chemicals.

Provisional Peer Reviewed Toxicity Values, or PPRTVs, are toxicity values derived for use in EPA's Superfund program when a value is not available in the IRIS database. They provide important information on the hazard and dose-response of chemicals. This information is then used by the Superfund program and regional decision makers to conduct site-specific risk assessments and make site-specific clean-up decisions.

PPRTVs are derived following a review of relevant scientific literature using the same methods, sources of data and guidance used by the IRIS Program to derive values. All PPRTVs receive internal review by a panel of EPA scientists and external peer review by independent scientific experts and are publicly available. PPRTVs provide hazard and dose-response information pertaining to chronic and subchronic exposures to substances of concern; present the major conclusions reached in the hazard identification and derivation of the PPRTVs; and characterize the overall confidence in these conclusions and toxicity values. References in PPRTV documents are linked to the HERO database to provide transparency and allow the user to access the literature on which the PPRTVs are based. Currently, the PPRTV database contains assessments for more than 300 chemicals.

The toxicity values developed through the PPRTV program are used by EPA and others to develop risk assessments that guide risk management decisions. These decisions affect the soil, air and water quality across the country. Through its PPRTV development efforts, EPA increases its capacity to protect public health and clean up contaminated communities.

New Respiratory Science Shapes Reference Concentration Methods

EPA has released an update of a 1994 document on the health effects of breathing harmful chemicals. The original document was entitled *Methods for Derivation of Inhalation Reference Concentrations and Applications of Inhalation Dosimetry* (sometimes referred to as *RfC Methods*). The 1994 *RfC Methods* outlined how to interpret the levels and

EPA Human Health Risk Assessments

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impacts of airborne gases. It explained the components of inhalation and airflow to specific areas of the lung.

Since the release of *RfC Methods* nearly 20 years ago, new scientific developments and advancements have occurred. Scientists now understand inhalation processes better and have improved ways to measure doses of gases. One example of scientific progress is the ability to use computational fluid dynamic models to estimate flow for different regions of the respiratory tract more accurately.

In September 2011, EPA released a summary report on advances in inhalation and gas dose measures for the regions of the lower respiratory tract. It emphasized new data on animal-to-human comparisons and children's inhalation patterns. EPA intends to use the report to support future revisions to the Agency's *RfC Methods* document. The summary report will help EPA use science-based inhalation and dose findings to conduct human health risk assessments.

Training and Education on State-of-the-Art Risk Assessment Practices

Sound environmental decision-making must be based on strong science. Risk assessment is a critical scientific tool used by EPA and others to inform decisions across the United States related to cleaning up the environment and protecting public health.

One of the challenges that the risk assessment community faces is having sufficient, up-to-date information and training on state-of-the-art principles and practices for human health, exposure, and risk assessment. EPA and state environmental agency staff members need comprehensive guidance on how to understand and conduct risk assessments. This is especially true today, when resources are scarce and knowledge about risk assessment is continuously evolving. Well trained risk assessment professionals help ensure that federal, state and local governments are able to effectively and efficiently implement their duties to protect the environment and public health.

In response to these needs, EPA is developing the Risk Assessment Training Experience (RATE) program. Partnering with the Interstate Technology and Regulatory Council (ITRC), affiliated with the Environmental Council of States, EPA will develop cutting-edge risk assessment training that can be used by federal, state and local governments to learn the principles and practices of sound human health risk assessment.

RATE is a comprehensive risk assessment guidance and training program that includes information about the fundamentals of risk assessment; hazard identification; dose-response and exposure assessment; and risk characterization, communication and management. The program will provide instruction through traditional classroom settings, but it will also use Web-based platforms so the courses will be accessible to a geographically dispersed audience.

This innovative program will help ensure that state-of-the-art methods are incorporated into risk assessment practice as they become available. It will also train the next generation of risk assessors and environmental leaders, helping to ensure that environmental decisions across the country are based on sound science and the most current risk assessment practices.

Body Weight and Oral Dose References

Chemical risk assessors frequently rely on animal models when considering the evaluating toxicity. Historically,

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when chemical-specific information for extrapolation to equivalent human oral exposures is unavailable, EPA risk assessors have used direct, that is ratios of 1 to 1, body weight (BW) for noncancer endpoints, and an uncertainty factor, while either BW 3/4 or BW 2/3 has been used for cancer endpoints.

An updated guidance released by EPA in 2011 recommends the use of BW 3/4 for both noncancer and cancer endpoints resulting from oral exposure, providing a hierarchy of approaches for interspecies scaling and laying out a rationale for the selection of 3/4 body weight.

By adopting BW 3/4 as the default for interspecies scaling, EPA takes another step toward harmonizing risk assessment for cancer and noncancer effects. As with many EPA guidance and guideline documents, Recommended Use of Body Weight 3/4 as the Default Method in Derivation of the Oral Reference Dose provides rationale and guidance for federal, state, municipal and international organizations, and has already been adopted by the California EPA as their default method for allometric scaling in their risk assessments.

The guidance document is available at http://www.epa.gov/raf/publications/pdfs/recommended-use-of-bw34.pdf.

Sustainable and Healthy Communities

Meeting the current needs of America's communities without compromising those of future generations is a major priority of the EPA and its researchers. The Agency's Sustainable and Healthy Communities research aims to help community leaders make decisions that meet their needs in ways that preserve the environment and enhance human health and well-being.

In response to the needs expressed by community stakeholders, EPA researchers use a holistic approach that reflects the three pillars of sustainability: economy, society and environment. This work provides the decision-support tools and information that communities need to develop proactive, strategic solutions for a prosperous, environmentally sustainable future.

This section provides highlights of some of the top research results EPA researchers and their partners have achieved in 2011 advancing Sustainable and Health Communities. It illustrates some of the specific impacts that are important to partners of the Agency's Office of Research and Development. The highlights presented were contributed by EPA's research labs, centers, and offices located around the country, and were performed by Agency scientists and engineers, as well as their partners, grantees, fellows, and collaborators from across the scientific community.

Toward Sustainability: Understanding Ecosystem Services

How can researchers identify and evaluate the benefits of a productive ecosystem? EPA and its partners are doing just that in Tampa Bay, Florida. Through a major study of the Tampa Bay estuary and its surrounding wetlands, scientists are demonstrating the critical importance of ecosystem services.

Wetlands protect communities from floods, and rivers and lakes provide food and water. Forests and beaches offer opportunities for recreation and relaxation. Bees pollinate crops. It is difficult to measure the economic value of these types of ecosystem goods and services. Due to this lack of scientific and socioeconomic knowledge about the benefits of nature's services, they have not been considered fully by policy makers and planners.

Working with the Tampa Bay Estuary Program, Tampa Bay Regional Planning Council, local governments, other research entities, and citizen and business groups, EPA's Tampa Bay Ecosystem Services research project aims to fill this knowledge gap.

Tampa Bay is Florida's largest open-water estuary. It supports one of the world's most productive natural systems and it is home to a large and growing urban center. Because residents' use of the ecosystem depends on its quality, it is vital that planners consider the value of ecosystem goods and services in land-use decisions.

The Tampa Bay study seeks to quantify the value of the goods and services currently provided by the Tampa Bay ecosystem. Scientists are working with ecological economists to measure their monetary and non-monetary values for human well-being. The scientists will model the relationships between stressors (i.e., factors that damage the ecosystem), ecosystem structure and function, and ecosystem services. They also will assess the likely change in environmental stressors and land-use patterns through 2050, and use a Web-based tool to characterize the effects on ecosystem services and human well-being.

The Tampa Bay project will ultimately enable decision makers to value nature's benefits more accurately, promoting sustainable development and improving environmental planning.

Ecosystem Services of Coral Reefs

Among the most biologically diverse ecosystems on earth and the largest living structures, tropical coral reefs are portals for exploration. They supply food in the form of habitat for important fishery species, protect shorelines, improve water quality, and provide opportunities for sport fishing, education and recreation.

Unfortunately, coral reefs are also one of the most threatened marine ecosystems. Coral reefs are sensitive because of their highly specific requirements for temperature, salinity, oxygen, light, and nutrients. Pollution, disease, climate change, physical contact, habitat destruction, and sediment buildup can all threaten these fragile ecosystems.

In 2011, Agency researchers completed analyses of coral reef surveys conducted in collaboration with partners from the U.S. Virgin Islands Department of Natural Resources in the waters around the U.S. Virgin Islands (USVI). The surveys provided a regional characterization of the number, species, sizes and condition of reef-building corals in the study area.

Measurements made during the survey provided a baseline of coral reef condition, and the information can be used by USVI to generate water quality criteria for coral reef ecosystems under the Clean Water Act. Additionally, the data can be used to estimate quantities of the ecosystem services, or benefits, they provide for the people of the USVI, including fishing, recreation and tourism, shoreline protection, and potential sources for new pharmaceuticals.

Developing methods that better characterize the benefits coral reef ecosystems provide will help stakeholders consider reef condition when making decisions in the coastal zone and in the watershed. Methods to estimate coral reef ecosystem services are currently under consideration for compensatory mitigation assessment of anticipated coral reef losses in Guam. Assessment of ecosystem services, instead of simple acreage replacement, may set an important precedent for future coral reef mitigation decisions by addressing human benefits and losses.

In addition, EPA research on Caribbean near-shore coral reefs found strong correlations between landscape development intensity (LDI) in the watershed and coral reef health, as measured by coral colony density, species richness, colony size, and the three-dimensional total area of coral reef cover. The LDI index that the researchers used proved to be a robust and effective indicator of human impact on the reefs, and further refinement of this tool will help with land-use planning and prioritization of conservation efforts. Results of the work were presented in the *Marine Ecology Progress Series* (April, 2011).

Developing methods to accurately quantify the ecosystem services provided by the coral reefs of the U.S. Virgin Islands and elsewhere will be a critical step in sustaining those benefits for current and future generations. Protection of coral reefs through water quality standards and the Clean Water Act will sustain the living organisms that provide those benefits.

Mapping Nature's Benefits: A National Atlas for Sustainability

Fresh air, clean water, safe food—these are important parts of daily life, but where exactly do they come from, and what factors limit or increase our access to them? The nation's ecosystems provide a vast array of what scientists refer to as "ecosystem services," ranging from clean and abundant water to recreational opportunities. However, these benefits are often taken for granted and not fully considered in environmental decision-making, at least partly because they are not well understood or characterized.

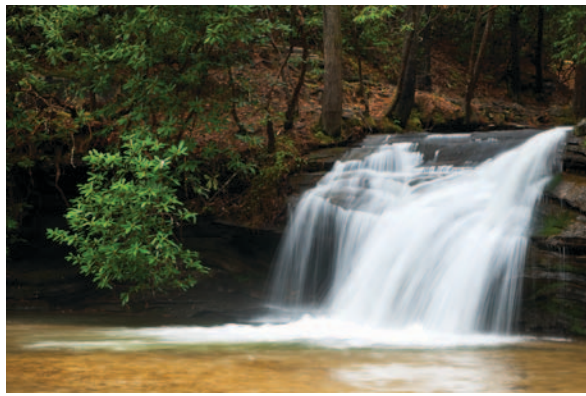
EPA researchers are collaborating with the USDA Forest Service and Natural Resource Conservation Service, US Geological Survey, National Geographic, NatureServ, and other partners to assemble the first ever *National Atlas for Sustainability*, a web-based mapping application that will show how environmental assets are distributed across the country. The easy-to-use tool will allow resource managers to display the types of services provided by nature in their selected area, examine factors that affect their condition and distribution, and evaluate current and future societal demand. Using this tool, the true value of ecosystem services may be considered for management decisions.

The categories of ecosystem services included in the Atlas are:

- Clean water for drinking
- Clean water for recreation and aquatic habitat
- Adequate water supply
- Food, fuel and fiber
- Recreational, cultural and aesthetic amenities
- Climate regulation
- Protection from hazardous weather
- Habitat and the maintenance of biodiversity
- Clean air

Using the best available scientific data, the National Atlas makes it simple and intuitive for anyone to learn about these resources.

The Atlas will also feature more detailed data for 50 to 250 cities and towns across the country. The "Urban Atlas," as this part of the tool is called, will include high-resolution maps and interpretive information on community characteristics such as: proximity to parks; demand for drinking water; the estimated health benefits of urban tree cover; walkability



measures, and; "heat stress" due to the built environment. Using this tool, communities will be able to identify the areas in their environments that provide needed benefit, and develop strategies to preserve, restore, and expand them. The "Urban Atlas" is featured in the Administrator's PLAN EJ 2014 for its ability to illustrate how and where community green infrastructure can benefit highly vulnerable, under-served, and disproportionately-burdened populations.

Future Atlas efforts will incorporate additional aspects of sustainability in the areas of housing, transportation and other urban infrastructure, and waste management, in collaboration with EPA's Office of Sustainable Communities and other EPA Program Offices, and EPA Regional Offices.

Measuring Sustainability

Sustainability is a simple but powerful principle that recognizes that the natural environment is the foundation for human survival and well-being. Achieving sustainability means creating and maintaining the conditions with which people and nature can coexist in productive harmony—conditions that provide present and future generations with food and resources, as well as social, economic and other human needs. Developing the science and engineering needed to inform progress in that direction is the "true north" of EPA's collective research and development efforts.

How do we know whether the environmental health of a region is declining or improving? EPA scientists piloted ways to measure and monitor prosperity and environmental quality by studying a large area of south-central Colorado, the San Luis Basin. For this, a multidisciplinary team of EPA scientists examined how fundamental components of the local environmental system relate to key aspects of human well-being, including social and economic factors. The research team set out to develop a straightforward, affordable method to measure and monitor important sustainability conditions for the area. To do so, researchers set three primary objectives: (1) determine if existing historical data sets could be used to estimate sustainability at a regional scale; (2) calculate these sustainability metrics through time (1980–2005); and (3) compare and contrast the results they found to determine if the region is moving toward or away from sustainability.

The team used available environmental, economic, and social data to calculate sustainability across four different metrics (standards of measurement), with each providing the following select insights:

- the "ecological footprint" metric linked the total area of biologically-productive land available with measurements of human consumption and waste generation;
- the "Green Net Regional Product" metric displayed how much "natural capital" is being used or conserved;
- the "Emergy" metric explored energy flows and inputs; and
- the "Fisher Information and Order" metric indicated the overall stability and order of natural systems.

Together, the four metrics provide information to answer some basic questions central to determining sustainability: How well can a region cope with change? How healthy is it economically? Is its energy use self-sufficient? Is its human population causing ecological damage?

A study on the fate of snowpack in the high mountains surrounding the San Luis Valley demonstrated how these Sustainability metrics can be used to illuminate threats to a region's long-term sustainability. Water is "stored" at high elevations in the form of the snowpack; as it melts, it recharges the groundwater and maintains unique geological and ecological features of the valley, like the Great Sand Dunes and wetlands. One policy-relevant consequence of this fact is that the natural and agricultural systems of the region are vulnerable to climate changes that affect the snowpack.

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Tradeoffs in Pursuit of Sustainability: Ecosystem Services and Biofuels

Mandates to produce biofuels from corn feedstock under the Energy and Independence Act of 2007 could lead to changes in land use and other factors. EPA's Future Midwestern Landscapes (FML) study, a place-based ecosystem services study covering a 12-state region of the upper Midwest, has completed development of a base-year landscape (ca. 2002) and a future (ca. 2020) projection of potential land use changes.

EPA researchers combined landuse/ landcover satellite imagery with digital cropland data from the U.S. Department of Agriculture to characterize agricultural management practices, including the use of chemical inputs, such as fertilizers and pesticides. This allowed them to assess impacts expected to occur as farmers increase the acreage of crops put in continuous corn rotation (year round) instead of rotating between corn and other crops, such as soybeans. This change in agricultural management is significant because continuous corn rotations require much higher levels of chemical inputs to maintain crop productivity.

The FML study also developed an improved water quality model that allows both estimates of runoff into surface water at a regional scale (important to estimate inputs to the Gulf of Mexico) and at a watershed scale (important to understand where best management practices would be most effective in reducing runoff). The model is simpler to use than existing regional and watershed scale models, requiring fewer data inputs, and showing improved predictability.

A prototype interactive Webtool is available to collaborators and clients (e.g. Fish and Wildlife Service, Army Corps of Engineers, Farm Service Agency) that projects the implications of agricultural management changes on a suite of ecosystem services, including water quality, habitat for migratory bird species, recreational opportunities, and more. Additional analyses are underway to characterize how agricultural management impacts air quality and associated human health outcomes.

Research Applied to Community Clean up

EPA researchers spent years developing a method to sequester lead in place by adding phosphate to contaminated soil. Lead, which is easily absorbed by children and leads to developmental deficits, can come from industrial waste, paints, and residues from old automotive fuel. Adding phosphate to the soil converts the lead to a less harmful form, thereby reducing children's risk without expensive and disruptive excavation projects.

In 2011, an On-Scene Coordinator in EPA's Region 9 (Pacific Southwest) worked collaboratively with the regional toxicologist and scientists from two EPA laboratories to successfully pilot this methodology. They applied the phosphate

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treatment and other sustainability-minded practices to clean up yards in a poor neighborhood in Oakland, California known for occurrences of lead poisoning.

The treatment, using a phosphate-rich fish bone waste product, was combined with mechanical isolation. Using a local business and labor center provided jobs in the community while investing residents in improving their health and environment. Costs for this innovative cleanup were 40% lower than conventional excavation and backfilling.

Measuring and Communicating Sustainability

A critical task for advancing research to support sustainable and healthy communities is the development of an inventory of existing sustainability indicators. To that end, a cross-organizational workgroup of EPA researchers and others reviewed indicators at various scales (national, regional, etc.), and developed a searchable database with linkages to EPA programs.

Nearly 1630 indicators were organized and classified, providing a "lay of the land" of existing indicators of varying scale, scope and topic. (Remaining indicators will be synthesized, classified and incorporated during subsequent annual updates.)

Future enhancement of the database will create an interactive, searchable web-based tool accessible to communities, allowing users to develop a "customized" list of suggested indicators and indices to support sustainability activities, such as cost-benefit analysis, monitoring and assessment, and community outreach.

As part of this work, EPA researchers are currently developing a measure that estimates overall environmental quality at the county level across the U.S. spanning the years 2000 – 2005. A prototype version of this Environmental Quality Index (EQI) has been developed, taking into account five domains that influence exposure and health: air, water, land, built, and sociodemographic environments.

In addition, EPA researchers have developed indicators and indices descriptive of human well-being that can be used in predictive models for evaluating the sustainability of alternative decisions influencing economic, social and environmental sectors. They have selected candidate metrics and indicators to develop a Human Well-being Index (HWBI) for the U.S. Current work is underway to modify and apply the index at various scales, as well as for different community typologies, including tribal communities specifically, that will be identified in other SHC research.

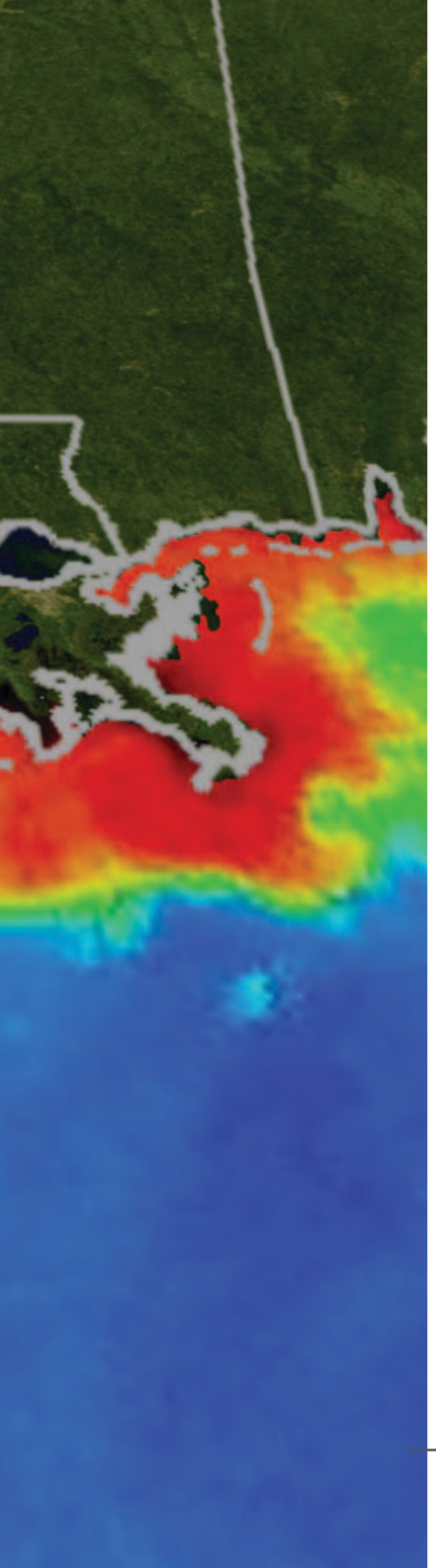
Community and Tribal-Focused Tools for Environmental Health Issues

In 2011, EPA scientists continued their development work on two easy-to-use, science-based geospatial tools designed to help communities and tribes prioritize environmental issues and identify ways to help reduce environmental risks, the:

1) Community-Focused Exposure and Risk Screening Tool (C-FERST), and
2) Tribal-Focused Environmental Risk and Sustainability Tool (Tribal-FERST).

During the year, EPA researchers conducted initial C-FERST pilot studies in collaboration with the EPA Community Action for Renewed Environment (CARE) program. Based on feedback from CARE community partners in Springfield, MA and Portland, ME, and EPA's Region 1(New England), C-FERST was enhanced for community issue identification and prioritization applications.

Researchers also initiated a Tribal-FERST



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pilot study with the Pleasant Point Passamaquoddy Tribe in Maine, and have partnered with the United South and Eastern Tribes (USET) to develop a tribally-focused guidance document and to connect USET's water quality exchange database and data transfer network with Tribal-FERST.

(For more information on C-FERST, see http://www.epa.gov/heasd/c-ferst; for more information on Tribal-FERST, see *Tribal Science* on page 98 of this document).

Update of the Electronic Report on the Environment

EPA's annual *Report on the Environment* (ROE) summarizes measurements that portray environmental conditions across the nation. The information in the ROE helps community leaders make good decisions about environmental education, training, policy and implementation. The indicators in the ROE describe conditions and trends associated with air, water, land, human health, and ecological systems at the national and regional level. EPA determines values for the indicators from actual measurements gathered for specific

areas at specific times. Cancer incidence, air toxic emissions and pesticide residues in food are some examples.

Successful ROE indicator developments and updates depend on data generated from monitoring by multiple federal agencies. Each agency follows an independent schedule for collecting new data and releasing it to the public. Advances in measurement technology, sample design, quality assurance and topics covered have made it possible to create a more complete environmental snapshot.

The ROE is available in electronic form on EPA's website. EPA updates the ROE indicators every three months in March, June, September and December. www.epa.gov/roe/

Help for Hypoxia

Excessive amounts of nutrient pollution—nitrogen and phosphorus—reaching the northern Gulf of Mexico have sparked cycles of algae growth and decay that have, in turn, led to an area of low dissolved oxygen. This "hypoxic zone" causes serious problems for aquatic organisms, threatening the ecological and economic health of one of the nation's largest and most productive fisheries.

The highest levels of nitrogen and phosphorus delivered to the Gulf come from watersheds in the central and eastern portions of the Mississippi River Basin that are drained by large, fast flowing rivers where little nitrogen and phosphorus are removed by natural processes.

Recently, EPA researchers have provided a new and more detailed understanding of the ecological processes that impact development of hypoxia in the area. The results significantly increase the data available for the region. They show that sediment oxygen consumption is a small component of total oxygen consumption for the system, relative to that of drifting organisms, including animals, plants, or

Satellite image showing algal bloom in the Gulf of Mexico. Photo courtesy of NASA/Goddard Space Flight Center Scientific Visualization Stuidio.

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bacteria that live in open waters. The results contradict earlier well-cited studies, and are being used to support the water-quality simulation models that provide important information for managing the impact of nutrients from the Mississippi/ Atchafalaya River Basin on the northern Gulf ecosystem.

Supporting Grizzly Bear Decision

In 1975, the U.S. Fish and Wildlife Service (FWS) added grizzly bears to a list of threatened species in the contiguous United States (the lower 48 states discounting Alaska and Hawaii). Protected by the Endangered Species Act, the grizzly bear population has slowly increased. However, a beetle infestation killing whitebark pine trees, a staple food source in grizzly bear country, suggests that the grizzly population is not yet in the clear.

EPA research recently helped settle a dispute over the status of these grizzly bears. In 2007, FWS removed grizzly bears from the threatened species list. This action prompted a court case that lasted four years. On November 2, 2011, the 9th District Court of Appeals upheld a lower court ruling keeping the grizzly bear on the threatened species list.

Support for this ruling came in the form of a scientific paper by EPA and partners that demonstrates the importance of whitebark pine nuts in Yellowstone grizzly bear diets. The court quoted the researchers' conclusion that "Grizzly bear survival in the Greater Yellowstone Ecosystem is strongly linked to variation in pine-nut availability." In light of the ongoing decline of whitebark pine, the court decided the grizzly population should remain under Endangered Species Act protection.

As described in the paper, scientists utilized the IsoSource model developed at EPA to estimate the importance of various foods in grizzly bear diets based on the stable isotope composition of the foods and grizzly bear tissue. This isotopic mixing model has been used widely throughout the world for such food web studies, as well as for other applications such as determining the proportions of various pollutant sources in air and water pollution studies.

Supporting EPA Research Partners for Sustainable and Healthy Communities

EPA supports the nation's leading scientists and engineers to facilitate the pursuit of high-quality research to build a strong scientific foundation for Agency actions and decisions. In addition, EPA researchers cultivate and maintain partnerships with colleagues at colleges, universities, research centers, sister federal and state agencies and other institutions to collaborate and advance sustainable and healthy communities.

The Agency awards research grants and awards in a diversity of environmental science and engineering disciplines—including work in *Sustainable and Healthy Communities*—through its Science

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to Achieve Results (STAR) program. Accomplishments of EPA partners in the areas of Sustainable and Healthy Communities for 2011 include the following.

Mold and Childhood Asthma

Research conducted as part of the Cincinnati Childhood Allergy and Air Pollution study found that infants exposed to "high concentrations" of mold in homes are four times more likely to develop asthma by age seven. The study, conducted by EPA scientists, Cincinnati Children's Hospital physicians, and the Department of Environmental Health at the University of Cincinnati, is the first of its kind to show this statistical relationship. The team's physicians concluded that this study "provides impetus to reduce the mold burden in infants' homes..."

The Cincinnati team followed the health of a cohort of infants and monitored their environment over seven years. They showed that the exposure to high "moldiness" conditions at home during the first year of life was critical to later development of physician-diagnosed asthma. No other exposure monitored was predictive of asthma development.

The Cincinnati team published the study, entitled *High Environmental Relative Moldiness Index During Infancy as a Predictor of Asthma at 7 Years of Age*, in the Annals of Allergy, Asthma and Immunology.

Researchers defined the level of "moldiness" in homes using the Environmental Relative Moldiness Index (ERMI) scale. The ERMI scale was developed by EPA scientists as a result of a DNA-based analysis of 36 indicator molds and a random sampling and analysis of U.S. homes (performed in conjunction with HUD). The ERMI metric research tool is now being used in other epidemiological studies of mold exposure and health outcomes.

Children's Environmental Health and Disease Prevention Research Centers

EPA has partnered with the National Institute of Environmental Health Sciences (NIEHS) to jointly support research centers devoted exclusively to children's environmental health and disease prevention.

The Centers utilize the expertise and resources of top universities and medical

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centers to focus on the important role that environmental toxicants play in the development of many childhood illnesses.

Through a multidisciplinary research approach including basic, applied, and community-based participatory research, the Centers translate and communicate their findings to clinical and public health professionals and policy makers to help protect children from environmentally-induced diseases.

Examples of research results in 2011 are highlighted below.

EPA Science Supports Environmental Justice

Fourteen EPA-commissioned scientific reviews and one summary overview examining the science of environmental justice were completed in 2011. The papers help explain why certain populations—minority, low income, and Native American—experience disproportionate environmental health risks.

The papers were published in the *American Journal of Public Health*, and were released during an EPA-hosted special session at the 139th annual meeting of the American Public Health Association.

In addition, EPA developed the report, An Update on Ongoing and Future EPA Activities to Empower Communities, and Advance the Integration of Environmental Justice in Decision Making and Research. The report highlights ongoing and future Agency actions in response to needs raised at *Strengthening Environmental Justice Research and Decision Making: A Symposium on the Science of Disproportionate Environmental Health Impacts*, a scientific symposium co-sponsored by the Agency in 2010.

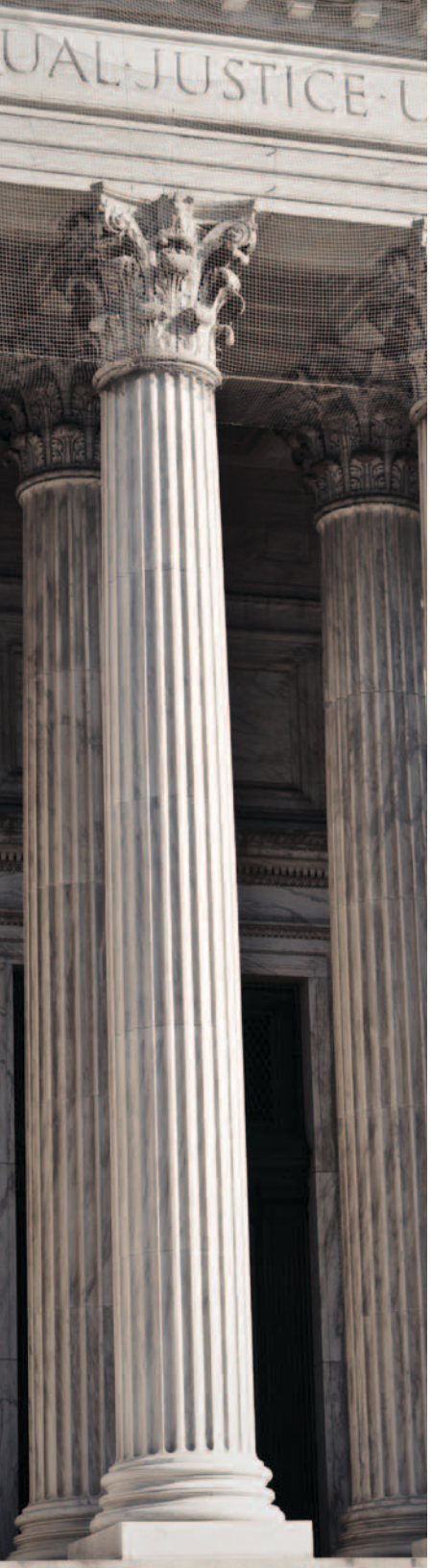
Also, EPA researchers are working to provide user-friendly, accessible tools that enable communities to define problems associated with disproportionate environmental exposures and health impacts. One such tool currently in development is the prototype *Community Cumulative Assessment Tool*, or CCAT, which guides users through the various steps of a cumulative risk-environmental justice assessment.

With CCAT, users can define objectives, create a partnership database, define the geographic and technical scope of the assessment, develop conceptual models, gather information, rank risks, and explore risk mitigation options. With this kind of information available, communities can better locate the source of problems and improve conditions for everyone.

Advancing the Understanding of Arsenic and Diet

A study by a team of scientists from the Children's Environmental Health and Disease Prevention Research Center at Dartmouth College advanced the understanding of the dietary sources of human exposure to arsenic.

The study measured the arsenic levels in urine samples from 229 pregnant women living in New Hampshire, and found that the level was significantly higher for women who had eaten rice within two days of the testing. Researchers are investigating whether the combined level of arsenic from both water and food could affect the health of the developing fetus and



young children.

Results were published in the Proceedings of the National Academy of Sciences. [Diane Gilbert-Diamond, Kathryn L. Cottingham, Joann F. Gruber, Tracy Punshon, Vicki Sayarath, A. Jay Gandolfi, Emily R. Baker, Brian P. Jackson, Carol L. Folt, and Margaret R. Karagas. *Rice consumption contributes to arsenic exposure in US women* PNAS 2011 : 1109127108v1-201109127.]

(For more information, see Prenatal Exposure to Pesticides Linked to IQ Deficits on page 38.)

Prenatal Exposure to Organophosphate Pesticides and IQ Deficits

Three independent investigations on prenatal exposures to organophosphate (OP) pesticides, from three Children's Environmental Health Research Centers, were published in 2011 in the peer-reviewed journal *Environmental Health Perspectives (EHP)*.

All three studies reached similar conclusions associating prenatal exposure to OP pesticides with IQ deficits in school-age children. All three found some evidence of an association between OP exposures in utero and negative impacts on intelligence and mental development at around seven years of age, including working memory, processing speed, verbal comprehension, perceptual reasoning, and full scale IQ.

The three studies were conducted at the University of California, Berkeley, School of Public Health; the Mailman School of Public Health at Columbia University; and Mount Sinai School of Medicine. All three involved cohorts of women enrolled during pregnancy.

(Also see *Study Improves Understanding of Arsenic in Food*, page 39.)

Citations for the three papers:

Engel SM, Wetmur J, Chen J, Zhu C, Barr DB, et al. 2011 *Prenatal Exposure to Organophosphates, Paraoxonase 1, and Cognitive Development in Childhood. Environ Health Perspect* 119(8): doi:10.1289/ehp.1003183

Bouchard MF, Chevrier J, Harley KG, Kogut K, Vedar M, et al. 2011 *Prenatal Exposure to Organophosphate Pesticides and IQ in 7-Year-Old* Children. Environ *Health Perspect* 119(8): doi:10.1289/ehp.1003185

Rauh V, Arunajadai S, Horton M, Perera F, Hoepner L, et al. 2011 *Seven-Year Neurodevelopmental Scores and Prenatal Exposure to Chlorpyrifos, a Common Agricultural Pesticide. Environ Health Perspect* 119(8): doi:10.1289/ehp.1003160

Safe and Sustainable Water Resources

Increasing demands are being placed on the nation's finite water resources that supply drinking water, provide water for other societal needs (including energy, agriculture and industry), and support healthy aquatic ecosystems.

EPA's Safe and Sustainable Water Resources research provides the science and innovative technologies that the Agency—and the nation—need to maintain drinking water sources and systems, as well as to protect the chemical, physical and biological integrity of our waters. Scientists and engineers are addressing 21st century water infrastructure and supply challenges by integrating research on social, environmental and economic factors to provide lasting, sustainable solutions.

This section features 2011 research achievements that are advancing safe and sustainable water resources.

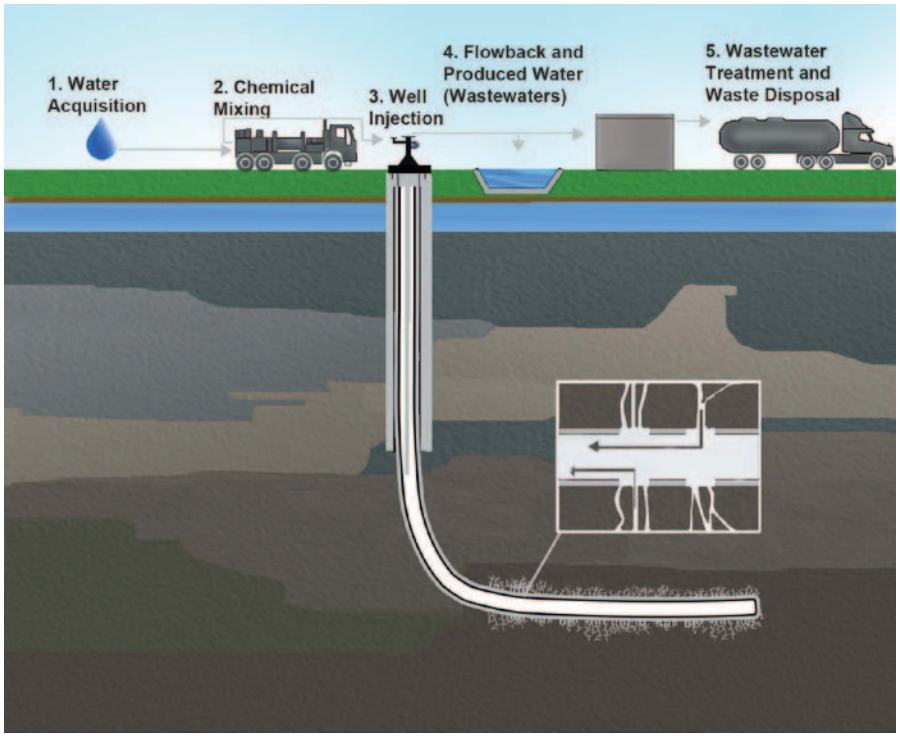
This section provides highlights of some of the top research results EPA researchers and their partners have achieved in 2011 advancing Safe and Sustainable Water Resources. It illustrates some of the specific impacts that are important to partners of the Agency's Office of Research and Development. The highlights presented were contributed by EPA's research labs, centers, and offices located around the country, and were performed by Agency scientists and engineers, as well as their partners, grantees, fellows, and collaborators from across the scientific community.

EPA Releases Final Research Plan on Hydraulic Fracturing

In November 2011, EPA announced the release of its final research plan to provide the key pieces of research needed to answer questions about the potential impacts of hydraulic fracturing on drinking water resources.

The U.S. Congress identified the need for a focused scientific study to determine potential impacts, if any, of hydraulic fracturing (HF) on drinking water. The stimulation technique known as hydraulic fracturing is used to release natural gas and oil from underground reservoirs. In March 2010, it requested that EPA conduct such a study.

To fulfill this request, EPA researchers began to develop a study plan, providing extensive opportunities for input from across the scientific community, industry, stakeholders and partners, and other interested parties and individuals. A draft study plan, incorporating such input, was reviewed by the Science Advisory Board (SAB), an independent panel of scientists. SAB found the study approach to be both appropriate and comprehensive.



The final plan to study the potential impacts of hydraulic fracturing on drinking water resources, calls for EPA researchers to look at the full cycle of water as it is used in hydraulic fracturing, from acquisition, to the addition of chemicals and other substances, to the actual fracturing of subterranean rock, and through the post-fracturing stage, including the treatment and disposal of water used during the processes. This work includes examining the potential impacts of large volume water withdrawals from groundwater and surface water resources; determining the potential effects of surface spills of HF fluids and chemicals; identifying potential impacts of the injection and fracturing process; and looking at the adequacy of wastewater treatment and disposal.

The research will involve laboratory studies, scenario evaluations, reviews of existing data, toxicity assessments and case studies. Case studies are located in DeSoto Parish, LA, and Washington County, PA, Kildeer and Dunn Counties, ND, Wise and Denton Counties, TX, Bradford and Susquehanna Counties, PA, and Las Animas County, CO.

To promote transparency, an EPA website provides information about the study, including the study plan and background (http://www.epa.gov/hfstudy). EPA has a more comprehensive hydraulic fracturing website that includes detailed hydraulic fracturing information, descriptions of hydraulic fracturing processes, and information on the regulations surrounding hydraulic fracturing (http://www.epa.gov/hydraulicfracturing/).

Untapping Innovation: Water Technology Innovation Cluster

EPA Administrator Lisa P. Jackson (at podium) and Karen Mills, Administrator for the U.S. Small Business Administration (seated), at the Water Technology Innovation Cluster announcement.

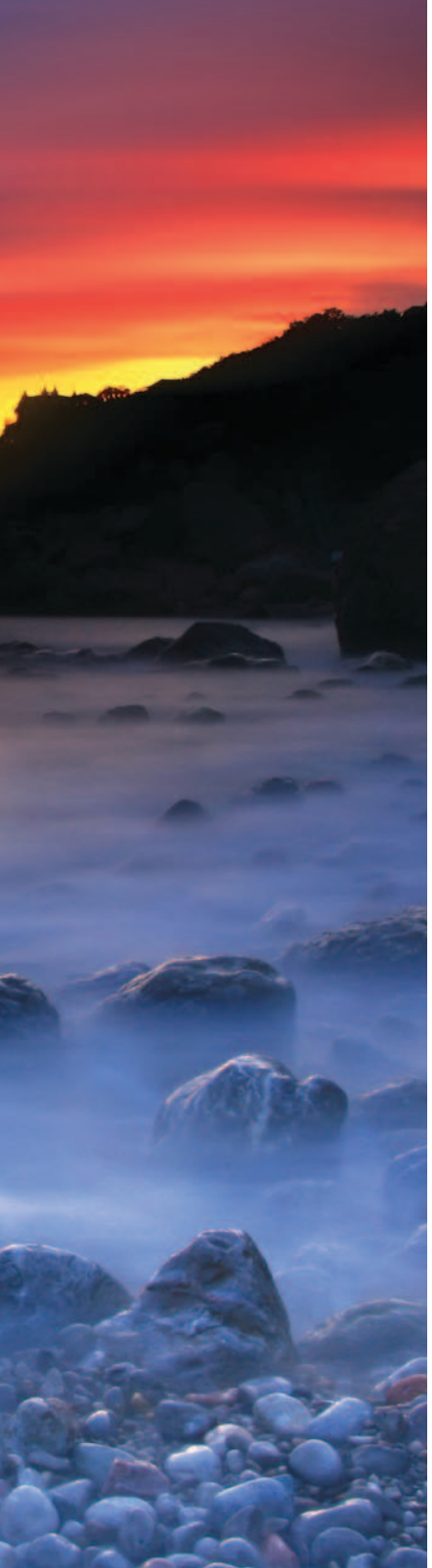
On January 18, 2011, EPA Administrator Lisa P. Jackson joined Karen Mills, Administrator for the U.S. Small Business Administration (SBA), to announce the formation of the Water Technology Innovation Cluster (WTIC).

A regional technology cluster such as WTIC is a geographic concentration of firms and supporting institutions that are committed to building a vibrant, technology-driven economy with a particular focus area. The Cincinnati region was selected for WTIC because it contains key ingredients for a successful cluster focused on water, including EPA's internationally recognized water research laboratory, and many proactive water utilities, such as the Greater Cincinnati Water Works (GCWW).

The new cluster will bring innovative water quality technologies to market and create jobs. During her opening remarks, Administrator Jackson pointed out that innovation is the 'sweet spot' where economic and environmental interests meet.

WTIC includes venture capitalists, commercial developers, technology firms, water utilities, economic development forums, academia, and local governments from Southwestern Ohio, Northern Kentucky, and Southeastern Indiana. It brings together a critical mass of public utilities, research partners, and innovative businesses in the name of strengthening health protections for millions of Americans and promoting investments in cutting-edge water technology.

One illustrative project conducted at WTIC is a collaboration between EPA and Cincinnati's GCWW to explore the effects of distribution infrastructures on water quality. For example, water might test "safe" when leaving a water treatment plant, but what happens to its quality as it flows through many miles of old pipe before splashing into someone's water glass is not always known. To provide answers, EPA and GCWW partners have established one of the first real-time, system-wide monitoring systems to assess water as it makes it journey away from the treatment plant. Cincinnati serves as the



Untapping Innovation: Water Technology Innovation Cluster, *Cont'd.*

first test site, and the technology has now been extended to three other cities.

WTIC's initial focus is on drinking water, with $5 million in EPA Science to Achieve Results (STAR) grants dedicated to clean drinking water research and the formation of the National Center for Innovative Drinking Water Treatment Technology.

The cluster also will support the development of green infrastructure projects, including two currently underway in the Cincinnati area: rain gardens at Shepherd Creek, and a collaboration with the Cincinnati Metropolitan Sewer District to redirect stormwater to create a new above-ground stream in the Lick Run Watershed.

Many small businesses in the regional area are engaged in water science and technology development, and $1.5 million will be available to these companies through grants from EPA's Small Business Innovation Research (SBIR) program to develop innovative technologies with water applications. EPA's SBIR program provides incentive funding to small businesses to translate their inventive ideas into commercial products that address environmental problems.

EPA Issues Draft National Coastal Condition Report IV

Millions of people flock to the coast every year for rest, rejuvenation, and recreation. And beyond a day at the beach, the sandy shores, mangroves, bays, estuaries and other coastal habitats that offer so much enjoyment also provide a host of other important benefits: habitat for a diversity of wildlife and birds; spawning and "nursery grounds" for many of the fish and shellfish that make up the bulk of the nation's 4.5-billion-dollar domestic sea food industry; and natural flood protection and water filtration, for example.

Understanding the condition of coastal waters and identifying areas that are in need of improvement are critical for maintaining the health and sustainability of coastal ecosystems, and priorities for scientists at the U.S. Environmental Protection Agency. Their work was a major contributor to the production of the Agency's *National Coastal Condition Report IV*, the fourth in a series of environmental assessments of U.S. coastal waters and the Great Lakes.

The report presents an assessment of coastal water conditions based on data collected from 2003 to 2006, and includes assessments of all the nation's estuaries in the contiguous 48 states and Puerto Rico, southeastern Alaska, Hawaii, and—for the first time—the U.S. Virgin Islands, Guam, and American Samoa. Changes over time from 1990 to 2006 are presented nationally and regionally.

EPA Issues Draft National Coastal Condition Report IV, *Cont'd.*

Although the overall condition of U.S. coastal waters is rated as fair in all four reports, a comparison of the condition scores shows that the overall condition of U.S. coastal waters has improved slightly since the 1990s.

The *National Coastal Condition Report IV* (NCCR IV) relies on coastal monitoring data from EPA's *National Coastal Assessment* (NCA) to assess coastal conditions, and presents four main types of data obtained from nationally consistent monitoring surveys collected at more than 3,100 sites: 1) coastal monitoring data; 2) coastal ocean/offshore monitoring data; 3) offshore fisheries data; and 4) assessment and advisory data—new to NCCR IV.

The data are the result of collaborations between EPA, the National Oceanic and Atmospheric Administration, the U.S. Fish and Wildlife Service, and coastal state agencies to assess the condition of the nation's coastal resources. Collaborating agencies strive to provide a detailed picture of the nation's coastal resources and to communicate these findings to the public, coastal managers, scientists, Members of Congress, and other elected officials.

The report concludes that the overall condition of the nation's coastal waters is fair. Five key indices of coastal conditions were: 1) water quality index; 2) sediment quality index (including sediment toxicity, sediment contaminants, and sediment total organic carbon (TOC); 3) benthic index; 4) coastal habitat index; and 5) fish tissue contaminants index.

For each of these five key indicators, a score of good, fair or poor was assigned to each coastal region of the United States. These ratings were averaged to create the overall regional and national scores. Component indicators for the water quality index, including dissolved oxygen, inorganic nitrogen, inorganic phosphorus, chlorophyll a, and water clarity, also were assessed.

The coastal habitat, sediment quality, and benthic indices show the poorest conditions throughout the United States. The indicators that show the best conditions are the individual components of water quality: dissolved oxygen, dissolved inorganic nitrogen, and sediment TOC. Water quality analyses indicated that 56 percent of assessed resources are in good condition, 35 percent are in fair condition, and 6 percent are in poor condition. Fourteen percent of estuarine waters are impaired based on the water clarity data presented in this report. Thirteen percent of estuarine waters are not suited for fishing, based on risk-based non-cancer guidelines for moderate consumption.

The report provides clear, accessible information to support informed decisions concerning protection of the nation's coastal environments, and its impacts will include increased public awareness and, it is hoped, actions to sustain and improve coastal conditions.

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Soaking it In: Green Infrastructure for Stormwater Management

In many U.S. cities, rainwater flows over impervious, man-made surfaces such as roofs and paved roads instead of more naturalistic areas such as forests or grasslands. The resulting runoff flows through traditional drainage pipes into what is called a combined sewer system. Consequently, when large rainstorms dump massive amounts of water, these sewer systems become susceptible to overflows and backups. Combined sewer overflows cause great risks to environmental and human health, flooding basements and contaminating water resources with human and industrial waste.

EPA researchers are investigating ways to use green infrastructure to efficiently and effectively curb combined sewer overflow occurances. Green infrastructure refers to wet weather management that is sustainable and environmentally friendly.

An ongoing study in the Shepherd Creek watershed of Cincinnati used an economic

incentive to encourage residents to adopt individual stormwater management practices of rain gardens and rain barrels. Rain barrels catch and store rainwater runoff from house roofs, and rain gardens help detain runoff on the ground. Researchers monitored the effectiveness of these installations in reducing overall stormwater runoff, measuring a small but significant change in water levels. Models predict a resulting 5–20 percent decrease in stormwater outflow due to the use of these green infrastructure practices. A final report on this study is currently in review and is planned for release in 2012.

EPA researchers are also partnering with municipalities to plan and implement stormwater management strategies including green infrastructure practices. For example, in Cleveland, OH, Agency scientists worked on a team to propose best stormwater management practices in response to a combined sewer overflow consent decree for the city. The proposal, currently in review, addresses stormwater management concerns with a variety of techniques such as measures to control the sources of runoff and thoughtful landscape planning of old and abandoned city sites.

Ideally, these projects will yield results that can be generalized to fit other systems and help lead the way to green stormwater management practices being adopted on a much larger scale throughout the United States and abroad.

Rain barrel installation collects water and reduces runoff, part of EPA's "green infrastructure" study in the Shepherd Creek watershed of Ohio.

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EPA Advances Scientific Understanding of Mountaintop Mining

Mountaintop mining is a form of surface coal mining in which miners remove plant life and the upper sections of soil with heavy equipment. They then use explosives to expose coal for extraction and dump the waste earth and rock in nearby valleys in a process called "valleyfill." As a result, mining waste buries the streams in these valleys. To date, mountaintop mining has buried an estimated 2,000 miles of small, upper-level Appalachian streams.

In April 2010, EPA announced that it would take action to clarify the environmental permit requirements for Appalachian mountaintop removal and other surface coal mining projects. These permit requirements protect Appalachian ecosystems in accordance with the Clean Water Act. One year later, in May 2011, EPA released two final reports that provide the best available science on the environmental impacts of mountaintop mining.

The first report, *The Effects of Mountaintop Mines and Valley Fills on Aquatic Ecosystems of the Central Appalachian Coalfields*, provides a state-of-the-science assessment on the ecological impacts of mountaintop mining and valleyfill operations. The report describes how mountaintop mining causes the permanent loss of springs, intermittent streams and small perennial streams. The chemical effects include persistent increases in major chemical ion concentrations downstream, decreases in water quality to levels acutely lethal to standard laboratory test organisms and elevation of selenium concentrations to levels often toxic to fish and birds. As a result, mountaintop mining produces consistent and significant degradation of small aquatic animal and fish communities.

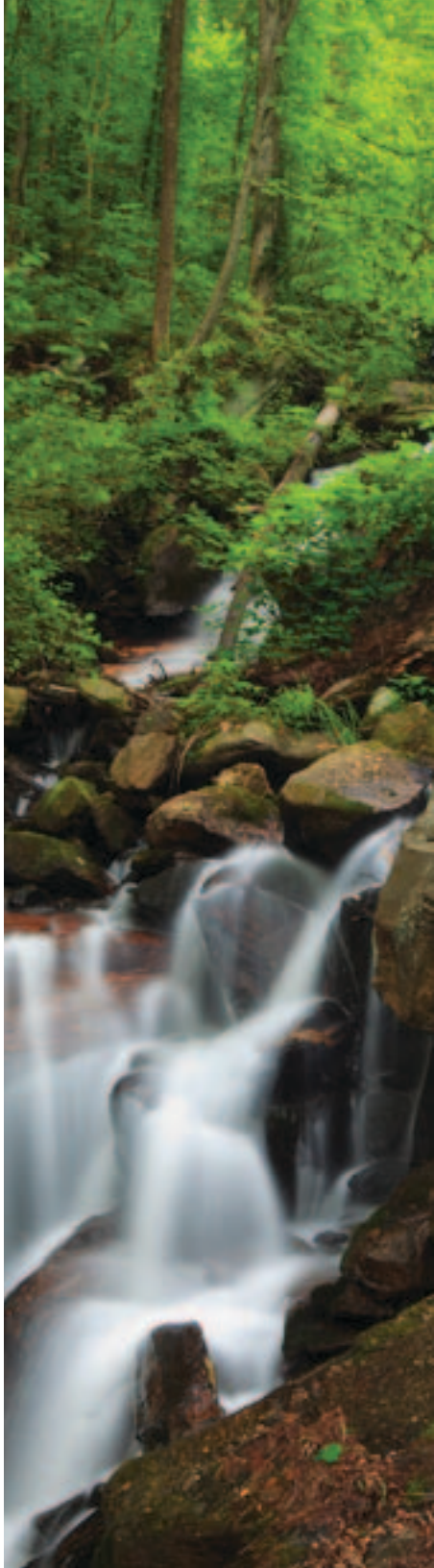
The second report, *A Field-Based Aquatic Life Benchmark for Conductivity in Central Appalachian Streams*, describes the science behind the water quality benchmarks. These benchmarks are designed to protect the aquatic organisms that live in Appalachian surface waters. They were developed by adapting the standard U.S. EPA methodology for deriving ambient water quality criteria to develop a protective benchmark for a mixture of salts in freshwater. The benchmark was derived for Central Appalachian streams using data from West Virginia; data from Kentucky were used to validate it.

EPA and Army Join Forces for Sustainability

The EPA has agreed to provide innovative research and technology to support the U.S. Army's Net Zero initiative for sustainability.

On November 28, 2011 EPA and the Army signed a memorandum of understanding to become partners in an Army initiative to achieve sustainable practices in military bases. This initiative, known as Net Zero, focuses on reducing the water and energy demands of military facilities as well as reducing waste produced by the facilities.

The term "net zero" refers to the ultimate goal of this initiative: transforming army installations into self-sufficient communities where the amount of water and energy and produced is equal to the amount consumed by the facility. The result would be a community whose overall impact on natural water and energy resources would balance out to zero



Tents and other temporary structures topped with solar panels are part of the Net Zero program.

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Net Zero: EPA Assistant Administrator Paul Anastas (Office of Research and Development) and Katherine Hammack, Assistant Secretary of the Army (Installations, Energy & Environment) sign a Memorandum of Understanding establishing a partnership to support sustainability.

impact. The concept of net zero also includes waste reduction to the point where all physical wastes of a facility would be reduced or recycled.

Net Zero's water focus will limit the amount of freshwater drawn from natural resources and will ensure that water leaving these army bases is returned to the natural watershed to feed into those same resources. Also, EPA's research and input will help the Army incorporate cutting-edge methods of recycling waste water and retrieving useful nutrients from waste waters.

Although each military base has unique resource demands, both EPA and the Army expect that the introduction of sustainable features will be applicable outside of military instillations and will serve as an example for the greening of other communities.

Sustainable Watersheds: Characterization and Mitigation of Fecal Pollution

At EPA's Experimental Stream Facility (ESF) in Milford, OH, scientists are studying various impacts on wadeable streams. Researchers used watershed sampling, rainfall information and high-resolution geographic information system (GIS) data to identify the origin of human waste (fecal) pollution in a watershed. These different data sources allowed watershed managers to understand the variety of sources of human fecal pollution in the East Fork Watershed of Southwestern Ohio, leading to more efficient, cost-effective and focused cleanup actions.

Small stream ecosystems comprise over 72% of the river miles in the United States; yet, the role they play in managing watershed-level water quality remains uncertain. The ESF is one of very few U.S. research facilities designed to conduct small stream research. ESF studies are designed to collect information on both watershed management and the impact of contaminants. Researchers can study how pollutant loads combine with

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characteristics of the stream habitat that may or may not change as a result of man-made stress.

With eight stream areas under study, the facility can provide a balanced perspective between the benefits of controlled laboratory study and field study. Researchers can observe and measure changes to stream ecosystems at the facility in ways that are not possible in traditional laboratory studies. Well-designed and controlled experimental stream studies are an important tool for providing the understanding necessary to move basic research and development from the laboratory to the field.

Healthy Watershed Integrated Assessment Workshop Report

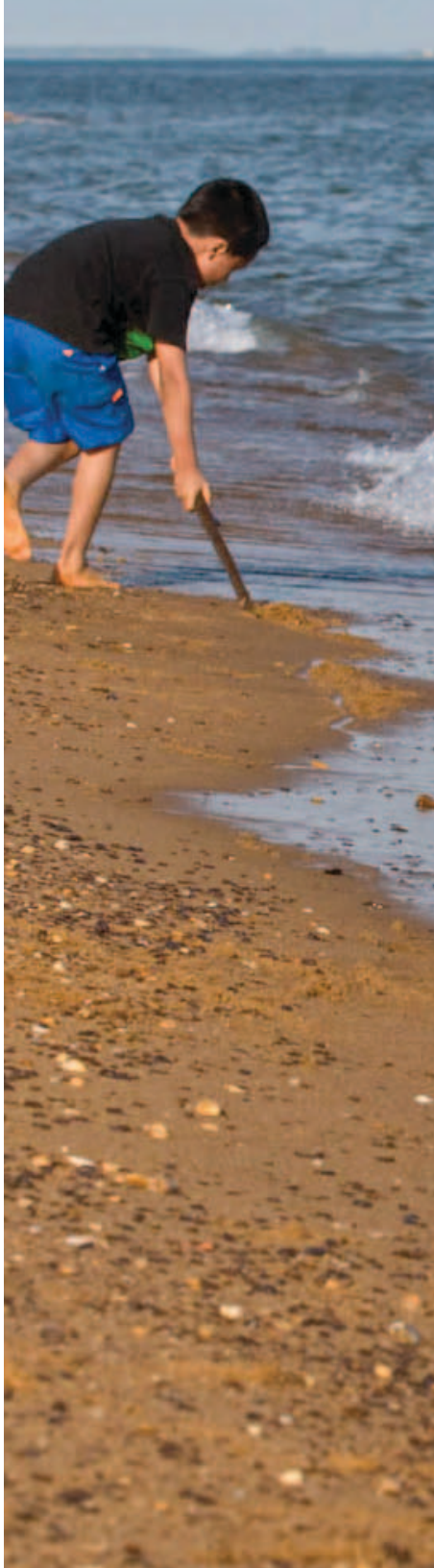
EPA developed The Healthy Watersheds Initiative (HWI) in 2009 to combat the decline in the health of the nation's aquatic ecosystems. The initiative focuses on maintaining healthy waters and meeting Clean Water Act goals using an integrated approach to maintain water quality and ecological integrity on a geographic, or watershed, basis.

In support of HWI, EPA released the *Healthy Watersheds Integrated Assessments Workshop* report in March, 2011 to reflect the outcomes of an experts workshop held the preceding winter. The report presents input from EPA programs and regions, other federal, state and local agencies, other organizations, national experts and practitioners to advance the state-of-the-science on integrated assessments of healthy watersheds.

Workshop participants explored how to use assessment results to guide strategic healthy watershed protection programs such as Virginia's Interactive Stream Assessment Resource (INSTAR) and Maryland's Green/Blue Infrastructure Assessment.

The workshop proceedings report explains that healthy watersheds can be sustained by diverting development pressures toward heavily degraded watersheds through smart growth, preserving open spaces and limiting new development in healthy watershed areas. Ongoing monitoring of the watershed's natural condition and the use of tools proven in the field are important for detecting threats to a watershed's health; these practices also make it possible to set minimum stream flow standards that are protective of watershed health. Education and outreach to all stakeholders, including the general public and policymakers, is also recommended for sustaining watershed health.

Research needs and data gaps were



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identified in the workshop report to guide the direction of future healthy watershed research. Some examples include studying climate-related effects on systems and indicators, determining how ecosystems recover and adapt to disturbances, and crafting guidance on how to maintain and protect the components of healthy watersheds.

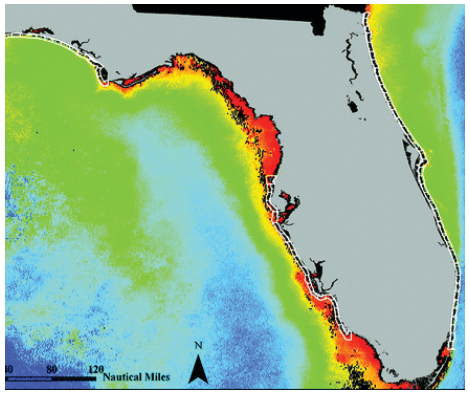
Risk of Illness Increases When Beach-Goers Contact Sand

For most people, plans for a sunny day at the beach do not usually include recovery from stomach illness after playing in contaminated sand. However, past research has shown that beach sand can be home to organisms such as bacteria, viruses and fungi known as fecal indicators. Fecal indicator organisms are a sign of the possible existence of fecal pathogens from human or animal waste.

EPA recently concluded a study on the risk of intestinal illness linked to sand contact and the density of fecal indicator organisms in the sand. Researchers asked visitors to two recreational beaches with nearby waste treatment plant discharges about their sand contact that day. Ten to 12 days later, researchers questioned the same beach visitors about their health symptoms.

Using thousands of interviews and more than 100 sand samples, researchers found that fecal contamination in the sand was associated with intestinal illness among visitors who dug in the sand, most especially those who were buried in the sand.

A paper describing this study and its results, *Fecal Indicators in Sand, Sand Contact, and Risk of Enteric Illness Among Beachgoers*, was expected to be published in early 2012. This information will help regulators set recreational water criteria to better balance beach usage with public health protection.



Evaluating Water Quality from the Sky

EPA researchers are exploring how to use satellite technology to monitor water conditions and help the Agency develop water quality criteria that protect the nation's water resources.

A study conducted in 2011 focused on using such technology for Florida's coastal waters. The purpose of the study was to evaluate the use of satellite measurements as a way to analyze water quality and to help regulators set standards for nutrient pollution.

Nutrient pollution, excess nitrogen and phosphorous carried in runoff and other sources from land sparks excessive algal growth in many water bodies, and could also occur in coastal waters. Researchers used the SeaWiFS satellite to measure the amount of chlorophyll-a, a pigment present in algae, as a way of monitoring nutrient pollution in coastal water.

Researchers compared thirteen year's worth of data from the SeaWiFS satellite to measurements from field studies to see if the satellite's readings could be used to measure water quality.

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Researchers concluded that this unique application of satellite data for monitoring water quality is effective and could be applied to other satellites and other coastal waters. A paper, An Approach to Developing Numeric Water Quality Criteria for Coastal Waters Using the SeaWiFS Satellite Data Record, describing the study and its results was published online in December, 2011 by Environmental Science and Technology.

Advancement of Wastewater Analysis Studies

Protecting the environment and human health is the mission of EPA scientists and engineers. EPA's ability to analyze wastewater to protect infrastructure and promote cost-effective treatment is critical to this mission. EPA continually strives to improve the analytical techniques it uses for wastewater analysis.

As part of its research efforts, EPA recently opened a new hub for studies on wastewater and pipe surfaces. The Advanced Materials and Solids Analysis Research Core (AMSARC) is located in Cincinnati, Ohio.

AMSARC scientists investigate the properties of materials ranging from bacteria and DNA to ceramics and man-made membranes. One of the state-of-the-art tools at this facility is a confocal microscope, which produces three-dimensional images. AMSARC also has a solids carbon analyzer. It measures the inorganic and organic carbon content of solid material.

The high-tech equipment at AMSARC benefits not only EPA researchers, but also other scientists across the nation. EPA scientists at AMSARC have formed partnerships with colleagues over a wide range of scientific fields and industry sectors. They will help EPA find new ways to improve water treatment and conveyance.

The AMSARC tools promote the flexibility and breadth of research at EPA by supporting water quality research, corrosion control and the characterization of bacteria. The EPA scientists at the research core are creating new analytical techniques for wastewater solids. In addition, they hone their skills to maintain proficiency in current state-of-the-art techniques.

AMSARC scientists are devoted to the idea of "green chemistry." This concept promotes the design of chemical products and processes that reduce or eliminate the use or generation of hazardous substances. AMSARC also supports an innovative and collegial community of researchers doing cutting-edge research.

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This will promote continued progress towards global sustainability, materials management, pollution prevention and the protection of public health.

Investigating and Preventing Pinhole Leaks

Imagine a tiny, pin-sized hole in one of the copper water pipes behind your kitchen or bathroom wall. Water slowly drips, drips, drips until the sheetrock, studs, and any insulation become a breeding ground for mold and mildew that can go undetected for months, leading to major damage, and even sickness.

Pinhole leaks in copper water lines are a major concern to both homeowners and drinking water due to the expense of repairs, health implications, and loss of water from undetected leaks in service lines.

EPA scientists are working to identify what waters are problematic in causing the corrosion of copper pipes, and to improve the understanding of how drinking water quality is related to the localized corrosion of copper pipes. They are focusing their efforts on the prevention of pinhole leaks and how to reverse corrosion once it has already occurred.

Researchers collected water and pipe samples from communities experiencing pinhole leak problems and from nearby communities without such problems. Using the data collected, as well as the documentation of full-scale case studies, they have compiled a database of corrosion distribution information and the associated water quality.

In addition to compiling this database and comparing water chemistries, Agency researchers designed and utilized a pipe-loop system to test water for its tendency to initiate pitting corrosion by continuously running water through a series of copper pipes. A small-scale, preliminary study using this pipe-loop system showed researchers that evidence of localized corrosion could be found after only 72 days of flowing water through the system. A tool like this pipe-loop system could prove very useful for water utilities.

The EPA-designed pipe-loop testing system offers the potential to provide a solution, giving water companies a low-cost early warning system for identifying water likely to lead to pinhole corrosion, and preventing homeowners from facing the damage and health risks that come from leaking pipes. Such pipe-loop testing systems could also help water companies to identify potential solutions for existing problems.

This on-going project is expected to provide assistance and guidance for identifying what water chemistries are problematic, and help utilities select and apply the most appropriate treatment to extend life of pipes.

A Water Partnership with Australia

In an effort to expand cooperation between the United States and Australia on integrated water management strategies and sustainable infrastructure, long-term adaptation to climate change, including water reuse and the efficient use of water resources that reduce energy and water consumption, EPA's Safe and Sustainable Water Resources program will work together with peers in Australia to explore new ways of ensuring long-term sustainability of water resources.

Over the last year, scientists and engineers from both countries have had technical exchanges using video and webinars to share best practices looking at stormwater reuse, water recycling and recovery. In addition, they have exchanged lists of projects that explore answering similar

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questions to help evaluate policy decisions and select more specific projects to collaborate on in more detail.

Over the upcoming year, EPA scientists and engineers will share information on chemical and microbial risk and the Australians will specifically share their water technology best practices.

This collaboration will build capacity and strengthen systems so they can deliver high-quality water and sanitation services to low- and middle-income countries. In addition to improving drinking water quality and health, the effort will help empower communities to implement cost-effective changes to water systems.

Evaluation of Arsenic Removal Technology

Municipal drinking water systems and private wells that tap groundwater sometimes have higher levels of arsenic than do those that rely on surface water bodies such as lakes and streams, the result of source water coming into contact with natural occurring arsenic in subterranean rock formations.

In response to this challenge and to help municipal water systems, EPA conducted the Arsenic Demonstration Program from 2001 to 2011. During that time, EPA researchers tested the reliability of small-scale arsenic treatment technology systems. Researchers evaluated the ease of operation, maintenance requirements and cost-effectiveness of the systems. In addition, they characterized treatment byproducts.

The program's three rounds of projects resulted in the construction of 50 small, full-scale arsenic removal systems across 26 states. These systems were funded by Cooperative Research and Development Agreements (CRADAs), which are partnerships between EPA and private companies to work together on research and development.

The information and data provided through the demonstration program will enable water utilities, state agencies and consulting firms to make informed decisions on the selection, design and operation of arsenic removal systems. The new technologies and the information the research provides are expected to help

Small-scale arsenic removal technology filter system, part of EPA's Arsenic Demonstration Program

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increase the number of water systems that are able to comply with EPA's revised arsenic drinking water standard.

Identifying PFCs in Surface and Well Water

EPA scientists have developed and applied analytical methods for characterizing the concentration of perfluorinated chemicals (PFCs) in surface and well water samples.

PFCs are synthetic chemicals used in a wide range of commercial and consumer products such as textiles, electronics, and stain-protective coatings. The scientists conducted a series of field studies to generate high quality environmental data.

EPA's Office of Water considered the results of the work when establishing the provisional health advisory guidelines for drinking water for two common PFCs (perfluorooctane sulfonate and perfluorooctanoic acid). In addition, EPA Regional offices are now using the methods to monitor surface and drinking water supplies to ensure exposures to these two PFCs from public drinking water supplies are safe.

Supporting EPA Research Partners for Safe and Sustainable Water Resources

EPA supports the Nation's leading scientists and engineers to facilitate the pursuit of high-quality research to build a strong scientific foundation for Agency actions. In addition, EPA researchers cultivate and maintain partnerships with colleagues at colleges, universities, research centers, sister federal and state agencies and other institutions to collaborate and advance safe and sustainable water resources.

The Agency awards research grants through its Science to Achieve Results (STAR) program. (See more about the Agency's STAR program in the *Supporting and Building Partnerships* section of this report.)

Accomplishments of EPA partners in the areas of *Safe and Sustainable Water Resources* for 2011 include the following.

Innovative Drinking Water Treatment Technologies in Small Systems

Over the past three decades, more than 80,000 chemicals entered the U.S. marketplace, posing potential risks to public health through drinking water systems. To manage public health risks posed by water contaminants and to advance sustainable drinking water protection, new technologies and approaches are needed that can remove chemical contaminants from drinking water sources without introducing unintended risks.

In July of 2011, EPA's Science to Achieve Results (STAR) grant program requested proposals to develop new technologies aimed at removing contaminants found in drinking water. EPA is particularly interested in technologies that address mixtures of contaminants and on approaches designed for small and disadvantaged systems. These are often the least able to afford or sustain water treatment technologies but are subject to the same regulations as larger systems.

Eight of the proposed research projects were awarded grants in December of 2011. Grantee projects are based in different locations across the county, some focusing on local water contamination while

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others focus on general water treatment techniques. For example, grantees from Lincoln University and the University of Missouri, Columbia are working to improve drinking water quality for small rural communities in Missouri while grantees from the University of California, Riverside and the University of Iowa are researching the use of nanofiber filters for small-scale water treatment systems.

Public Health Protection through Water Infrastructure Sustainability

With an estimated 240,000 water main breaks per year in the United States, the country is in need of new approaches to identify, characterize, repair and manage pipeline failures and other areas key of weaknesses of water distribution systems. Sustained public health protection relies upon an intact water infrastructure system, which includes drinking water and wastewater conveyance systems and related treatment facilities.

In 2009, EPA's Science to Achieve Results (STAR) grant program asked for proposals for applied research that would increase understanding of the links between water infrastructure and public health protection, as well as suggest practical solutions for more sustainable infrastructure.

Eight targeted research awards were granted in January 2011. Ongoing work includes:

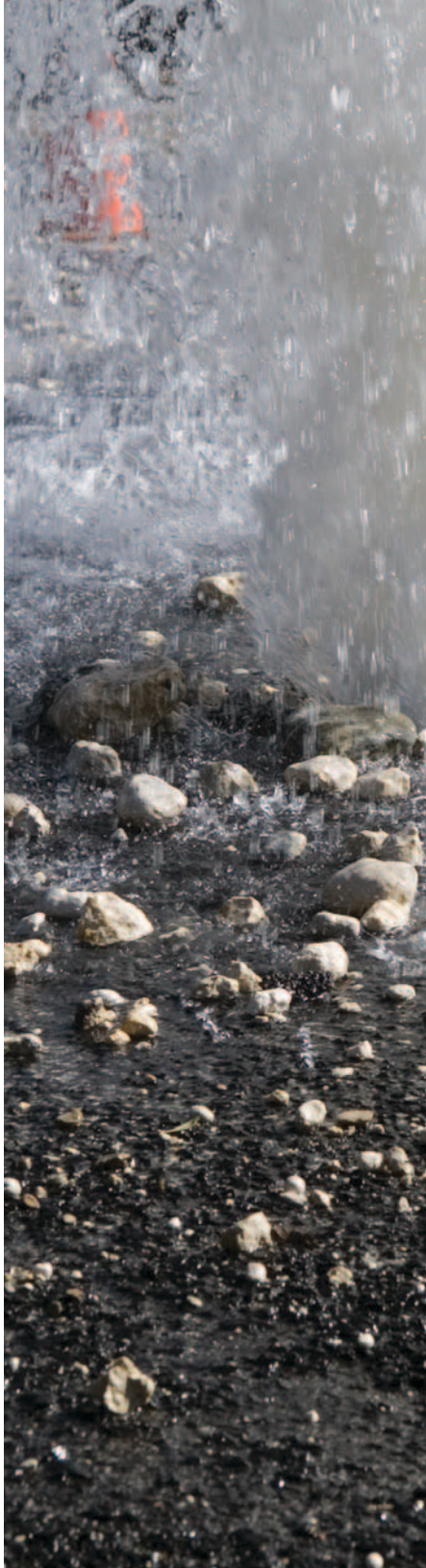
- quantifying the extent of leaks from urban sanitary sewers and potential effects on drinking water sources;
- evaluating pipeline coating technologies as substitutes for lead and copper pipe replacement;
- comparing water distribution rehabilitation scenarios and the effects on animal cells and genetic material exposed to the water;
- developing self-powered sensors to monitor water supply networks;
- identifying how biofilms attach and detach from pipes;
- using "forward osmosis" techniques to design and construct membranes for wastewater treatment;
- developing efficient pipeline inspections based on genetic markers from bacteria; and
- studying rural water supplies and improving water treatment in these systems.

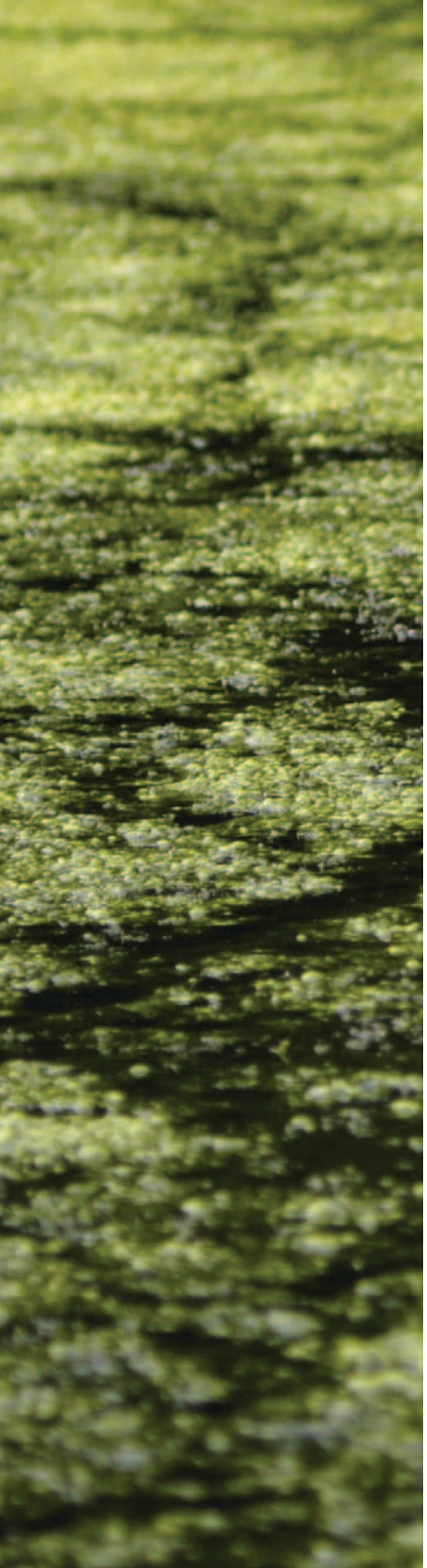
These two to six year research grants will contribute to the sustainability of drinking water and wastewater systems and help ensure the protection of public health.

STAR Grantee Accomplishment in Water Research

Research results from EPA STAR grantees in 2011 also include:

- Researchers at University of Washington developed a high-throughput method to generate novel antibody-like "probes" for pathogen detection in water. The researchers filed a patent for the ratiometric pre-rRNA method (International Patent Number PCT/US09/67565 titled RATIOMETRIC PRE-RNA analysis).
- Researchers from the University of Cincinnati successfully isolated and purified a commonly found microcystin, microcystin-LR (MC-LR), from a large bloom of blue green algae in South Florida. Research results will provide a better understanding of the occurrence and





Safe and Sustainable Water Resources

2011 Accomplishments – In Brief, Cont'd.

interactions of selected cyanotoxins in freshwater estuaries, as well as the role of novel TiO2-based catalytic materials to destroy cyanotoxins in water as an approach to develop engineering technologies utilizing solar radiation.

- Researchers at Middle State Tennessee University successfully isolated 17 novel legionella-like amoeba-resistant bacteria (ARB) from water samples. Those responsible for ensuring safe and clean water will have an expanded list of potential pathogens to look for when sampling for respiratory infectious agents.
- Researchers at the Lamont Doherty Earth Observatory and Woods Hole Oceanographic Institution developed a quantitative polymerase chain reaction-based method to assay zooplankton predation rates on harmful algae. These results may lead to improved representation of phytoplankton mortality in predictive models of bloom formation, thereby aiding the forecasting and mitigation of Alexandrium blooms by coastal managers.
- Researchers at the University of Delaware investigated the population dynamics of toxic and non-toxic cyanobacteria in the upper reaches of Chesapeake Bay. Researchers were able to demonstrate that natural mesozooplankton were better grazers of both toxic and non-toxic strains of Microcystis than their cultured counterparts, microzooplankton. Researchers summarized that the ability to synthesize microcystin does not seem to offer toxic Microcystis populations a significant defense against grazing by co-occurring zooplankton communities.

Supporting and Building Partnerships

EPA supports the nation's leading scientists and engineers to facilitate the pursuit and dissemination of high-quality research to build a strong scientific foundation for Agency actions and decisions. Additionally, EPA researchers cultivate and maintain partnerships with research colleagues at colleges and universities across the world, at partner federal and state agencies, and other entities throughout the scientific community.

The Agency's extramural research program funds research grants, graduate and undergraduate fellowships, and large research centers through a competitive solicitation process and independent peer review. These programs engage the nation's best scientists and engineers in targeted research that complements EPA's own outstanding intramural research.

EPA is also one of 11 federal agencies that participate in the Small Business Innovation Research (SBIR) program, enacted in 1982 to strengthen the role of small business in federal research and development, create jobs, and promote technical innovation. EPA's SBIR program awards funds to innovative small businesses that have novel concepts for products and technologies that will help spur economic growth while advancing a more sustainable future.

EPA Greater Research Opportunities (GRO) Fellow Ciarra Greene is a chemistry major at Northern Arizona State University.

EPA Research Grants and Awards

EPA Extramural Research Grants and Fellowships for 2011

EPA funds research grants and graduate fellowships in numerous environmental science and engineering disciplines through its Science to Achieve Results (STAR) program.

EPA issued 137 Graduate Fellowships, 80 grants, 37 Small Business Innovation Research (SBIR) awards, and numerous Greater Research Opportunities undergraduate fellowships to support environmental research conducted in 2011. Highlights are included below.

The STAR program engages the nation's best scientists and engineers in targeted research that complements EPA's own intramural research program, and helps the Agency support partners in other federal agencies.

Grants are awarded through competitive solicitation processes followed by independent peer review. Supported research includes work on drinking water, water quality, global change, ecosystem assessment and restoration, human health risk assessment, endocrine disrupting chemicals, pollution prevention and new technologies, children's health, and the health effects of particulate matter.

In addition, through this same competitive process, EPA periodically establishes large research centers in specific areas of national concern. Currently, centers focus on children's environmental health, hazardous substances, clean air, and estuarine and coastal monitoring.

STAR Graduate Fellowships

The STAR Graduate Fellowship Program supports masters and doctoral candidates working towards advanced degrees and careers in environmental science and engineering.

137 STAR Graduate Fellows were awarded to support graduate work in human health and environmental research in 2011 (This includes funds awarded in Fiscal Year 2011, or in late 2010)

Greater Research Opportunities (GRO) Fellowships

The Greater Research Opportunities (GRO) fellowships support undergraduate students in environmental fields of study. The goals of the program are to bolster the environmental generation of tomorrow, inspire and train diverse communities, and boost excellent research and development that advances the protection of human health and the environment through education.

Eligible students receive support for their junior and senior years of undergraduate study and for an internship at an EPA facility during the summer between their junior and senior years. The fellowship provides up to $19,700 per academic year of support and up to $9,500 of support for a three-month summer internship. The Agency awards approximately 40 new fellowships each year.

EPA Research Grants and Awards, *Cont'd.*

STAR Grants to Support Air Pollution Health Effects Research

Five projects received grant funding totaling nearly $1.5 million to explore air pollution health effects by taking advantage of previous investments in health and exposure data collection. Research explores new health and exposure questions by emphasizing the use of existing data from health studies to analyze health outcomes for which the link to air pollution is not well established, or to identify at-risk populations.

Recipient(s)	*Title*	*Amount Awarded ($)*
NYU School of Medicine Hunter College New York University University of Pittsburgh	Intra-Urban Variation of Air Pollution and Cardiovascular Health Effects	$299,998
Colorado State University University of Colorado	Exploring New Questions of Multiple Air Pollutants, Sources and Health in Denver	$298,362
Harvard School of Public Health	Are Diabetics and the Neurologically Impaired at Increased Risk from Air Pollutant Exposures?	$299,903
Harvard School of Public Health Brigham Young University Imperial College Johns Hopkins University	The Effect of Air Pollution Control on Life Expectancy in the United States: A Population-Based Analysis of Major Metropolitan Areas	$300,000
Brigham Young University	Associations of Short-Term Pollution Exposures with Childhood Autoimmune Disease	$298,857

EPA Research Grants and Awards, *Cont'd.*

STAR Grants to Support Black Carbon Research

EPA awarded nine grants totaling $6,669,863 for research on the climate and air quality impacts of the pollutant black carbon. Research is intended to reduce uncertainty about black carbon effects and to improve the tools and understanding of black carbon in the face of global climate change. These projects will provide answers to science questions regarding this pollutant and will help policy-makers mitigate the emission of black carbon and related pollutants.

Recipient(s)	*Title*	*Amount Awarded ($)*
University of California - Riverside	Understanding the Hygroscopic Properties of Black Carbon/ Organic Carbon Mixing States: Connecting Climate and Health Impacts of Anthropogenic Aerosol	$449,925
University of Illinois at Urbana-Champaign	Particle-Resolved Simulations for Quantifying Black Carbon Climate Impact and Model Uncertainty	$449,902
University of California - Irvine	Characterization Of Emissions From Small, Variable Solid Fuel Combustion Sources For Determining Global Emissions And Climate Impact	$900,000
University of Illinois at Urbana-Champaign Argonne National Laboratory NESCAUM	Linking Regional Aerosol Emission Changes with Multiple Impact Measures through Direct and Cloud-Related Forcing Estimates	$899,773
University of Washington	BC and Other Light-Absorbing Impurities in North American Great Plains Snow: Sources, Impacts, and a Comparison with North China Snow	$825,315
University of Wisconsin – Madison Georgia Institute of Technology	Development of a Quantitative Accounting Framework for Black Carbon and Brown Carbon from Emissions Inventory to Impacts	$899,600
Rutgers University	Improved Prediction of the Vertical Profile of Atmospheric Black Carbon: Development and Evaluation of WRF-CMAQ	$449,916

EPA Research Grants and Awards, *Cont'd.*

Recipient(s)	*Title*	*Amount Awarded ($)*
University of Iowa National Oceanic and Atmospheric Administration University of Colorado at Boulder	Constraining Urban-To-Global Scale Estimates of Black Carbon Distributions, Sources, Regional Climate Impacts, and Co-Benefit Metrics with Advanced Coupled Dynamic - Chemical Transport - Adjoint Models	$895,432
Carnegie Mellon University	Black Carbon, Air Quality and Climate: From the Local to the Global Scale	$900,000

STAR Grants to Support Computational Toxicology

Four grants totaling nearly $3 million were awarded to advance the science of computational toxicology with a focus on biologically-based multi-scale modeling. The research produced will help scientists better understand and measure the effects of chemical exposure on the human body.

Recipient(s)	*Title*	*Amount Awarded ($)*
The Hamner Institutes	A Multi-scale Dose-response Model of AHR Toxicity Pathway Activation in the Human Liver	$750,000
University of North Carolina at Chapel Hill	Predictive QSAR Models of Hepatotoxicity	$750,000
Indiana University - Bloomington	Ontologies for Data & Models for Liver Toxicology	$749,705
Virginia Polytechnic Institute and State University	Model of Toxicant Response in Engineered Liver	$750,000

EPA Research Grants and Awards, *Cont'd.*

Grants to Support Nanomaterials Research

In partnership with the National Science Foundation and the U.S. Department of Agriculture, EPA awarded five grants totaling nearly $3 million to support fundamental and applied research related to engineered nanomaterials. Two focal areas of research include:

1. Evaluation of potential exposures to engineered nanomaterials including an exploration of environmental and biological fate, transport, and transformation of these materials throughout their lifetimes; and
2. Increasing the scientific understanding of engineered nanoscale additives and ingredients intentionally introduced into food matrices for delivery of important micronutrients and modification of sensory attributes.

Recipient(s)	*Title*	*Amount Awarded ($)*
University of Michigan - Ann Arbor Michigan State University	Environmental Transformation And Biological Fate Of Fresh And Aged Cerium Oxide Nanoparticles	$600,000
University of Kentucky	Environmental Behavior And Bioavailability Of Ag And Ceo2 Nanoparticles: The Role Of Surface Functionalization and its Interaction with Natural Organic Substances and Iron Oxohydroxides	$599,840
University of Delaware	Uptake of Specific Engineered Nanoparticles (ENP) by Sludge Particulates as Affected by the Presence of Dissolved Organic Matters (DOM)	$599,678
Virginia Polytechnic Institute and State University	Transformation and Fate of Nanomaterials During Wastewater Treatment and Incineration	$599,859
Purdue University Johns Hopkins University	Photochemical and Fungal Transformations of Carbon Nanotubes in the Environment	$600,000

EPA Research Grants and Awards, *Cont'd.*

Recruiting the Best: EPA Grant Solicitations

RFAs announced to support research in 2011 are outlined below.

Developing the Next Generation of Air Quality Measurement Technology To support research into the development, improvement, and demonstration of air pollution monitoring and measurement technologies.

Extreme Event Impacts on Air Quality and Water Quality with a Changing Global Climate To support the development of assessments, tools, techniques, and the demonstration of innovative technologies that provide information and the capacity to prepare for climate-induced changes in extreme events.

Dynamic Air Quality Management To support research laying the scientific foundation for improving the air quality management system, including by increasing the rate at which new information is incorporated into regional and local air quality management activities.

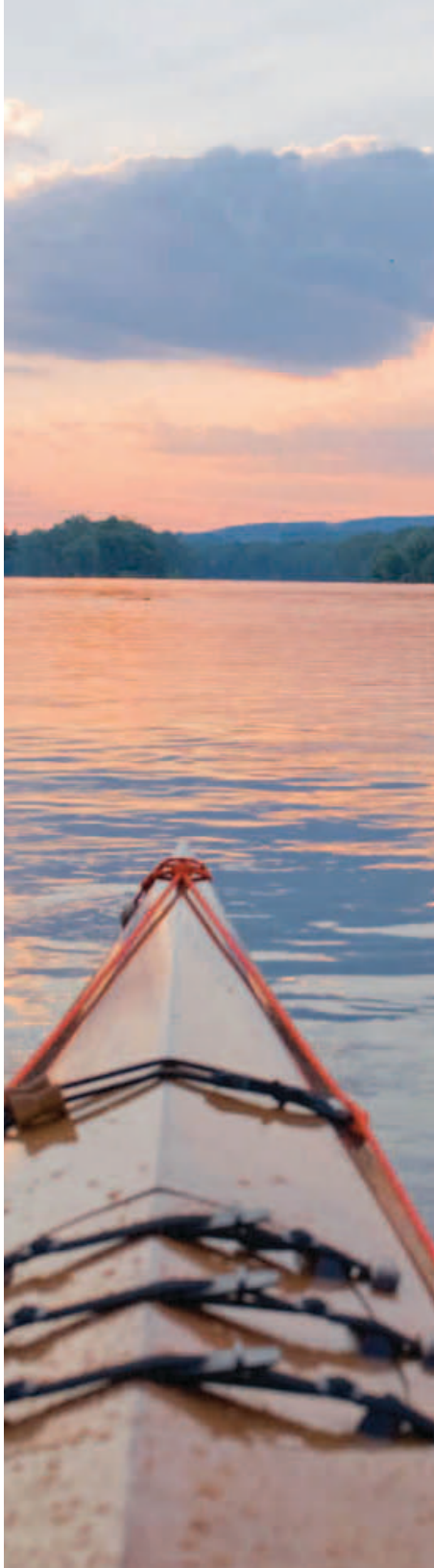
Developing High-Throughput Assays for Predictive Modeling of Reproductive and Developmental Toxicity Modulated Through the Endocrine System or Pertinent Pathways in Humans and Species Relevant to Ecological Risk Assessment To support research on the development of high-throughput assays for use in analyzing chemicals, or mixtures of chemicals, to explain how exposure can be causally related to adverse, apical outcomes related to development and reproduction.

Source Attribution of Radiative Forcing in Chemical Transport Models To support the development of advanced modeling capabilities that account for the dynamics of chemical transport, short-term climate changes ("radiative forcers"), and air quality.

Environmental Impact and Mitigation of Oil Spills To support a research program for the development of innovative technologies for use decreasing the impact of oil spills impacts, as well as incorporating an effective community outreach program.

Sustainable Chesapeake: A Collaborative Approach to Urban Stormwater Management To advance the scientific and practical understandings of how to promote and sustain effective, community-based stormwater management for reducing water-borne pollution entering Chesapeake Bay. EPA is specifically interested in funding research projects that engage the lay public and scientific experts in the co-development, trial, and objective assessment of innovative, local solutions to shared stormwater problems. (For more about this program, see *Sustainable Chesapeake* in the "Safe and Sustainable Water Resources" section of this report.)

Research and Demonstration of Innovative Drinking Water Treatment Technologies in Small Systems To support the development of new, or innovative modifications of existing



Highlights From 2010 EPA Regional Science Partnerships, *Cont'd.*

treatment technologies that can perform significantly better than current technologies. (For more about this program, see *Innovative Drinking Water Technologies* in the "Safe and Sustainable Water Resources" section of this report.)

To receive e-mail notices about future EPA STAR grant and other funding opportunities, please visit: http://epa.gov/ncer/listserv/.

Stoking the Economic Engine: EPA's Small Business Innovation Research Awards

There are approximately 25 million small businesses in the U.S. today. As the leading source of employment growth, these firms have generated 60 to 80 percent of new jobs over the past decade and are responsible for developing most of the country's new technologies.

Today, EPA is helping to tap the economic engine and creative energy of small businesses to help meet environmental challenges while they help lead an economic recovery.

EPA's Small Business Innovation Research (SBIR) program was established to ensure that new technologies are developed to solve priority environmental problems. In 2011 EPA awarded nearly $4.4 million to 37 small companies to support the development of new technologies for protecting the environment and public health.

Twenty-seven small businesses received "proof of concept" awards up to $80,000 (phase I recipients). Ten companies that received similar awards in 2010 were awarded additional 2011 funding up to $225,000 to move their technologies towards commercialization and implementation (phase II recipients).

Phase II winners include small businesses in California, Colorado, Florida, Massachusetts, Michigan, and New Mexico. Their projects include reducing toxic chemicals from landfills, producing an environmentally friendly adhesive, reducing methane emissions by converting dilute methane waste gas streams into useful fuel, and designing a real-time environmental water monitoring sensor.

Stoking the Economic Engine: EPA's Small Business Innovation Research Awards, *Cont'd.*

Phase I Recipient	*Title*	*Amount Awarded ($)*
ACTA Technology Inc.	Greener and More Energy Efficient Renewable Energy Resource – Geothermal Heat Pumps	$80,000
Adherent Technologies Inc.	Emission Suppression System for Outdoor Wood Boilers	$80,000
Advanced Diamond Technologies Inc.	Development of a Scalable, Low-Cost, Ultrananocrystalline Diamond Electrochemical Process for the Destruction of Contaminants of Emerging Concern (CECs)	$79,995
Algal Scientific Corporation	Anaerobic Pre-Treatment for an Algae-Based Wastewater Treatment System	$79,278
Cool Energy Inc.	Low Temperature Stirling Engine for Waste Heat Recovery from Distributed Power Sources	$79,096
EcoChem Analytics	A Real-Time, Sensitive and Affordable Fast-Response Elemental Carbon Monitor	$79,022
Eltron Research & Development Inc.	A Solvent-Free, Nanopowder Production Method	$80,000
Faraday Technology Inc.	Functional Chrome Coatings on Hard to Access, Internal Surfaces of Industrial Parts from an Environmentally Benign Trivalent Chromium Bath	$80,000
FBS Inc.	In-Situ Imaging of Water Pipelines Using Ultrasonic Guided Waves	$79,956
FuelCell Energy Inc.	Industrial Flue Gas Cleanup Using DFC Technology	$79,936
General Systems Research LLC	Cost-Effective Algae Biomass Production for Oil integrated with Wastewater Treatment and Valued By-Product	$80,000
H.I.P. Hot-In-Place Paving LLC	Evaluation of the 100% Recyclability of Superpave Hot Mix Asphalt	$80,000
Los Gatos Research	Compact, Cost-Effective Nitrogen Dioxide Analyzer for NAAQS Compliance Monitoring	$79,965
Lynntech Inc.	Microelectrochemical Capillary System for Environmental Analytical Lab on a Chip	$70,000
Membrane Technology and Research Inc.	Novel Membranes for Natural Gas Dehydration	$80,000

Stoking the Economic Engine: EPA's Small Business Innovation Research Awards, *Cont'd.*

Phase I Recipient	*Title*	*Amount Awarded ($)*
Micro-Tracers Inc.	Combination of Chlorine-Free Electrolytic and Photochemical Methods for Sterilization of Contaminated Waters	$73,433
OmniLane Inc.	L-(+) Lactic Acid Production from Biodiesel Waste Using Pelletized Fungal Fermentation	$79,996
Operational Technologies Corporation	Handheld FRET-Aptamer Sensor for Chem-Bio Threats	$79,984
OPTRA Inc.	Fourier Transform Infrared Phase Shift Cavity Ring Down Spectrometer	$79,638
Reactive Innovations, LLC	Advanced Contaminant Inactivation System for Drinking Water	$79,994
SkySight Technologies LLC	Full Scale Anemometer	$80,000
Sustainable Innovations LLC	Recycling of Greenhouse Gases to Fuels & Chemicals	$79,980
TDA Research Inc.	A New Renewable Polymer from Bio-Oil	$80,000
TDA Research Inc.	New Sorbents to Control CO_2 and Multi-Contaminant Emissions	$80,000
TDA Research Inc.	Pipeline-Quality Methane from Anaerobic Digestion Systems	$80,000
Trillium FiberFuels Inc.	Development of a Fermentation Compatible Xylose Isomerase	$79,885
Viresco Energy LLC	Low Oxygenate Bio-Oil Through Two Stage Hydro-Pyrolysis	$79,825
		Total: $2,139,983

Stoking the Economic Engine: EPA's Small Business Innovation Research Awards, *Cont'd.*

Phase II Recipient	*Title*	*Amount Awarded ($)*
Aspen Products Group, Inc.	Reduction of Hazardous Air Pollutant Emissions from Commercial Kitchens	$225,000
Defiant Technologies, Inc.	Handheld Detection System for TCE and PCE	$225,000
Eltron Research & Development Inc	Low-Cost Retrofit Emissions Control in Off-Road Sources	$224,998
Instrumental Polymer Technologies, LLC	Silane-Terminated Aliphatic Polycarbonate Dendrimer Solutions for Environmentally Green Coatings	$225,000
Intelligent Optical Systems Inc.	Distributed Optical Fiber Sensor for Long-term Monitoring of Groundwater Trichloroethylene Levels	$224,996
Lao K, LLC	Mill Trials of a Novel Formaldehyde-Free Soy-Based Wood Adhesive for Making Plywood	$224,000
Membrane Technology and Research Inc.	Novel Membrane Process to Utilize Dilute Methane Streams	$225,000
Mobius Technologies, Inc.	Development of Micronized Polyurethane as a Comprehensive, 100 Percent Recycled Resin for Green Building Materials and Systems	$225,000
Smart Polymers Research Corporation	Quantum Dot/Aptamer Real-Time Flow Sensor	$225,000
Technova Corporation	Value-Added Use of Milled Mixed-Color Waste Glass as a Supplementary Cementitious Material in Environmentally Friendly and Energy-Efficient Concrete Building Construction	$225,000
	Total:	$2,248,994

EPA-Supported Small Businesses Recognized for Innovation, Jobs, Impact

Past EPA, SBIR awardees continued to show how investments in innovative small businesses as they work to bring sustainable technologies to the marketplace serve as catalysts for a growing and vibrant economy. Examples include:

- NanoMech, the developer of an innovative, environmentally-friendly nanostructured coating for the automotive and aerospace industries, was honored with a visit

Stoking the Economic Engine: EPA's Small Business Innovation Research Awards, *Cont'd.*

from Secretary of the U.S. Treasury Timothy Geithner, in March, 2011, who showcased the company to demonstrate how businesses that engage in innovative research can spur economic growth and lead to high-wage jobs.

- Ecovative Design was named a 2011 Technology Pioneer by the World Economic Forum in recognition of the company's efforts to use technology to change and improve the way businesses operate. The company has developed two materials (MycoBond™, and Greensulate™) produced with a technology that begins by growing white rot fungus on agricultural byproducts, reducing waster as it produces marketable products.
- The Operational Technologies Corporation (OpTech) received the Tibbetts Award from the Small Business Administration in 2011 for their success in driving innovation and creating new jobs. OpTech research helped develop small chains of synthetic DNA that can detect bacteria and other contaminants in food samples, including bioterrorism agents and foodborne pathogens.
- Advanced Technology Materials, Inc. (ATMI), also a recipient of a 2011 Tibbets Award, was inducted as an inaugural member of SBIR Hall of Fame for its development of the Novapure Dry Scrubber System, which uses an innovative solid scrubber material designed specifically to reduce toxic air emissions from the semiconductor industry.

EPA scientists Win Presidential Science Award

Two EPA scientists were named recipients of the Presidential Early Career Award for Scientists and Engineers (PECASE)—the highest honor bestowed by the U.S. government on outstanding science and engineering professionals in the early stages of their independent research careers. The award recognizes excellent research and leadership in sciences.

The recipients were Dr. Gayle Hagler and Dr. David Reif.

Dr. Hagler was nominated for leading research in the development and use of new technologies, such as electric vehicles and GPS, to measure and map air pollutant emissions near roadside locations. She also researched roadside landscaping to reduce the effects of harmful air pollutants. Dr. Reif was nominated for developing tools for prioritizing and profiling chemicals for potential toxicity to human health and the environment, as well as studying the various subsets of childhood asthma in order to develop more personalized diagnoses, management, and treatment of the disease.

The award noted that both recipients have demonstrated a strong commitment to community service through their leadership in various outreach activities such as presenting at workshops, participating as science career panelists for visiting student groups and by using their research to mentor and teach others.

EPA scientists Win Presidential Science Award, *Cont'd.*

To read more about the awardees experience during the award ceremonies—including meeting President Obama—visit: www.epa.gov/sciencematters/december2011/meeting-the-president.htm

President Obama addresses PECASE honorees at the White House.

Everybody Wins: EPA's P3 Competition for Sustainable Design

From beeswax to bikes and beets to bacteria, EPA's 2011 P3—named for People, Prosperity and the Planet—Award Competition fostered an outstanding range of environmental innovation. From the 55 teams that competed, the Agency announced ten P3 Award winners who received another grant to implement their projects.

EPA's P3 competition offers students the opportunity to identify an environmental problem and design a solution. Working in teams, students work to solve environmental challenges in ways that benefit people, promotes prosperity and protects the planet—all at the same time.

Since its launch in 2003, some 2000 students have been involved in the program, representing 400 teams from almost every state.

The competition has two phases. For the first phase, teams are awarded seed money based on proposals submitted to design and develop prototypes for their sustainable solutions. Teams then bring their projects to showcase at the National Sustainable Design Expo in Washington D.C. in the Spring to meet the judges and compete for the P3 Award, and for a second grant (phase II) to further develop and implement their designs.

For 2011, winning teams provided impact in four important areas:

1. **Education** – *Stanford University* designed teaching units for local schools using principles of renewable energy to fulfill Standards of Learning requirements.

2. **Campus & Community** – *Duke University* designed a learning lab where students and local professionals develop stream restoration, wetland mitigation and storm water management measures for the regional water basin.

3. **Small-Scale Development** – *University of Illinois-Urbana Champaign* designed a low-cost system that uses bone char for removing arsenic and uranium from groundwater of the Pine Ridge Reservation in South Dakota; *Purdue University* designed a hydropower system for rural communities that provides low-cost electricity from local materials; and the *University of Georgia* designed a milk cooling system powered by renewable energy that will increase the amount of milk that can be sold by small rural dairy farmers.

4. **Business of Sustainability** – *University of Illinois-Urbana Champaign* designed

Everybody Wins: EPA's P3 Competition for Sustainable Design, *Cont'd.*

a system and business for a solar-powered automatic watering system for container planters; *Drexel University* designed a lightweight green room system that can be installed with minimal structural reinforcement; *University of Massachusetts-Lowell* developed an environmentally-safe flame retardant; *Oklahoma State University* designed a process that uses bacteria to convert hydrogen and CO_2 from renewable and waste sources to make ethanol; *University of Delaware* developed a process for making material from plant oils and chicken feathers and then designed and produced clothes and shoes using these new materials.

In addition to this year's winning teams, winners from past years continued to show how the seeds sown by EPA's P3 Award lead to lasting results. For example:

- A team representing Harvard University, MIT, and two Chinese universities founded the nonprofit One Earth Design (OED) that now employs 29 people in 2011. Their design for a solar-powered device that cooks, provides heat, and generates electricity has been recognized by the Dutch Postcode Lottery Green Challenge, St. Andrews Prize for the Environment, MIT $100k Competition, Clinton Global Initiative, Lemelson Foundation, Legatum Center for Development and Entrepreneurship, and Yunus Innovation Challenge.
- A 2010 P3 winner from Duke University leveraged their grant with support from the Lord Foundation and a sponsorship from DukeEngage to construct two stormwater enhancement areas, one completed in collaboration with the Eno River Association, and the other built through a collaboration with East Carteret High School.
- A 2009 team from the Massachusetts Institute of Technology (MIT) that designed a solar power generator that produces electricity using heat rather than photovoltaic cells was featured in Discover Magazine and won several awards, including the ASME IShow, National Collegiate Inventors & Innovators Alliance Award, and the MIT 100K 20 Year Award. The team has now established the nonprofit organization STG International.
- University of California Davis teammates from a 2008 P3 winning project launched the company Micromidas a year after winning, and have since raised $3.6 million in venture capital funding. Micromidas expanded to 22 employees in 2011.
- A 2007 winning team from Western Washington University, recognized for their work developing a process to tap methane from dairy cow manure as a car fuel, is now working with the local transportation district to convert biodiesel buses so they run on methane.
- The Learning Barge, designed as part of a 2007 winning P3 project out of the University of Virginia, is now owned and operated by the Elizabeth River Project. The Learning Barge educated more than 13,000 visitors in its first few years of operation, and in 2011 created seven new jobs.
- Founders of a 2005 P3 team representing Oberlin College that

Everybody Wins: EPA's P3 Competition for Sustainable Design, *Cont'd.*

developed a data monitoring display system that shows real-time energy and water use in dormitories and other large commercial buildings are now the principles for Lucid Design Group, a software company specializing in environmental monitoring and visualization technologies. The company grew to 18 employees in 2011.

EPA's P3 competition is open to students in all areas of study and from any accredited U.S. two- or four-year college or university.

EPA Partnerships

Supporting Human Health and Environmental Science in EPA Regions and Indian Country

EPA has ten regional offices across the country, each of which is responsible for meeting the Agency's mission to protect human health and the environment in the states and territories within its region. To support those efforts, Agency scientists and engineers form partnerships to effectively respond to the high-priority, near-term research and technical support needs of regional offices.

In addition, Agency scientists work closely with the National EPA-Tribal Science Council to help integrate Agency and tribal interests, specifically with respect to environmental science issues in Indian Country.

Annually, the Agency supports targeted collaborative research and technical support activities that are designed to: (1) provide the regions and communities across the nation with near-term research on high-priority localized needs; (2) improve collaboration between regions and Agency laboratories and research centers; (3) build the foundation for ongoing and future scientific interactions; and (4) develop useful tools for state, local, and tribal governments to address near-term and emerging environmental challenges.

Agency Science Partnerships Tackle Water Quality Issues

There are over 3.5 million miles of rivers and streams and 39.9 million acres of lakes and reservoirs in the U.S., covering an enormous and diverse landscape. Not surprisingly, the condition of our nation's waters varies widely. Cities and town, farmlands, mines, factories, sewage treatment facilities, dams, and many human activities on the land have

Supporting Human Health and Environmental Science in EPA Regions and Indian Country, *Cont'd.*

significant impacts on the quality of our waters. Freshwater and tidal ecosystems support complex and important food web interactions and provide habitat needed to support numerous threatened and endangered species.

Understanding the condition of these waters is critical if we are to develop effective plans to maintain, manage, and restore them. The following EPA partnerships were designed to advance that goal:

Dissolved Oxygen in the Chesapeake Bay

Fluctuations in the level of dissolved oxygen (DO) are a major environmental stressor in the Chesapeake Bay and its tidal tributaries. Elevated nutrient levels have resulted in significant decreases in DO, leading to fish kills and other impacts on the ecosystem.

EPA partnered with the National Oceanic and Atmospheric Administration (NOAA) and the Maryland Department of Natural Resources to deploy, operate, and analyze the results of a vertical profiler, a monitoring technology that is able to measure DO, salinity, and temperature hourly at 1-meter intervals in a column of water. This technology has the potential to provide scientists and decision makers with information on the variability of DO that has not been available in the past.

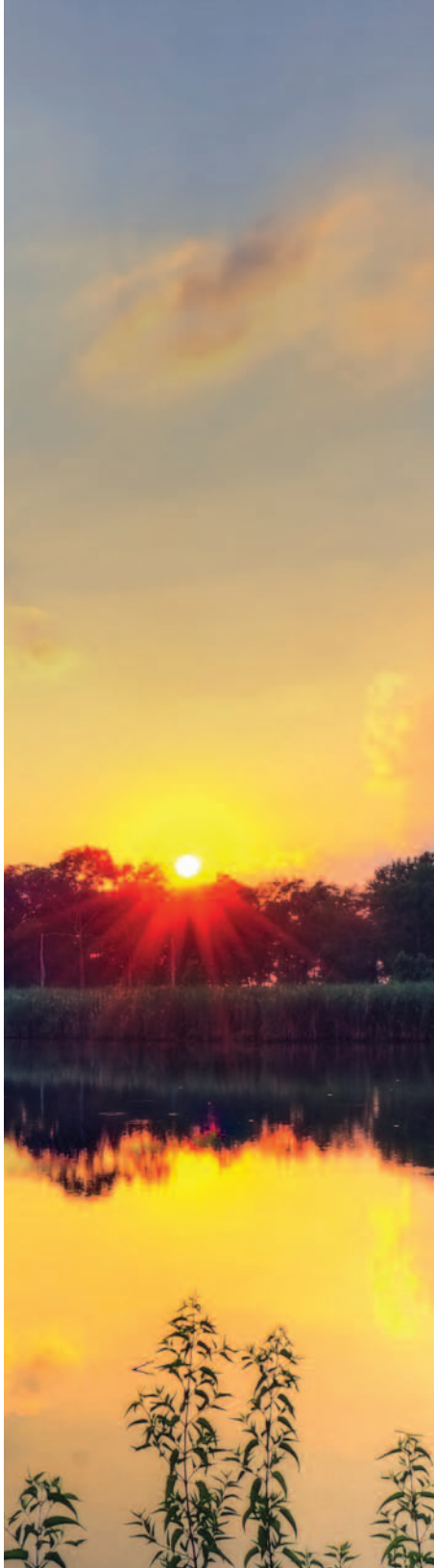
Research results, combined with data from several similar concurrent projects, suggest the need to revisit the monitoring approaches now being used in the Chesapeake Watershed. The results have potential implications for the approach used by the Chesapeake Bay Program and the states for monitoring and assessing the instantaneous minimum criteria for their impaired waters listing assessments, and for implementation of Total Maximum Daily Loads of pollutants impacting DO levels. Results also point out the need for further development and validation of the technology available to monitor short term, deep water DO levels. Because of this research, researchers have made improvements to the vertical profiler and NOAA intends to continue deployment of this technology.

Idaho Pebblesnail is Key to Developing New Ammonia Criteria

Ammonia is one of the most important pollutants in the aquatic environment. It is highly toxic and waste fluids, such as municipal wastewater or runoff from concentrated animal feeding operations, must be treated extensively to lower the concentrations of ammonia in surface waters.

Currently, there are separate ammonia criteria for freshwater depending on whether salmonids or mussels are present. Salmonid fish include salmon, trout and whitefish. When conducting research in lakes, streams and rivers using the current criteria, scientists first have to determine if these fish or mussels are present. Scientists also suspect that the current criterion is not protective of freshwater snails.

EPA collaborated with the U.S. Geological Survey to develop a method to breed and raise Idaho pebblesnails (Fluminicola sp.) and test their sensitivity to ammonia. The Idaho pebblesnail is a freshwater snail common in the western U.S. Toxicity data from the lab-controlled



Supporting Human Health and Environmental science in EPA regions and Indian Country, *Cont'd.*

studies showed that it is among the most sensitive species evaluated for developing the ammonia criteria.

The data also prompted a significant change in the way the ammonia criterion is stated. The criterion will now apply nationwide to all aquatic species. Permit writers will no longer have to determine if salmonid fish or mussels are present in a given water body. This will make it much easier to be consistently protective of all aquatic life, including threatened or endangered freshwater snails. EPA is revising the 2011 National Aquatic Life Ambient Water Quality Criteria for Freshwater Ammonia to reflect this change.

Getting the Word Out: The Possible Hazards of Fish Consumption

Fish are important in a healthy diet. They are a lean, low-calorie source of protein. However, some fish may contain methylmercury or other harmful chemicals. . Even though these chemicals may be present in the water at low levels, because of bioaccumulation, organisms living in the water contain these toxic chemicals at much higher concentrations. These toxic chemicals are further concentrated in the fish at higher levels of the food chain.

Federal, state, Tribal, and local governments monitor local waters and issue fish consumption advisories when the fish are unsafe to eat. The advisories may recommend that people avoid eating certain kinds or certain amounts of fish.

Some advisories apply to specific water types. Some may focus on specific groups of people. Advisories may apply to locally caught fish and fish purchased in stores and restaurants.

EPA collaborative research aimed at getting the word out about fish consumption include:

Regional Tool Identifies Populations with Increased Mercury Levels

A 2004 New York State study found that blood mercury concentrations in adult New York City residents were three times the national estimate, with one in four New Yorkers, and almost half of New York City's Asian population, exhibiting elevated blood mercury levels.

In response, EPA conducted a geographic analysis to identify areas and populations to target for outreach, education, and other efforts aimed at reducing risks associated with eating some species of fish and shellfish. Agency scientists collected and analyzed existing data on age groups; birth rates; socio-economic status; ethnicity; restaurant, market, and grocery store fish sales; fish tissue contaminants; and other indicators.

The resulting work, completed for

Getting the Word Out: The Possible Hazards of Fish Consumption, *Cont'd.*

New York State and being finalized for New Jersey, identifies areas and populations most in need of outreach based on their exposure to certain fish and shellfish. The program will be piloted in 2012, in partnership with the pediatric environmental health unit at Mt. Sinai. Results will be shared with pediatricians and ob/gyns in affected areas to help them target their outreach efforts with women of child-bearing age and children.

Reducing Exposure to Mercury on the Cheyenne River Reservation

As part of a collaborative study with the Cheyenne River Sioux Tribe (CRST) Department of Environmental Protection, scientists collected three years of field data to simulate the environmental fate of mercury and the dynamics of bioaccumulation within tribal livestock ponds. Researchers found elevated levels of mercury in fish tissues and released a fish advisory based on these findings. The advisory recommended reducing consumption of fish, especially for sensitive individuals, such as the pregnant and elderly.

Field and laboratory procedures have been transferred to the CRST and have resulted in capacity building with Tribal personnel. CRST livestock ponds were one of the five model ecosystems used in the Benefits Assessment for EPA's Clean Air Mercury Rule to better understand processes driving mercury cycling in aquatic systems.

Water treatment facility.

Increasing Efficiency at Local Wastewater Facilities

Wastewater utilities across the country are facing challenges to improve their efficiency while keeping rates affordable for the communities they serve. These challenges include high municipal wastewater volumes, increased treatment costs, and rising energy costs. In the U.S. alone, over 16,000 operational wastewater facilities treat approximately 34 billion gallons of municipal wastewater daily. With this high volume, the total nationwide cost for wastewater treatment and collection is estimated to be $189.2 billion annually. Additionally, energy costs from wastewater and water services often represent 30% or more of a municipality's total energy costs. These rising energy costs represent a major challenge for water and wastewater utilities that are also facing the challenges of increasing demands due to population growth, more stringent regulations, and aging infrastructure.

EPA research partnerships in support of increasing efficiency at local wastewater facilities include:

Missouri Water Utilities Become More Energy Efficient

Agency scientists believe that

Increasing Efficiency at Local Wastewater Facilities, *Cont'd.*

increasing energy efficiency is one of the most effective ways to reduce costs and improve environmental performance. EPA and the Missouri University of Science and Technology entered into a collaborative effort with the eight communities participating in the Missouri Water Utilities Partnership to increase energy efficiency at community wastewater facilities. The objective of the project was to help these communities, and others like them, to reduce utility costs and pollution while improving reliability and performance. Researchers assisted the communities in assessing their energy efficiency and effectiveness, provided recommendations regarding wastewater treatment and use, and presented the results of their changes to a broader community audience through outreach and the development of written cases studies.

Because of this research, many of the communities that participated in this project gained more than a 20% reduction in energy use. The case studies are helping other communities analyze their own situation by providing ideas for energy efficiency and effectiveness. Finally, the data collected from this effort are informing the research community on the condition and specifications of these utilities to better aid technological development needed for wastewater treatment.

Revised EPA Wastewater Stabilization Ponds Design Manual

One particular technology that helps to reduce energy needs at wastewater facilities is stabilization ponds. Wastewater pond systems provide energy efficient, reliable, low cost, and relatively low maintenance treatment for municipal and industrial wastewater discharges. Wastewater stabilization ponds can be 3 to 10 times more energy efficient when compared with digesters and aerators. This provides a more sustainable alternative for wastewater treatment.

In 2011, Agency scientists collaborated to revise the EPA Wastewater Stabilization Ponds Design Manual, originally published in 1983. This revised manual provides updated information and guidance for the design and operation of over 8,000 wastewater treatment ponds, which is more than 50 percent of the wastewater treatment facilities currently operating in the U.S. Using this guidance for proper design and operation, these ponds are capable of meeting strict environmental standards with minimal biosolids management requirements and very reasonable energy costs, helping to protect the environment and reduce energy needs.

Conversion of Wastewater Facilities into Biorefineries

Reclaiming wastewater to generate biofuels is one strategy that Agency scientists hope will ease the environmental impacts and treatment costs of wastewater streams. EPA collaborated with Mississippi State University to investigate the potential for using municipal wastewater in the production of biofuels. Using wastewater obtained from a Tuscaloosa, Alabama municipal wastewater treatment plant and working at laboratory-scale, researchers demonstrated that ozone disinfection is a robust and effective disinfectant for wastewater. Further, the studies showed that

Increasing Efficiency at Local Wastewater Facilities, *Cont'd.*

microorganisms capable of producing large quantities of oil can be grown in ozonated wastewater.

The results of this project provided valuable input for current pilot-scale testing at the Mississippi State University Energy Institute. Wastewater from various municipalities and industries will be tested for oil accumulation to ultimately produce biofuels from the oils.

Mississippi river and surrounding area.

New Technologies Used to Detect Emissions

EPA scientists are developing new technologies to better identify sources and to quantify emissions of gases or vapors. These emissions come from a variety of sources including vehicles, boats, industrial equipment, and oil and gas exploration activities. Emissions due to equipment leaks in the natural gas industry alone are estimated to be 146.9 billion standard cubic feet.

Identifying and controlling these emissions is an enormous challenge nationwide. EPA partnerships working to meet that challenge include:

Detecting Emissions from Oil and Gas Operations Using Remote Sensing

Emissions of volatile organic compounds (VOCs) and greenhouse gases from oil and gas exploration and production activities contribute to increased ozone levels in the ambient air, and pose a threat to air quality in and around communities in the Rocky Mountains. Furthermore, our ability to estimate the emissions from these activities is limited. EPA has collaborated with the states of Colorado and Wyoming to conduct field studies using a highly sensitive instrument mounted on a mobile platform to detect and quantify oil and gas emissions. The mobile unit is equipped with a fast-response cavity ringdown spectrometer, a device that can obtain rapid measurements downwind of potential sources, and a precise global positioning system to map air pollution patterns in areas around sources. Data collected with this remote method have improved knowledge of air pollutant emissions from production and storage equipment.

As a result of these field studies, the project team has improved the overall performance of the mobile detection and quantification method, which can now produce emission flux estimates of methane and VOCs from individual sources. When the mobile method is fully developed, this technology can be passed on to state and local health departments to monitor air quality in communities near oil and gas exploration and production activities.

Infrared Cameras Find Emissions Leaks along the Mississippi River

Leaking organic vapors from barges and railcars along the Mississippi River industrial corridor affect air quality in nearby cities. In the past, the use of infrared technology to discover hydrocarbon leaks has been used along pipeline routes throughout the country. EPA partnered

New Technologies Used to Detect Emissions, *Cont'd.*

with the Louisiana Department of Environmental Quality (LDEQ) to test the ability of infrared cameras to "see" hydrocarbon emissions invisible to the human eye along the Mississippi River. With the use of the HAWK® surveying instrumentation from a helicopter flying low over the pipelines, barges and railcars, and entering that information into LDEQ's existing GIS databases, EPA was able to identify the leakers and have them repaired.

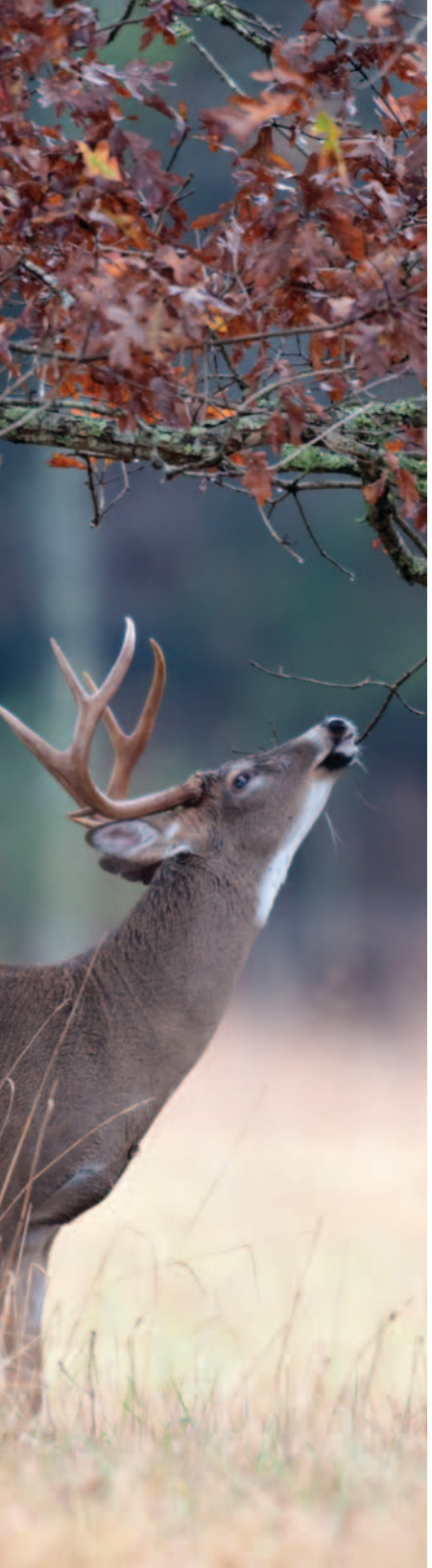
Prototype cameras are now making inspections safer and more effective. This information will also help determine if the existing regulations are sufficient to protect the environment and the public from unauthorized releases of hazardous chemicals.

Green Infrastructure Research Shaping Community Projects

Communities are increasingly seeking to implement green infrastructure practices, such as rain gardens, bioswales, and permeable pavements, to help manage urban and suburban stormwater volume and quality and to help control sewer overflows. Green infrastructure can be a cost-effective approach, compared to using strictly "gray infrastructure" (below-ground pipes, sewer inlets, high-rate treatment plants, etc.), and can provide significant community benefits. Green infrastructure projects can help to keep stormwater out of combined sewers, leaving more capacity in these systems and decreasing the chance of overflows. Overflows of septic sewage are a threat to public health, impair our valuable water resources such as rivers and streams, and pollute the land surrounding these surface waters.

EPA has developed a portfolio of green infrastructure research. The results of this research are now informing EPA permitting and enforcement actions, and providing new options for communities to meet regulatory standards. Scientists have recently completed a study that demonstrated the value of the use of rain barrels and rain gardens in a suburban neighborhood to decrease stormwater volume to sewer systems and receiving waters. EPA is also evaluating the effects of green infrastructure implementation in Cincinnati, Cleveland, and other midwestern urban areas, where researchers have conducted extensive studies of the condition of urban soils and the suitability of the soils for infiltration practices.

This research has produced valuable information that is being used in community planning decisions and enforcement actions. For example, the Northeast Ohio Regional Sewer District has negotiated a green infrastructure pilot program under their consent orders, and will undertake this program to set practical standards for performance and cost that will complement and build on other "gray" improvements to the combined system. It is anticipated that the green infrastructure investments will not only keep stormwater volume out of smaller combined sewer systems, but also increase the amount of green space in urban core areas, and provide more and higher-quality ecosystem services. These investments can help to stabilize and revitalize distressed neighborhoods and protect Lake Erie from the numerous beach closures caused by combined sewer discharges. EPA has taken the lead in working with other communities to understand how to share and manage risk with communities and get them on the right track to effective management and compliance with the Clean Water Act.



Controlling Lyme Disease in the Northeast

In the northeastern U.S., Lyme disease (LD) infection rates continue to increase and have reached epidemic levels in many communities. LD is the second most frequently reported disease in New England states. It is also the most common of all vector borne diseases reported in the U.S. The black-legged tick, *Ixodes scapularis*, is the primary vector of the LD pathogen, *Borrelia burgdorferi*.

New research shows links between land use, biological diversity, and LD transmission. In 2006, EPA developed a research initiative to improve the understanding of these links. Agency scientists have been collaborating on research, management and control of black-legged tick populations in Massachusetts and have tested the efficacy of four poster deer stations (passive deer feeding stations that force deer to rub against pesticide-impregnated application rollers) for reducing tick populations and LD risk. The outreach tools that are being developed support the Agency's Landscape, Biodiversity and Human Health Community of Practice (CoP), which is intended to foster closer collaboration between diverse communities, including public health practitioners, land use planners, ecologists and the public. This work will allow the State of Massachusetts to more effectively provide guidance on LD and help the Agency implement sustainable solutions.

EPA plays an important role in developing and implementing sustainable, environmentally sound approaches under integrated pest management to improve control and management of vector-borne diseases on a landscape scale while reducing exposures to toxic chemicals. EPA is now building new partnerships with public health practitioners, land use planners, ecologists and the public to produce new knowledge and sustainable tools to reduce the risk of disease and minimize adverse impacts to the environment.

Tribal Science

Working with tribal nations to promote clean, healthy environments is a critical part of fulfilling EPA's mission. EPA is committed to building strong and sustaining partnerships with American Indian tribes and Alaska Native villages for the protection of the environment and human health.

The National EPA Tribal Science Council (TSC), composed of a single tribal representative from each of the nine EPA Regions, provides a platform for interaction between Tribal and EPA scientists to work collaboratively on environmental science issues. The TSC serves to inform EPA about significant tribal environmental issues and to lay the groundwork for addressing these challenges in conjunction with tribal partners.

2011 Tribal science partnership projects include:

National Tribal Science Priorities

In June 2011, the TSC concluded its collaborative stakeholder-driven process to identify national tribal science priority issues. The six-month selection process promoted broad engagement of tribes to identify two tribal priorities: (1) Climate Change; and (2) Integration of Traditional Ecological Knowledge in Environmental Science, Policy and Decision-Making.

Implementation of the priorities will strengthen EPA and tribes' ability to improve human and environmental health in Indian Country.

The TSC is currently working to integrate activities that support the priorities into tribal programs and operations on the national, regional, and local levels.

Decision Support Tool for Tribes

In collaboration with tribes and other partners throughout the country, EPA is developing the Tribal-Focused Environmental Risk and Sustainability Tool (Tribal-FERST), a web-based decision support tool designed to empower tribes with the best available human health and ecological science. Tribal-focused tools are often not readily available to help tribes prioritize environmental issues and understand unique exposure pathways. Tribal-FERST is a user-friendly, science-based tool that will contribute to sustainable, cost-effective solutions to improve public health and the environment on tribal lands.

Tribes may use the tool to:

- Create a data table to identify and prioritize local environmental issues
- Follow guidance on developing strategies for conducting tribal assessments
- Download information about environmental health and wellness
- Access traditional ecological knowledge as data sets or fact sheets
- Map exposures and risks
- Explore potential solutions to environmental problems
- Link to other tools relevant to tribal-focused assessments

Tribal Science, *Cont'd.*

In November, EPA's Sustainable and Healthy Communities Research Program launched a pilot study with the Passamaquoddy Tribe at Pleasant Point in Maine. The Passamaquoddy Tribe will use the tool to inform environmental and economic decisions about solid waste, community sustainability and other issues of concern, while providing suggestions for making Tribal-FERST a more robust and user-friendly tool.

Providing Technical Support for Hazardous Waste Sites

In 2011, EPA provided technical support to hazardous waste sites nationwide through the Superfund and Technology Liaison program and specialized EPA technical support centers. A number of targeted research projects and publications resulted from these technical support activities. These research projects focused on timely and relevant research to answer specific hazardous waste related questions. The research projects were community-focused and included alternate water supply evaluations; watershed cleanup approaches; heavy metals contaminated soils, leaching, and bioavailability research; research involving preservatives for groundwater samples with binary mixtures of in situ chemical oxidants and chlorinated solvent contaminants; polychlorinated biphenyl sampling and remediation research; and an evaluation of the potential societal impacts of remediation of heavy metals in a large urban community. The results of these projects will assist in reducing community exposure to contaminants in both urban and rural areas. Communities across the country will benefit from effective and efficient cleanup remedies and assistance with promotion of overall community and environmental health.

Homeland Security

Strengthening Community Resilience to Homeland Security Threats

EPA's Homeland Security Research supports the Agency's role as the lead federal agency for protecting water systems and all decontamination following incidents involving chemical, biological, or radiological contaminants. The research strengthens the resiliency of communities to prepare for and respond to such incidents by providing water utility managers, laboratory technicians, on-scene coordinators, risk assessors, risk communicators and emergency responders with the scientific expertise, tools and technology to detect, prepare, respond to and recover from terrorist attacks and other disasters.

This section provides highlights of some of the top research results EPA researchers and their partners have achieved in 2011 advancing Homeland Security. It illustrates some of the specific impacts that are important to partners of the Agency's Office of Research and Development. The highlights presented were contributed by EPA's research labs, centers, and offices located around the country, and were performed by Agency scientists and engineers, as well as their partners, grantees, fellows, and collaborators from across the scientific community.

Strengthening Community Resilience to Homeland Security Threats

EPA has and will continue to have responsibilities in response to disasters. According to a recent assessment, rare, extreme weather events are becoming more common. Over the past decade, between 40 and 80 disasters have occurred each year. These included Hurricane Katrina, the historic flooding of the Mississippi River, and devastating tornados throughout the Midwest and Southeast. In 2001, an intentional release of anthrax spores killed five people and injured several more. The spores contaminated at least 17 buildings and required an immense site investigation and cleanup effort by EPA and partner agencies and departments. The estimated total cost was $1 billion.

Examples of Major EPA Responses

Three Mile Island (1979)

U.S. Impacts from Chernobyl (1986)

Midwest Floods (1993)

Los Alamos and Hanford Fires (2000)

9/11 Terrorist Attacks (2001)

Capitol Hill Anthrax (2001)

Columbia Shuttle Disaster (2003)

Gulf Coast Hurricanes (2005)

Deep Water Horizon (2010)

Japan Nuclear Power Plant Emergency (2011)

The Homeland Security Research Program (HSRP) was established to conduct applied research and provide technical support that increases the capability of EPA to carry out its homeland security responsibilities. The HSRP helps build systems-based approaches to addressing

Strengthening Community Resilience to Homeland Security Threats, *Cont'd.*

these environmental problems by working with Agency partners to plan, implement and deliver useful science and technology products. HSRP maintains robust coordination efforts with other federal agencies including the Department of Homeland Security, the Department of Defense, and the Centers for Disease Control and Prevention, among others. HSRP's research is conducted and science products are constructed to address "all hazards," filling science gaps associated with chemical, biological and radiological contamination intentionally released by terrorists or caused by natural disasters or accidents.

The program is organized into three themes:

- Securing and Sustaining Water Systems;
- Characterizing Contamination and Determining Risk;
- Remediating Indoor and Outdoor Environments.

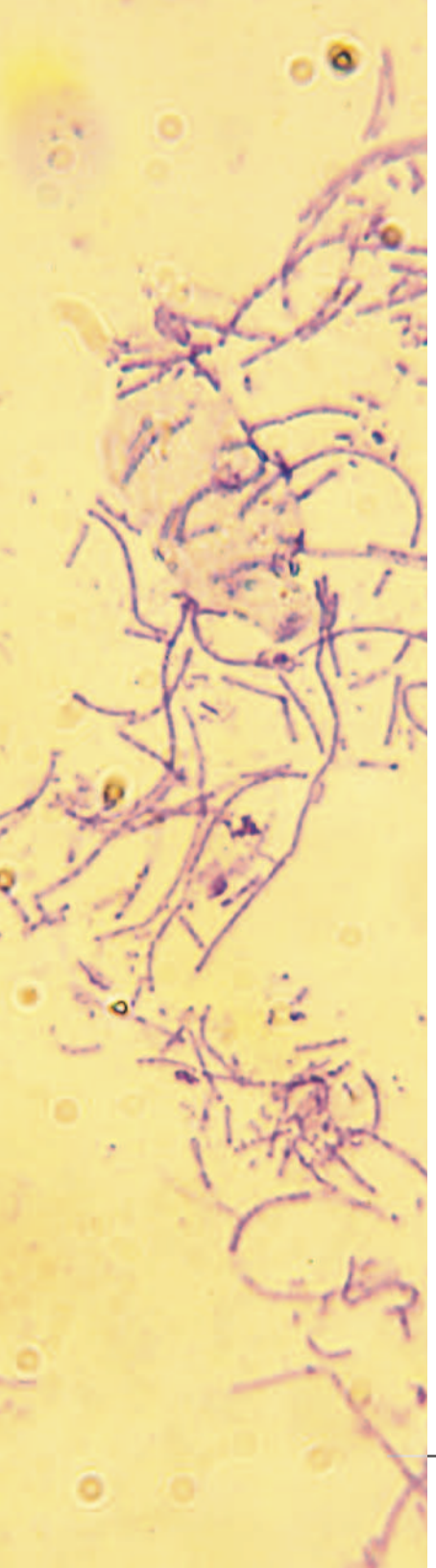
Natural and man-made disasters cause population loss, economic instability and property damage. A resilient community needs to be able to prepare for these kinds of challenges, respond to them, and recover from them. Strengthening communities so that they can withstand natural and manmade disasters is a major EPA goal. It is also an essential part of the Agency's commitment to sustainability.

Scientific and technological questions around large biological, chemical and radiological events remain. Emerging chemical and biological threats, as well as cyber threats, present unique challenges to our level of preparedness and response capabilities. Incidents such as anthrax clean-ups in New England and the domestic impacts of the Japanese nuclear plant meltdown at Fukushima affirm the importance of maintaining our scientific expertise (i.e., retaining, adapting and adding to the Agency's cadre of scientific and engineering subject matter experts) so that EPA can address the scientific uncertainties and technical unknowns encountered in major responses.

If a terrorist released millions of lethal microbes into a building or mass transit system, how would first responders address these dangers and how would biohazard teams clean them up? Researchers in the homeland security area have made many great advances in developing decontamination techniques, but to date, the work has mostly been on a small scale in research laboratories.

To approach this problem, EPA is leading a research project called the Bio-Response Operational Testing and Evaluation (BOTE). The BOTE field demonstration tests followed several years of research and collaboration with the Department of Homeland Security, the Defense Threat Reduction Agency, the Centers for Disease Control and Prevention, the Federal Bureau of Investigation and Department of Energy. The information and data from BOTE will help agencies make decisions about homeland security threats such as a biological attack with anthrax.

The purpose of this project is to conduct and evaluate field-level facility, biological remediation studies of various decontamination technologies and to exercise biological incident response from



Responding to Anthrax Attacks: the Bio-Response Operational Testing and Evaluation (BOTE) Project

initial health/law enforcement response through to environmental response and remediation. Field tests started with an intentional release of a surrogate organism named *Bacillus atrophaeus*.

In Phase I of BOTE, scientists evaluated three decontamination methods: spraying with pH-adjusted bleach, fumigation with vaporized hydrogen peroxide, and fumigation with chlorine dioxide. The HSRP team compared the effectiveness and ease of using the three treatments. They also weighed costs, damage to the facility, types and quantities of generated waste, and potential recontamination risks. In addition, the scientists examined the potential for spores released indoors to escape from the building and contaminate soil outside. The researchers also measured how likely it was for the spores to be resuspended in the air after they had settled. The project managers will use the data from these tests to develop and recommend ways to protect future residents in actual incidents, from exposure to spores after returning to a decontaminated building.

Phase II of BOTE involved mimicking a potential real-life scenario in which government officials were informed of an intentional anthrax-like, building-wide release. In this scenario, a covert release contaminated several buildings. The exercise tested the preparedness and response capabilities of health and law enforcement officials and on-scene environmental response teams.

Thus far, the BOTE project has shown that various remediation technologies and operational practices can be effective for the full-scale decontamination of anthrax in buildings. BOTE sample analyses data interpretation and reporting are currently underway.

Microscopic enlargement of anthrax bacteria (*Bacillus anthracis*).

Improving Laboratory Capacity and Capability

Determining the type and extent of contamination in the aftermath of a terrorist incident or other disaster is essential for emergency response, recovery and remediation operations. Fast, accurate laboratory analysis often is critical.

EPA formed the Environmental Response Laboratory Network (ERLN) to respond to chemical, biological and radiological threats on a nation-wide scale. The ERLN is a national network of selected, existing public and private sector laboratories. Its goal is to provide consistent analytical tools and high-quality data. EPA scientists have developed reliable sampling and analytical methods for ERLN personnel.

One of these methods is a cutting-edge technique called Rapid Viability Polymerase Chain reaction (RV-PCR). This method provides a faster and more accurate way for laboratories to analyze samples suspected to contain anthrax than traditional culture methods. It allows laboratories not only to detect anthrax but also to determine if the detected bacteria are capable of causing human infection.

By using this improved method, scientists were able to decrease the total time to analyze 24 samples from 24 hours to 15 hours. In addition, it only takes 3-4 more hours to analyze subsequent batches of samples. This technique will allow scientists to analyze many more samples per day.

Sample preparation, however, is the slowest step in detecting pathogens. Before analysis, the microorganism of interest must be removed from the material being analyzed (e.g., soil, water or wipes). Extracting target microorganisms from soil is particularly difficult because of the high number and variety of other naturally occurring microorganisms. Non-target organisms often mask the presence of target organisms. It is critical to isolate only the organism of interest and to do so at a high concentration.

EPA developed the Automated Immunomagnetic Separation (AIMS) method to improve anthrax spore extraction from soil. Compared to other methods, AIMS extracts a greater number of anthrax spores from several types of soil. By capturing more spores from the sample, laboratories can detect and quantify the amount of anthrax in soil more accurately.

It is also critical to be able to detect pathogens in the air. During 2011, EPA tested an air sampler device that was able to separate captured particles by size better than by previous methods. This is important because particles affect the human respiratory system differently depending on their size. Therefore, particle size data is needed to predict the effects of air contamination on human health. The new sampler can gather test materials from an entire area. It also can be used as a personal sampler when worn on clothing near the face. Its design eliminates sample loss and minimizes sample contamination.

By developing these new methods, EPA is moving closer to fulfilling its homeland security mission and its overall mission to protect human health and the environment.

Responding to the Detonation of a Radiological Dispersion Device

A radiological dispersion device (RDD) or, "dirty bomb," is a combination of chemical explosives and radioactive material. Such an explosion could spread radioactive material over a wide area. A RDD explosion is especially problematic in a heavily populated, urban area. RDDs lead to surface contamination dispersed unevenly by wind, weather, and vehicular and pedestrian traffic.

The Department of Homeland Security published the National Response Framework (NRF) to guide response to disasters and emergencies in a unified and coordinated way. These potential disasters range from small, local incidents to large catastrophes. The explosion of an RDD would be one such disaster.

The NRF assigned EPA the task of leading the decontamination of buildings, equipment and outdoor areas following a large-scale radiation contamination incident. The Agency held a series of workshops to study waste disposal problems that might result from an RDD. Lessons learned will be applied in future research activities.

EPA has also studied alternative approaches and techniques for cleaning-up radioactive contamination from an RDD. In one study, HSRP scientists investigated Cesium-137 (Cs-137) contamination --, one of the radioactive isotopes most likely to be used to make an RDD. Researchers applied Cs-137 to samples of unpainted concrete. They then decontaminated each sample using a chemical or mechanical treatment. The techniques included spraying-on liquid removed by vacuum, a strippable coating, surface grinding and ablation. The results for Cs-137 removal using the different techniques ranged from 36 to 96 percent effective.

Scientists prepared several peer-reviewed reports that described the findings from these studies. They wrote the reports for federal, state and local emergency management authorities, response planners and support personnel. The reports will help these officials choose the best technologies for specific clean-up operations.

Helping Water Utilities Detect and Respond to Contamination

Many intentional and accidental incidents have the potential to threaten the security of public drinking water supplies. EPA is developing automated contamination warning systems (CWSs) to detect contamination events in public water distribution systems. EPA's CWSs are actually combinations of several different types of warning systems. They use remote technology to monitor water quality and the physical security of water systems. CWSs also integrate public health reports of disease outbreaks and customer complaints about water quality. The goal of using CWSs is to catch problems early and so reduce their impact on public health and clean up costs. Since 2006, EPA has been collaborating with several drinking water utilities to test CWSs in Cincinnati, Philadelphia, New York City, Dallas, San Francisco, Los Angeles and Singapore. More than 30 utilities around the country are exploring using these tools.

EPA has developed modeling software to help water distribution operators design sensor networks for their systems and to respond to contamination. Researchers continue to update and improving them. To determine which improvements to focus on in 2011, EPA researchers engaged participants in the Office of Water's Water Security Initiative and other users.

EPANET comprises several computer models used by water utilities and homeland security researchers to understand contamination threats to water distribution systems. EPANET estimates the flow and quality of water in specific water utility distribution systems. Early versions of EPANET were only able to predict the spread of one contaminant at a time. Since 2007, however, EPA has expanded the capabilities of the models. EPANET now models the movements and interactions of multiple chemicals and/or pathogens. This new software, EPANET-MSX, was updated in 2011 to better support homeland security applications.

Along with other updates in 2011, researchers added multiple-contaminant capability to EPA's sensor placement modeling tool, the Threat Ensemble Vulnerability Assessment and Sensor Placement Optimization Toolkit (TEVA-SPOT). TEVA-SPOT helps operators decide where to place sensors in water distribution systems to protect against both intentional and accidental contamination.

The EPA's event detection software called CANARY—after the proverbial "canary in the coal mine"—interprets continuous monitoring data. It can discriminate between normal changes in water quality and contamination events. CANARY, most recently updated in 2011, can detect both intentional contamination and routine problems.

Also in 2011, EPA, in partnership with the American Water Works Association convened workshops to explore what to do if local public water supplies were destroyed, damaged or contaminated. More than sixty technical experts attended the five workshops. Experts reviewed ways of providing emergency drinking water supplies. EPA's report, *Planning for an Emergency Drinking Water Supply*, summarizes workshop recommendations. The report also helps public water utilities create emergency response and contingency plans.

Water utility experts recommended that community planners prepare for drinking

Helping Water Utilities Detect and Respond to Contamination

water supply emergencies. Local officials are encouraged to work with utilities and state agencies to stockpile emergency water supplies. In local disaster response exercises, agencies also should include the possibility of water service being lost or disrupted. Planners are encouraged to look for gaps between projected needs for emergency water supplies and local, state, federal and nonprofit organization resources. In addition, citizens are to be reminded of steps that they can take to prepare for a water emergency, including storing a 3- to 5-day supply of potable water. More than 3500 water utilities have participated in AWWA's webinars describing EPA's report and planning guidance.

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Join EPA's Dr. Bill Sanders 1-2pm at EPA booth 1341 to discuss STAR & P3 grants, fellowships & SBIR awards **#SOT2011**

Dir of EPA's Clean Air Research, Dan Costa "We need to do more than look at just one pollutant. We need a multipollutant approach."

Are children born premature sensitive to air pollutants? @EmoryUniversity @Georgia_Tech center to investigate #SOT2011 http://bit.ly/gjleqN

Does air pollution affect your child's learning? @HarvardResearch to investigate pollution acr

Is your commute making tigate #SOT2011 http://bit.ly/gjleqN

Dr Anastas: "we don't want to make things just a little less bad. We want to move towards a systems perspective."

Join EPA's Dr Jennifer Orme-Zaveleta, 11am @ EPA booth 1341 to talk about clean, adequate & equitable water supply #SOT2011

"Green alternatives should be less toxic than current chemicals" EPA's Dr Richard Judson shows tools used 2 test 4 toxicity risk @ #SOT2011

Celebrating #InternationalWomensDay & all women scientists & engineers who protect our planet & health - here's one: http://bit.ly/fmX7Ts

EPA hosts Tribal Science Webinar (new process to ID science priorities in Indian Country) Mar 9 11am-12:30pm ET http://bit.ly/h9MolT

At #SOT2011? Join EPA's Dr Robert Kavlock 9:30am @ EPA booth 1341 to discuss sustainable development of chemicals

Join EPA's Dr Dan Costa at 11am at EPA booth 1341 to discuss EPA's air quality research #SOT2011 http://bit.ly/ieOr5o

Dr Teichman reviews EPA's 40th anniv highlights including: removing acid from rain and lead from gasoline (and air) #SOT2011

Dr Teichman: more highlights of EPA's 40 years: clearing second hand smoke, improving vehicle efficiency and emissions controls #SOT2011

Teichman: "EPA does research! Office of Research & Development provides the foundation 4 everything EPA does" http://bit.ly/6sz4uY #SOT2011

Example of important EPA research on air polllution: http://twitgoo.com/20no7t from Dr Teichman's talk @ #SOT2011

At SOT2011? EPA's Deputy Administrator Bob Perciasepe gives today's keynote on EPA Vision 8- 9am (ET)

"Good science allows us to articulate what we must do" (for env. protection) from Perciasepe #SOT2011

Our work becomes more complex but very important to communicate how and what we do + how affects communities -Perciasepe #SOT2011

"It's about going beyond boundaries, seeing big picture, being proactive. Green Book will help us shift our vision" Perciasepe #SOT2011

to give us foresight to make right decisions toward sustainability -Perciasepe #SOT2011

Want to join ToxCast effort? http://1.usa.gov/g7dQwK EPA's Chemical Prioritization Communities of Practice stakeholder group #SOT2011

Thx to work of #SOT2011 better equipped to make strong scientific case to take comprehensive actions thru innovative solutions -Perciasepe

EPA Reaching Out To Empower Women Around The World today's blog in our Women in Science series: http://bit.ly/go2RFm

"Learning the Science to Protect the Planet" http://bit.ly/h7jynk part of EPA's Women In Science blog series

Chemistry Teacher? U have to watch EPA's Dr Peavey "Moving schools to sustainable, green chemistry" http://bit.ly/dI4Re0 VIA @beyondbenign

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RT @EPAgov Our updated #japan #radiation site makes it easier to get monitoring data: http://epa.gov/japan2011 | More improvements coming.

From Tide Pools to Children's Health – One Scientist's Journey http://bit.ly/epjUR7 (part of EPA's women in science blog series)

RT @HealthyLegacy Great interview with Paul Anastas last night on Marketplace--take a listen! #greenchemistry #mngreenchem http://ow.ly/4lwOM

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