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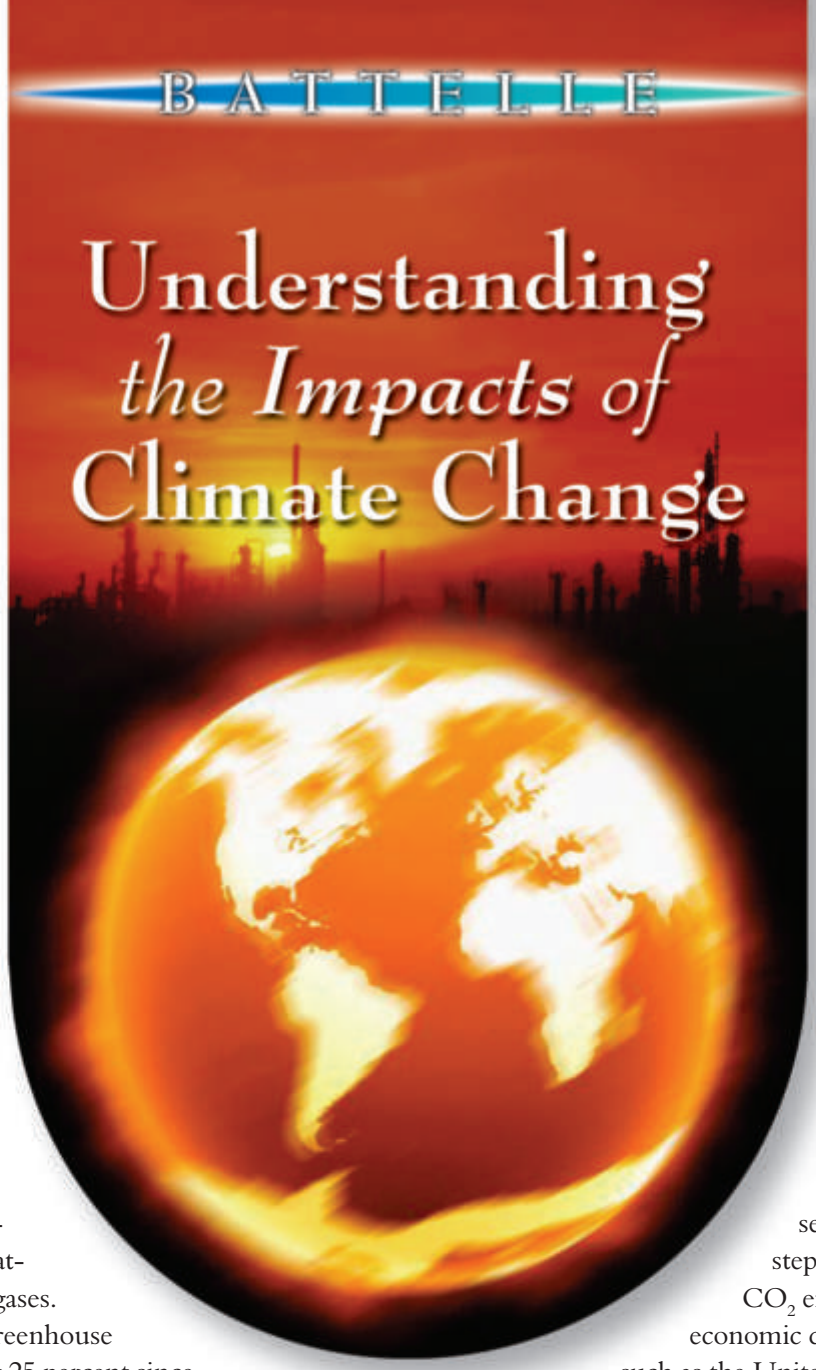
# Environmental Updates
Highlights of Battelle's International Environmental Leadership
Fall 2005

# CLIMATE CHANGE




Over the past century, the Earth's average temperature has increased by approximately 1° F, with 10 of the warmest years on record occurring since 1990. There have been numerous worldwide scientific studies exploring possible contributory factors to this warming trend. The most recent Intergovernmental Panel on Climate Change Third Assessment Report (2001) concluded "new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities."

There is a belief that increasing concentrations of greenhouse gases in the atmosphere are accelerating the rate of global climate change. Many chemical compounds found in the Earth's atmosphere act as greenhouse gases. Levels of several important greenhouse gases have increased by about 25 percent since large-scale industrialization began around 150 years ago; atmospheric levels of carbon dioxide in particular are higher today than they have been for more than 400,000 years.

Carbon dioxide ($CO_2$) is believed to be the largest contributor to the overall increase in greenhouse gases. Relatedly, scientific studies have shown that an increased amount of $CO_2$ by human activities has occurred over the last few hundred years. These specific human activities include burning fossil-fuels such as gasoline, coal, and natural gas, all of which contribute to the buildup of $CO_2$ in the atmosphere. Fossil fuels alone are responsible for approximately 98% of U.S. $CO_2$ emissions.

What does all of this mean in terms of specific impacts to the environment? A May 2001 National Research Council study stated, "Greenhouse gases are accumulating in Earth's atmosphere as a result of human activities, causing surface air temperatures and sub-surface ocean temperatures to rise. Temperatures are, in fact, rising. The changes observed over the last several decades are likely mostly due to human activities, but we cannot rule out that some significant part of these changes is also a reflection of natural variability." Some believe that the environmental damage will have such severe impact that immediate steps should be taken to reduce $CO_2$ emissions, regardless of the economic costs to advanced nations such as the United States. Yet others refer to the global temperature observations from over thousands of years which indicate that global temperatures fluctuated greatly in the past, long before the introduction of human industrial activity.

While potential future environmental impacts of climate change have yet to be defined in absolute terms, Battelle is positioned to help government policy makers and companies act in the face of this uncertainty. This issue of *Environmental Updates* highlights Battelle's role in various climate change activities, including greenhouse gas emissions management, carbon sequestration, and technology strategy evaluations.

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# Reducing Greenhouse Gases on a Global Level

The ratification of the Kyoto Protocol and the commencement of the European Emissions Trading Scheme at the beginning of this year has resulted in a very different set of operating rules applying to companies located throughout the various countries of the world. This is also true for divisions of the same company operating in different countries.

Whereas most companies operating only in the U.S. have yet to be directly affected by limitations on their greenhouse gas (GHG) emissions, for many European companies, just the opposite is true. Emissions from major facilities face limits on emissions of GHGs much like those for conventional air pollutants.

The imposition of emission limitations on European facilities creates a range of uncertainties for those affected. While companies know the amount of emission reductions they need, figuring out the most cost-effective means to achieve these reductions is not an easy task. Companies may change their operations to reduce their emissions or they may acquire emission allowances from other companies that do not need them. They may also acquire approved emission reduction credits created under the Joint Implementation (JI) or Clean Development Mechanism (CDM) programs of the Kyoto Protocol.

Major capital changes that may reduce GHG emissions will often have lifetimes that extend far past the year 2012 when the Kyoto Protocol and the first phase of the European Emissions Trading Scheme expire. Specific requirements beyond these initial phases are currently unknown.

The market price of European Union (EU) emission allowances has been volatile, reaching over $30 per metric ton of $CO_2$ equivalent in the summer of 2005. JI and CDM emission reduction credits can be acquired for one fifth of this amount. However, until these credits are actually created and approved, there is uncertainty as to whether they will be delivered and useable in the EU program.

To help make sense of these involved complexities, Battelle experts are currently assisting international companies with understanding both their GHG emissions and their options for reducing them. Battelle is also quantifying the emission reductions and cost effectiveness of various GHG emission reduction technologies.

Additionally, working with the petroleum industry, Battelle developed guidelines for reporting GHG emissions throughout oil and gas operations worldwide (see www.ipieca.org/downloads/climate_change/GHG_Reporting_Guidelines.pdf) and is supporting individual companies in conducting corporate GHG emission inventories using the SANGEA™ Emissions Estimation Software co-developed by Battelle staff (see http://ghg.api.org).

To learn more about how Battelle assists industrial clients in understanding and reducing GHG emissions, contact Mr. Christopher Loreti at (781) 869-1419, loretic@battelle.org or Dr. Bernhard Metzger at (781) 869-1409, metzgerb@battelle.org.

# Basalt – A Better Sequester?

## Scientists Attempt to Permanently Trap Carbon Dioxide in Deep Basalt

Laboratory studies by researchers at the Battelle-operated Pacific Northwest National Laboratory (PNNL) indicate basalt formations may quickly and effectively sequester carbon dioxide ($CO_2$), the predominant gas implicated in global warming.

Researchers hope to test their findings when they inject 3,000 tons of carbon dioxide – approximately the amount of $CO_2$ that a 150-megawatt, coal-fired power plant emits daily – 3,000 feet into Washington State's Columbia River basalt formation. Their goal is to determine if the massive lava layers can permanently store the $CO_2$.

"If the process is viable, we think basalts in the Pacific Northwest could sequester more than a century's worth of the $CO_2$ generated in the region and create a major opportunity for zero-emission power generation in the Northwest," said Dr. Pete McGrail, project manager.

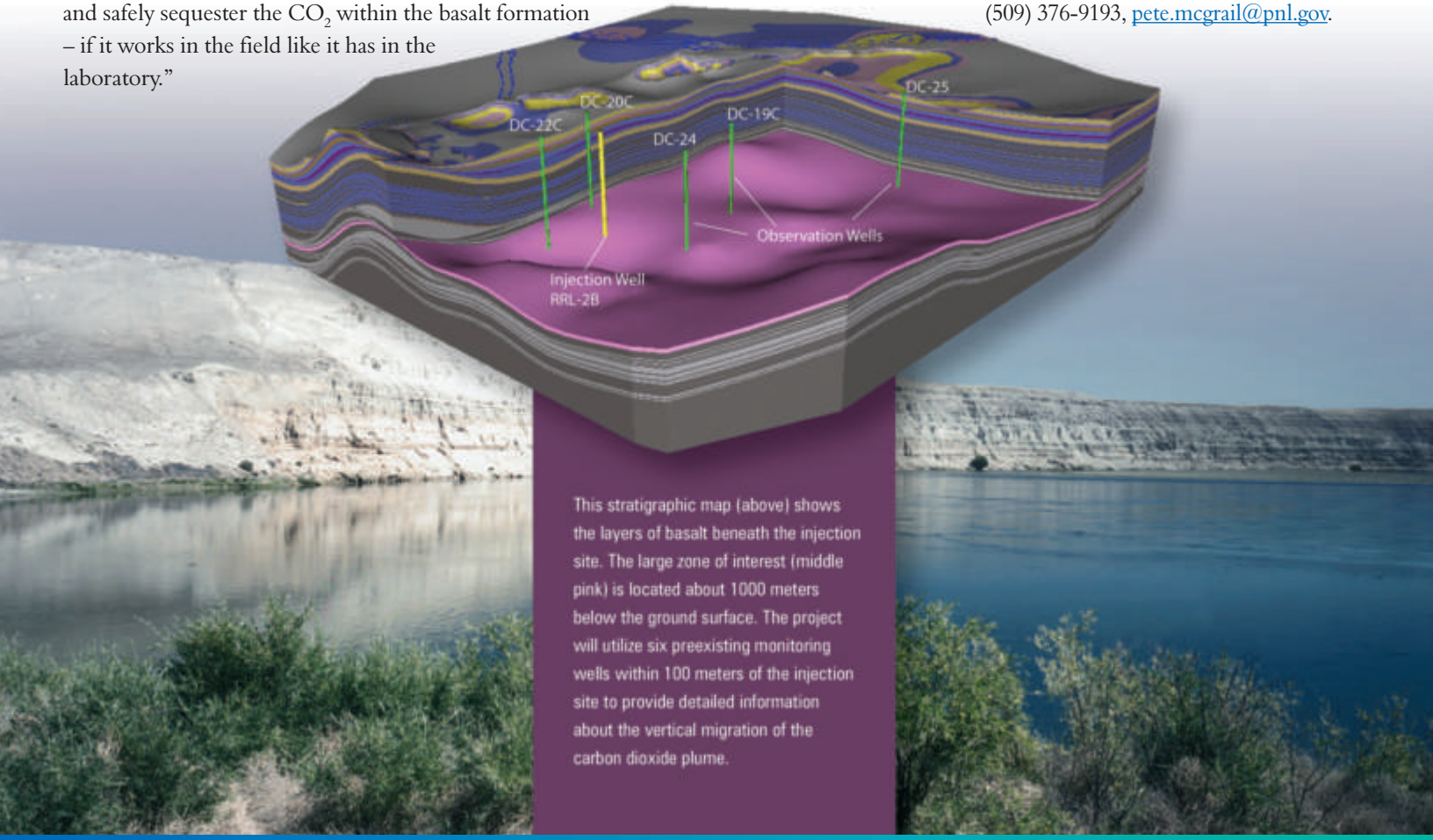
"Experimental data from our laboratory studies show that carbon dioxide injected into the volcanic rock should begin interacting with the minerals in the basalt to form calcite, which is the primary carbonate mineral in limestone, in four to six weeks," McGrail said. "This carbonate mineralization will permanently and safely sequester the $CO_2$ within the basalt formation – if it works in the field like it has in the laboratory."

To help determine how much of the injected $CO_2$ has been mineralized, McGrail's team plans to drill down at an angle to the injection shaft and retrieve core samples 6 to 8 months and then 18 months after injection. Using a variety of geophysical monitoring methods, they also plan to track movement of the $CO_2$ underground. They will use the experimental data to forecast the timing and extent of the sequestration in basalts.

McGrail points out that the $CO_2$ injection will occur only after the site north of Richland, Washington, has been prepared and the necessary permits have been obtained.

The work was enabled through a U.S. Department of Energy award to the Big Sky Regional Carbon Partnership. The Partnership, led by Montana State University, includes a host of universities, national laboratories (such as PNNL), international research institutes, and private companies as partners. The project is part of the President's Global Climate Change Initiative designed to reduce the nation's greenhouse gas emissions intensity 18 percent by 2012.

For additional information, contact Dr. Pete McGrail at (509) 376-9193, pete.mcgrail@pnl.gov.




This stratigraphic map (above) shows the layers of basalt beneath the injection site. The large zone of interest (middle pink) is located about 1000 meters below the ground surface. The project will utilize six preexisting monitoring wells within 100 meters of the injection site to provide detailed information about the vertical migration of the carbon dioxide plume.

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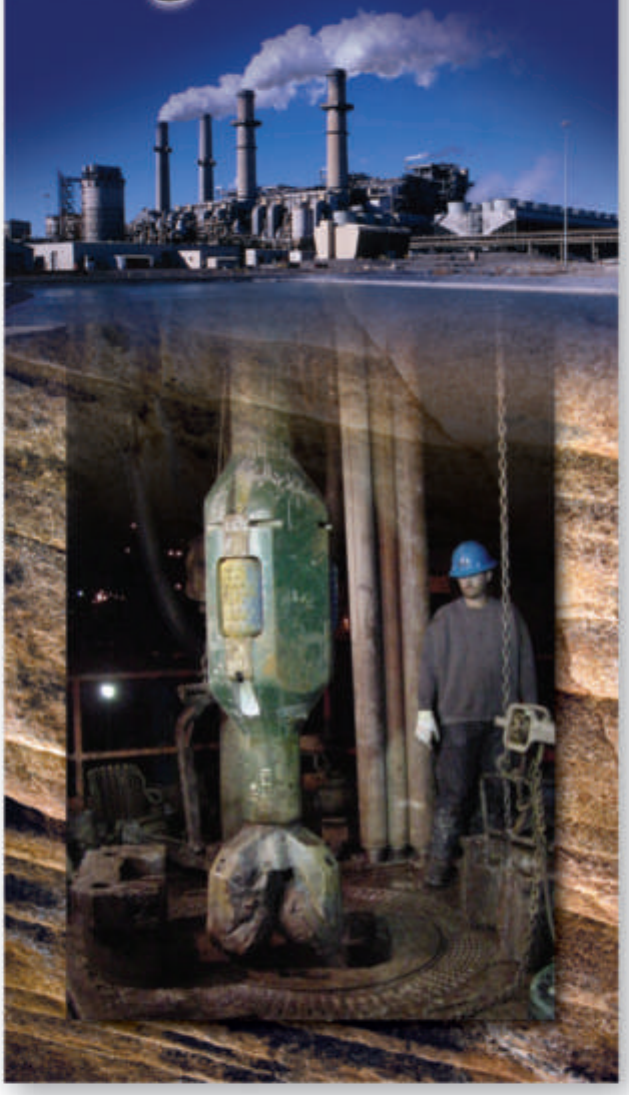
# Capture *and* Storage of $CO_2$ in Geologic Formations



Carbon sequestration, the act of capturing and permanently sequestering carbon dioxide ($CO_2$), is one strategy used to reduce $CO_2$ emissions in order to mitigate its effect on climate change. To this end, Battelle is participating in several regional and site-specific carbon sequestration projects. A number of these projects are based in the Ohio River Valley region in the Midwestern United States, which is home to a large number of $CO_2$ point sources including coal-fired power plants, refineries, and other industrial facilities.

On a regional level, Battelle is leading the Midwest Regional Carbon Sequestration Partnership (MRCSP – www.mrcsp.org), a consortium of more than 30 organizations including U.S. Department of Energy (U.S. DOE), the Ohio Coal Development Office, several utilities and industrial companies, and research partners including geologic surveys, universities, and non-government organizations across seven states. The primary goal of the MRCSP is to be the premier resource in its region for identifying the technical, economic, and social considerations associated with $CO_2$ sequestration and creating viable pathways for its deployment. Phase II of the MRCSP will involve multiple field demonstrations of geologic sequestration over four years starting in late 2005.

The Ohio River Valley $CO_2$ Storage Project at the American Electric Power's (AEP) coal-fired Mountaineer Power Plant is the first site-specific investigation in the world located at an active power plant. The key sponsors include the U.S. DOE, AEP, BP, Ohio Coal Development Office, Schlumberger, Battelle, and the Battelle-managed Pacific Northwest National Laboratory. The project has recently completed its site characterization phase, involving drilling and testing an approximately 2800-m deep exploratory well and conducting a seismic survey. The results have been used to identify $CO_2$ storage zones, evaluate storage integrity, and conduct reservoir modeling and risk assessment to support the design and permitting of a potential future $CO_2$ injection and monitoring phase. The current work includes a design and feasibility assessment for building a $CO_2$ capture facility that will provide a test bed for integrated assessment of capture, local transport, injection, and monitoring of carbon capture and storage (CCS) under realistic conditions.

Additionally, having identified a strong need to obtain geologic data from deep rock formations at a low cost, Battelle has developed collaborative efforts with regional oil and gas companies to obtain these data during exploratory well drilling. Battelle is also working with Stanford University's Global Climate and Energy Program through their Department of Geophysics to explore optimum strategies for reservoir stimulation and lateral well drilling as well as to investigate issues of induced seismicity based on geomechanical data. Similarly, Battelle and Central Research Institute for Electric Power Industry (CRIEPI) in Japan have collaborated on a Japanese Government-funded project to understand the impact of $CO_2$ movement in shallow formations through fieldwork in Ohio and laboratory work in Japan.

For more information, please contact Dr. Neeraj Gupta at (614) 424-3820, gupta@battelle.org or Mr. David A. Ball at (614) 424-4901, balld@battelle.org.

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# WANTED:
## The Right Technologies *at the* Right Price

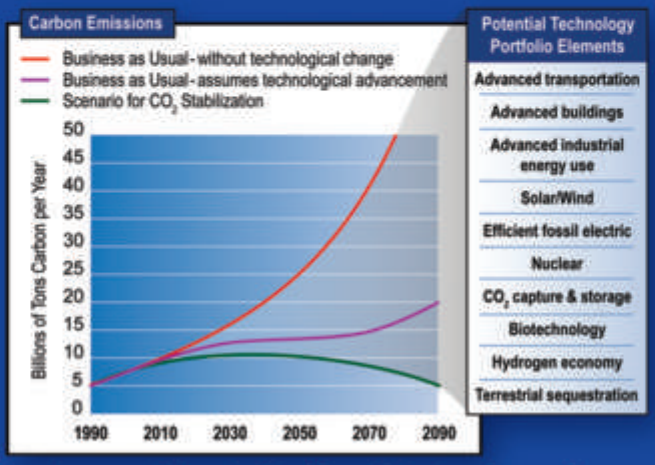
The Earth's average temperature is rising. So is the level of carbon dioxide ($CO_2$) in Earth's atmosphere. Blame it—in part—on human beings. Fossil fuel emissions from energy production are considered the greatest contributor to rising $CO_2$ in the atmosphere and, ultimately, global climate change.

Scientists at the Battelle-managed Pacific Northwest National Laboratory (PNNL) are developing a technology strategy to address the risks of increasing $CO_2$ concentrations and their effect on global climate change as well as the costs associated with limiting $CO_2$ concentrations.

"The need to develop a portfolio of energy technologies is the first and most enduring lesson that comes out of this work," said Dr. Jae Edmonds, who manages the Global Energy Technology Strategy Program at PNNL's Joint Global Climate Research Institute (JGCRI).

"Energy plays a critical role in our standard of living as well as in climate change," Edmonds said. "Because energy from fossil fuels is inexpensive, there is not yet an incentive to stop using it."

JGCRI researchers have developed a unique integrated modeling framework for evaluating the interactions between energy technologies and market forces under different scenarios of economic growth and a variety of policy and institutional settings. This work suggests that developing a portfolio of technologies could have a dramatic effect on the cost of addressing climate change. The portfolio would include improved versions of more familiar technologies such as fossil fuels as well as economically competitive versions of less-familiar technologies such as advanced biotechnology.



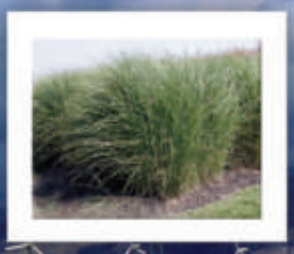

Based on research from the Global Energy Technology Strategy Program (GTSP), JGCRI researchers are exploring potential technologies for an energy portfolio—specifically energy-producing technologies that can be competitive with fossil fuels or technologies that can reduce the $CO_2$ in our current energy system.

Edmonds and his colleagues are conducting in-depth research on technologies that are critical to achieving an energy system with net-zero carbon emissions. These technologies include carbon dioxide capture and storage, a technology that captures $CO_2$ from the smokestacks of power plants and deposits it deep underground; renewables, such as wind and solar; and specialty crops, such as switch grass. Like other plants, switch grass takes $CO_2$ out of the air during photosynthesis, but it can be burned to produce energy. This results in a recycling of atmospheric $CO_2$ instead of releasing fossil $CO_2$.

For more information on GTSP see the program's web site at http://www.pnl.gov/gtsp/index.stm.

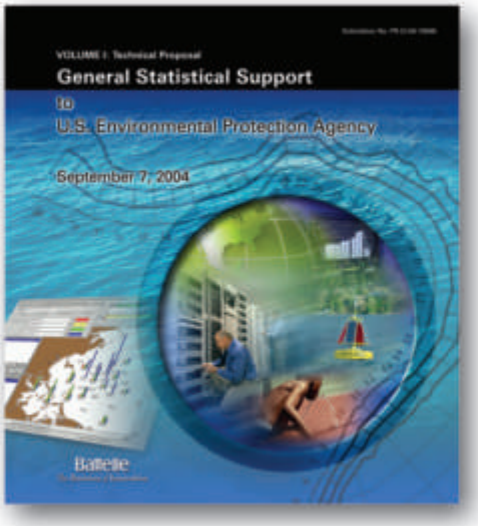
### Climate Research—Integrating the Scientific and the Human Sides

PNNL's Joint Global Change Research Institute takes a broad view of climate change, seeking to understand the connection between humans, climate, technology and economics. Using an integrated assessment approach, JGCRI researchers are developing a strategy for identifying the appropriate technologies for preventing or slowing down the release of carbon dioxide into the atmosphere. They focus on technologies for particular regions or parts of the world—that could be implemented on a scale large enough to achieve the required emissions reductions. Created in 2001, the JGCRI is a collaborative effort between PNNL and the University of Maryland. For more information on JGCRI, see the institute's web site at http://globalchange.umd.edu/.



# Battelle Awarded Task-Order Contract to *Support EPA's Office of Water*

In May 2005, EPA awarded Battelle a five-year, level-of-effort, task-order contract to provide general statistical support to programs within the Engineering and Analysis Division of the Office of Science and Technology within EPA's Office of Water. For the past two decades, Battelle has provided technical support to water quality assessment and management programs for EPA and other agencies to help in regulating, protecting, and improving water resources and supplies in the United States. Battelle also serves as one of EPA's premier statistical contractors, having held many task-order contracts with EPA over the past 25 years to provide statistical support to such areas as assessment of toxic substances.




Initially, the primary focus of this contract will be to provide technical support to EPA's ongoing industrial effluent guidelines and limitations program, as well as to general program areas such as treatment and disposition of biosolids, biological and ecological assessment of water bodies, and monitoring of industrial effluents and water quality. Battelle will provide EPA with technical support in spatial and survey statistics, the design and evaluation of sampling plans and studies investigating the efficacy of chemical analysis techniques and industrial processes, and database and documentation support. EPA has specified that the contract may be used by offices outside of the Engineering and Analysis Division within EPA, when those organizations require technical support that falls within the scope of the contract.

For more information regarding this new contract, please contact Dr. Robert Lordo at (614) 424-4516, lordor@battelle.org.

# Ms. Deborah Drum *Joins* Battelle

Battelle is pleased to announce that Ms. Deborah Drum recently joined its Applied Coastal and Environmental Services group as a Program/Project Manager and Director of its West Palm Beach, Florida, office. Ms. Drum brings 15 years of experience and leadership in environmental stewardship and conservation to Battelle, with particular emphasis on Everglades restoration, watershed management, and interagency action planning designed to restore and protect coastal ecosystems. Her expertise includes analyzing environmental and marine policies and developing communication protocols to facilitate understanding between scientists and policy makers.

Ms. Drum comes to Battelle after 11 years at the South Florida Water Management District, where she most recently served as the Director of the Coastal Ecosystems Division. In addition to leading coastal sciences support activities, she also performed corporate, strategic planning, and multimillion-dollar budget oversight duties for coastal watersheds.

Ms. Drum's career has included directing resources from the Florida state legislature to restore and protect the coastal ecosystems throughout south Florida and assuring accountability for the completion of water quality improvement projects. She was instrumental in developing strong interagency and nonprofit relationships throughout Florida that resulted in completion of priority coastal restoration projects and elevated the awareness of key coastal issues in south Florida. Ms. Drum earned an M.A. in marine affairs from the Rosenstiel School of Marine and Atmospheric Science and a B.A. in marine science affairs from the University of Miami. For more information, contact Ms. Deborah Drum at (561) 656-6304, drumd@battelle.org.

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