U.S. Environmental Protection Agency
Proposed UIC Regulations for Geologic Sequestration of Carbon Dioxide

December 3-4, 2007

Meeting Summary*

WELCOME AND OPENING REMARKS

Gail Bingham, meeting facilitator from RESOLVE, opened the meeting by welcoming participants to the workshop. Cynthia Dougherty, Director of U.S. EPA's Office of Ground Water and Drinking Water (OGWDW) and Brian McLean, Director of Atmospheric Programs in EPA's Office of Air and Radiation (OAR) offered an overview of the workshop. Ms. Dougherty welcomed participants and stated that the focus of this first of two planned public workshops is to discuss regulatory approaches for sequestration and storage of carbon dioxide under the Underground Injection Control (UIC) program to inform the upcoming proposed rule on geologic sequestration of carbon dioxide (CO_2). Dr. McLean noted that carbon capture and storage (CCS) is part of a suite of climate change mitigation technologies that has tremendous potential to reduce greenhouse gas emissions. He stated that challenges to implementation do exist and that stakeholder dialogue will help EPA develop an approach that is transparent, protective of human health and the environment, adaptive, and cost effective. Both Ms. Dougherty and Dr. McLean highlighted the continuing close coordination within EPA to leverage staff expertise and promote sound policies, as OAR addresses climate change issues and the Office of Water (OW) develops regulations to protect underground sources of drinking water (USDWs). EPA is also working closely with Department of Energy (DOE) to exchange information and identify collaborative opportunities for research and pilot projects.

Ms. Dougherty reviewed the major elements of CCS and EPA's applicable statutory authority. The Safe Drinking Water Act of 1974 (SDWA) requires EPA to develop minimum federal regulations for state and tribal UIC Programs to protect underground sources of drinking water. The UIC Program regulates injection of all fluids, whether liquid, gas, or slurry. The existing UIC Program provides a regulatory framework for the geologic sequestration of carbon dioxide. She emphasized that the program's specific goal for the upcoming regulation is to ensure that CO_2 does not endanger USDWs. Ms. Dougherty concluded with a synopsis of UIC Program activities for 2007 and 2008, including guidance, permitting of pilot-scale projects, workshops, and rule development. She noted that EPA Administrator Stephen Johnson announced that the Agency plans to issue the proposed rule in the summer of 2008.

Ms. Bingham reviewed the workshop agenda, ground rules, materials, and objectives, which included the following:

- Share information about EPA's rulemaking process

* This document is a summary of the December 3-4, 2007 public workshop to discuss management of underground injection of carbon dioxide for geologic sequestration under the Safe Drinking Water Act (SDWA). Please note that participant and speaker comments described in this summary do not necessarily represent the views or position of the Environmental Protection Agency.

- Provide an opportunity for dialogue between EPA and stakeholders on issues related to this proposed rulemaking
- Identify key questions and considerations that will help inform a regulatory framework
- Provide a basis for comments and possible future stakeholder dialogue on the proposed rule

Please see Appendix 1 for the workshop agenda, and Appendix 2 for the workshop participant list.

EPA'S PROPOSED RULEMAKING PROCESS

Stephen Heare, Director of OGWDW's Drinking Water Protection Division, and Ann Codrington, Chief of the Prevention Branch, presented information on EPA's proposed rulemaking process for geologic sequestration of CO_2 under the SDWA. Mr. Heare reiterated that the purpose of the dialogue is to identify issues and a range of ideas that will inform the development of the proposed rule. Describing the background of CCS, he noted that the potential storage capacity in the U.S. is large and widespread. The most promising storage options include deep saline aquifers and depleted oil and gas reservoirs.

Mr. Heare described the UIC well classes that were created under the statute: Class I wells are used for injection of manufacturing wastes, RCRA and radioactive waste. Class II wells are used for injection of oil and gas-related fluids. Class III wells are used for mineral extraction and include solvent and uranium mining fluid injection. Class V wells include fluids not covered in the other classes. He noted that Class IV wells are banned except as part of authorized remediation projects.

Implementing the UIC Program is accomplished through a number of authorities, with 33 states holding primary enforcement authority for the Program, EPA leading implementation of the Program in 10 states, and shared implementation in the remaining states. Mr. Heare described the increased interest in geologic sequestration of CO_2 from Congress and a diverse stakeholder community. He also mentioned ongoing geologic sequestration projects, such as the DOE-led Regional Carbon Sequestration Partnership pilots in the U. S. as well as several international projects.

Ms. Codrington detailed the scope of the UIC rulemaking process which will be guided by SDWA mandates and the key principle of ensuring that injected fluids do not endanger underground sources of drinking water (USDWs). She noted that EPA will look to the existing UIC Program regulations to inform the rulemaking and determine how the unique characteristics of CO_2 may influence the standards. She noted that the process follows EPA's traditional regulatory path, but is proceeding at a faster rate. In closing, Ms. Codrington presented milestones for the rulemaking process, including anticipated dates for a proposed UIC rule in July 2008 and a final rule in late 2010 or early 2011.

Following EPA's presentation, and again on the morning of day 2 of the workshop, participants were invited to write and submit questions about the proposed rulemaking process. In response

to stakeholders' questions from both sessions, EPA staff offered responses and clarifications, summarized below. (Due to workshop time constraints, EPA could not answer all questions submitted. Please see Appendix 3 for a list of these questions and EPA's written responses.)

Rulemaking Process and Schedule
The Environmental Protection Agency is expediting the proposed rulemaking process, though the technology is in the early stages, because the Agency recognizes widespread interest in a consistent national regulatory framework among stakeholders. EPA also based its decision on the rulemaking timeline on comments from Congress, industry, NGOs and other stakeholders, expressing a desire for regulatory certainty. EPA sees a greater risk in no action – that is, a proposal at an early stage may have greater benefits than taking no action at all. Currently, wells may be permitted as Class V wells using EPA's Underground Injection Control Program Guidance (UICPG #83) *Using Class V Experimental Technology Well Classification for Pilot Geologic Sequestration Projects.* Alternatively, wells may be permitted using existing regulations for Class II Enhanced Recovery Wells (if the wells will be conducting enhanced recovery of oil or gas). Class I wells are also an option but at this time the Agency is not aware that any of the partnerships are permitting wells as Class I wells.

EPA did consider timing the final rule to be able to use information from the Future Gen project and DOE regional carbon sequestration projects coming online, but the current expectation is that the final rule will be issued before the projects can supply usable data. At the same time, EPA recognizes that the process needs to allow for modifications from additional data and continued dialogue on the proposal. The Agency may issue a Notice of Data Availability (NODA) to address new data that comes in after the proposal, and could adjust the rule to include the most recent information.

The Office of Management and Budget (OMB) will review the proposed rule, and EPA is requesting a shortened schedule for that review.

EPA Authority
While UIC regulations exempt natural gas, a hydrocarbon, and some hydraulic fracture fluids, any other fluid is subject to UIC regulation under the SDWA. EPA has authority to regulate all fluids (liquids and gas) under the UIC Program regulations. This authority extends to wastes and non-wastes, including CO_2 in a non-liquid phase and in a supercritical state, whether CO_2 is defined as a pollutant or fluid. EPA has not been asked to regulate CO_2 from stationary sources under the UIC Program, such as agricultural or terrestrial sources.

The Safe Drinking Water Act does not provide EPA with the authority to regulate indirect harm to drinking water, e.g. through excessive pumping (drawdown) and atmospheric effects.

State Authority
States can have more stringent UIC Program requirements (for the regulation of injection wells) than the minimum federal requirements. In order to coordinate with states on rule development, the UIC Program is working with its regional counterparts to ensure they are aware of Headquarters' activities through monthly calls and an internal Agency workgroup. States then work with the regional UIC offices on state regulation development. The issues of how authority

will be transferred from state oil and gas authorities to other state agencies, as well as issues related to enhanced oil recovery (EOR), being discussed as part of the rule-making.

Well Classification
Currently, the EPA and other permitting authorities may issue permits for CO_2 wells using the Class V guidance (UICPG # 83) or existing Class I and Class II regulations. EPA has heard stakeholder concerns that Class I designations could be negatively associated with hazardous wastes, and is open to the option of establishing a new well class or subclass for CCS.

Area of Review
The size of an area of review (AOR) will depend on the specifics of the individual site and characteristics such as viscosity of the CO_2 and thickness of the injection zone/formation. The EPA is open to considering all ideas for AOR as the proposed rule is developed, including issues related to vulnerabilities such as potential for induced seismicity and the use of no drill zones to mitigate vulnerabilities.

The EPA does not anticipate granting waivers of the UIC Program if USDWs are not identified in the site area. USDWs are present virtually everywhere throughout the United States and the SDWA may apply even in the absence of identified USDWs.

Risks/Permanence of CO_2
The proposed rule will address the potential risks to USDWs posed by sequestration of CO_2 and will include monitoring requirements to ensure that CO_2 remains in the injection zone. Risks to potable water supplies from injection could include contamination due to loss of injection well integrity, fluid interactions, and risks associated with artificial penetrations or other geologic features that may be potential migration pathways. EPA may institute monitoring requirements to address these and other related risks.

Long-term Liability
With regard to legal liability for CO_2 for potential impacts and long-term stewardship, current UIC regulations require owner/operators to have financial responsibility to cover closure and any mitigation or remediation. Given the volumes of CO_2 and the pressures required for storage, the current model may need to be expanded.

Regarding timing, many States require a 30-year period for closure requirements, but EPA will need to determine the scope of SDWA applicability. Liability is included in existing UIC regulations through financial responsibility for closed wells, but there is not a specific law establishing a set period of time. EPA plans to seek stakeholder comments on this issue and learn from dialogue throughout the rulemaking process.

Property Rights
The issues of property rights, ownership of pore space, indemnification, and subsurface trespass are outside the scope of the UIC rule-making. States have different approaches to address these issues and EPA plans to continue discussing concerns with stakeholders.

Data and Information
The EPA will look at data from existing projects and incorporate as much information as possible into the proposed rule. The Sleipner project in the North Sea is one potentially useful international model. Information from the National Energy Technology Laboratory (NETL), Regional Partnership Projects, and other DOE research will also inform EPA's approach. This information is available on DOE's website. EPA plans to provide information on its research on the Agency website. EPA has also reviewed the Interstate Oil and Gas Compact Commission (IOGCC) recommendations and model statutes and regulations. The Agency has or will consider many of IOGCC's suggestions regarding regulatory development and has invited members of both IOGCC and the Ground Water Protection Council (GWPC) to sit on the regulatory workgroup, as these members represent co-regulators.

While EPA has not specifically mapped the capacity and location of aquifers, the Agency does have related data and plans to collect more.

Federal Legislation
EPA has not taken a position on the merits of having federal legislation, but the Agency is aware of Congressional activity CCS/geologic sequestration and related issues including liability, long-term stewardship, and the schedule of the rule.

PRESENTATION: OVERVIEW OF CO_2 GEOLOGIC SEQUESTRATION TECHNOLOGY

Charles Christopher, a CO_2 storage consultant to BP America, presented his views on the key requirements for CCS implementation. These include technical capabilities, financial feasibility, a workable regulatory system, and public acceptance. Regarding the current state of CCS technology, Mr. Christopher emphasized that available methods have not yet been tested at the scales needed to handle the very large volumes of CO_2 anticipated and that regulators should not anticipate huge advances in capture technology, as it is already efficient. He also described the potential impacts of technical problems with wellbore integrity, seals, faults, and leakage, both on local and global scales. He noted that the cost of CCS today is high in most cases, but comparable to renewable energy generation. A major financial consideration is that it now takes 30% of a coal burning plant's power to capture the CO_2 that the facility discharges. He suggested that financial incentives are needed to create markets for CCS technologies. Finally, Mr. Christopher stated that CCS implementation must be supported by stable, predictable regulations, along with effective communication and demonstration projects to gain public acceptance.

Mr. Christopher provided answers and clarifications to several stakeholder questions, highlighted below:

Risks

- Isolated cases of magma intrusion and subsequent CO_2 leakage through faults, such as occurred at Mammoth Mountain, are not comparable to what would happen in an oil field, where CO_2 leakage is predicted to be slow.

- High quality site characterization, including the accurate identification of faults and formations that may serve as conduits for CO_2 migration is necessary to address leakage issues. Additional consideration must also be given to pressure fronts, as well as the presence and identification of redundant seals. Small wells would be the most likely sources of leaks.
- CO_2 does not corrode the concrete seal of a well because no fresh CO_2 enters into the area between the well casing and well tubing, so the corrosion process stops. Also, many of the reaction products are plugging agents.
- He shared that he did not have information available to answer a question about earthquake potential.

Capacity

- CO_2 storage capacity cannot be accurately predicted (on a national, per annum basis) because of the uneven distribution of sources and sinks throughout the county; but there will be less space available than needed to offset all fossil fuel use.
- Storage capacity may be a problem in the long term unless the nation reduces usage of fossil fuels.

Monitoring

- The effectiveness of seismic monitoring is highly dependant on the geologic formation. The deeper the formation, the more dense the CO_2 and the higher the seismic contrast. 4-D imaging, which is 3-D imaging in time sequence, is more useful for showing movement of CO_2.

EOR

- In EOR and enhanced gas recovery (EGR), CO_2 dissolves in water under high pressure and interfaces with the oil until becoming one phase from top to bottom. Then it is captured, separated from the gas, and injected again.
- CO_2 from EOR should be mixed with H_2S as a solvent to make it miscible with oil. From power plants, stack gas is about 12-20% CO_2. Nearly pure CO_2 is needed for injection, but this level of purification takes significant amounts of energy.

Cost

- Capture technology is not yet economically valuable, but is very efficient. A serious reduction in cost is needed.
- Plants use 30% of their energy to sequester CO_2 by compressing and moving it down the pipeline.
- His greatest concern with CCS is that it will not be implemented. It is needed to prevent huge increases in CO_2 in the atmosphere, but society needs to be willing to pay more for energy to make it economically feasible.

INTERACTIVE STAKEHOLDER PANEL: POTENTIAL RISKS AND TECHNICAL CHALLENGES TO PROTECTION OF UNDERGROUND SOURCES OF DRINKING WATER FOR GEOLOGIC SEQUESTRATION OF CARBON DIOXIDE

Six stakeholders representing a variety of interests shared their perspectives on potential risks to USDWs associated with geologic sequestration of CO_2 and how UIC regulations could address these risks. The stakeholders included Jens Birkholzer of Lawrence Berkeley National Laboratory, Tom Curtis of the American Water Works Association, Susan Hovorka of the University of Texas, Scott Imbus of Chevron, George Peridas of the Natural Resources Defense Council, and Lee Whitehurst of the U. S. EPA.

Drinking Water and Other Public Health Concerns

Some of the stakeholders stated that migration of CO_2 and changes in water chemistry are the most significant concerns. When CO_2 dissolves in water, it forms a weak acid and interacts with minerals. However, several panelists emphasized that the highest potential impacts of CO_2 are through mobilization of organics or metals, rather than leakage or corrosion. Field studies have shown the occurrence of CO_2 reactions with other constituents, the byproducts of which may migrate into USDWs as contaminants. However, some panelists emphasized that CO_2 will not necessarily contaminate drinking water sources. One panelist suggested that, until more is known, projects should avoid higher-risk situations such as injection into coal seams or large-scale injection.

One panelist suggested that climate change and greater water demand may lead to the need to draw upon currently unused water supplies as public drinking water sources. Improved technology and treatment techniques could make it feasible for currently non-potable water to become a viable drinking water source. This should be considered when considering CCS at a site, as changes in underground chemistry resulting from CCS could inhibit treatment techniques if these sources are needed for public drinking water in the future.

Panelists raised another potential concern relating to elevated pressure in injection zones. Injection can elevate pressure in saline formations, moving saltwater into freshwater, potentially causing contamination and large areas of elevated pressure. Overlap of pressure changes among sites may be significant as well, but little information is available. Other panelists stated that pressure changes could cause water to spread into the sea and that water migrating into a freshwater aquifer might not necessarily be “dirty” water.

A stakeholder emphasized that concerns about biologic sensitivity and ecosystem impacts are not significant because CO_2 is already prevalent in the geosphere.

One panelist added that not acting to advance research on and implementation of CCS technology presents a significant risk to drinking water due to the risks that climate change may have on USDWs and water availability. Several panelists agreed that many unknowns exist and we have not yet addressed all the questions that may arise.

Risk Reduction Tools and Approaches

Several panelists emphasized that site assessment and characterization is the best method for dealing with risks of contamination of USDWs. This involves looking at the geologic formations, hydrology, geochemisty, structure, artificial penetrations, and other features to anticipate risk, select a proper site, and devise preventative measures to minimize problems. Planners should also consider future scenarios in the injection horizon, evaluate potential CO_2 migration pathways, and identify potential pressure changes, all of which would inform a monitoring strategy. One panelist emphasized that tools for predicting pressure are very mature. The panel briefly discussed how to balance the need for high quality geologic data for site characterization with the risks associated with increasing artificial penetrations within a site (for the purpose of gathering geologic data). Some panelists commented that significant data are already available on most major basins and almost all have existing well penetrations that could be used for data gathering. Others suggested looking for other sources of information or converting data wells into injection wells over time.

Monitoring and containment are other methods of reducing risk. Facilities can use monitoring to test the performance of the seal and well. Pilot tests and site characterization will provide information on the best location for monitors. Containment systems can also help reduce risks, but some panelists suggested that the containment requirements should be performance-based rather than prescriptive of the technologies to be used. Some panelists believed one good containment system is sufficient, preferring to use proven modeling and performance based criteria rather than following prescriptive containment requirements. Others panelists supported the concept of requiring both primary and secondary containment systems ("double containment").

Risk may also be managed through mitigation. One panelist stated that CO_2 is very responsive to pressure as a mitigation technique in the event of movement to an undesired location. Injecting fluids in an adjacent well at a regulated pressure can guide CO_2 back to the containment area. Another mitigation option is changing injection patterns once a problem is detected. Site-specific contingencies could be built into plans to provide guidance in the event of an unexpected event.

Several panelists offered suggestions for specific permitting requirements to protect USDWs. Examples include additional monitoring for seismic activity and miscibility, as well as periodic review cycles over the lifetime of the project.

Well Lifespan and Closure

Some panelists stated that concerns about CO_2 leakage (beyond a 20- to 30-year timeframe) will decrease over time as more CO_2 dissolves in the native formation fluids. Others suggested the value of performance-based criteria for ending a project rather than a specific timeframe and indicated that site-specific assessments of risk are needed to determine an accurate lifetime prediction. A panelist suggested that adequate resources are needed to support protection activities throughout the lifespan of the project.

Adaptive Regulatory Approach
Panelists agreed that an adaptive regulatory approach can help EPA deal with the continuously developing understanding of CCS. They suggested using pilot tests to study CCS and verify accuracy and understanding as the technology moves into larger scale application. One panelist suggested that the AOR be allowed to adapt as the project ages to minimize upfront resource demands and allow for verification of the model over time.

Other Regulatory Considerations
One panelist commented that the technology exits to operate a site with nearly no leakage, but the challenge is to develop regulatory requirements to meet this goal.
Some panelists suggested EPA use what is already known about CCS and related technologies and regulatory programs to provide a starting point for regulation. They suggested EPA review the IOGCC recommendations and international efforts from Mexico, Australia, and the EU.

SMALL GROUP DISCUSSIONS AND REPORTS

On day 2, participants met in small groups to discuss three questions: 1) What are the drinking water and other public health concerns from the potential effects of underground injection on the drinking water that this regulations should address? 2) What other comments and suggestions do you have about the proposed regulation? 3) What additional questions do you have? Representatives from each group then shared the group's thoughts with the rest of the participants. (Please see Appendix 4 for a compilation of comments submitted by participants on these three questions.) Several themes emerged from the conversations:

- Stakeholders have some concerns about impacts on drinking water and public health that may result from the geological sequestration of CO_2.
- Long-term liability issues should be addressed in the regulation.
- EPA should consider a performance based and/or risk-based regulatory model.
- An adaptive regulatory approach for underground injection of CO_2 has many benefits.
- Strong public outreach and education are necessary for an effective regulation.

Drinking Water and Public Health Concerns
Common environmental and health concerns reported included: mineralization, mobilization of metals, lower pH as a result of CO_2-water interactions, and brine displacement. Some groups believed that CO_2 will inevitably change water chemistry in violation of primary drinking water standards. One long-term effect could be salinization of future drinking water sources that could impact treatment processes. Groups also reported increased potential for seismic activity as a concern, depending on requirements for evaluating seismicity during permitting. Over-pressurization was noted as a potential problem, though participants suggested that this may not be a problem at all sites. One group suggested EPA consider the overall environmental and public health benefits of putting CO_2 in the ground rather than being released into the atmosphere.

One group recommended that EPA address the metals potentially affected by CO_2 as part of secondary drinking water standards. Another group suggested that EPA establish a tiered response system to manage leakage.

Long-term Liability
Participants raised numerous questions about how EPA would handle long-term liability of injection projects and sites. Key questions included:

- How long will owner/operators be held liable for CO_2 impacts, and what impacts?
- What distance would be covered under liability?
- How will cross-boundary liability be handled among states and possibly across international lines?
- How will property rights be assigned? How far down into the injection zone?
- Will the insurance industry be involved in the process?

Some groups suggested that the federal government establish a program for assuming liability after closure. An effective transfer mechanism is also needed to deal with liability at the end of a project. Some participants added that in CCS, risks are concentrated early in the process rather than in the long-term. Others raised the idea of a fund for future site needs, modeled after Comprehensive Environmental Response, Compensation and Liability Act (Superfund), to which owners/operators would contribute. Other groups countered that Superfund is not a good model because it has been subject to extensive litigation. The program would need reliable oversight to ensure that funds remain available and are not diverted to other uses. Another group suggested that a portion of the liability could be handled by insurance.

Several groups expressed the need for very long-term liability coverage to cover possible impacts (e.g. up to one hundred years). One group suggested breaking liability into categories for operating life, closure, and post-closure. Liability may decrease over time as risk decreases (with increasing stability of a CO_2 plume).

Groups also discussed the nature of the liability and impacts that could trigger liability, such as the size and frequency of leaks, and whether contamination of USDWs occurred. They also questioned how liability for CO_2 releases underground would be balanced against liability for climate change and global warming.

Performance-Based Standards
Several groups suggested that the regulation include performance-based standards. Requirements could focus on endpoints and objectives for containment and allow for various monitoring tools at different sites. The regulations could require risk management programs with these standards as well as mitigation requirements. This approach addresses the issue of a wide variety of site characteristics and the large difference among sites and locations, which make using specific requirements challenging. Groups added that this approach depends on an accurate site characterization process so the site-specific features are understood.

Some suggested that probabilities could be assigned for risk, but others questioned whether enough information exists to provide these data.

Adaptive Regulatory Approach
Many groups emphasized the need for an adaptive approach to regulating underground injection of CO_2. Two types of adaptability emerged from the discussion: adaptation over time where agencies factor in new information into the regulation; and flexibility in regulatory requirements

that allows provisions to be appropriately applied to different sites, different characteristics, and different risks.

Participants urged EPA to use additional data and information to improve the rule over time, particularly given the early stages of testing of some CCS technology. One group suggested a stepwise approach in which the use of AOR is pilot-tested and lessons learned are incorporated before a final regulation is published. Groups suggested having information collection guidelines to collect information in ways that make it easy to learn from and better understand data/project status. Some also noted, however, that industry also needs to have confidence about the requirements and responsibilities involved in a permit. One group suggested including integrating modeling of the CO_2 plume into the permit.

Groups stated that the regulatory scheme may have to include oil and gas fields and coal seams as well as saline aquifers, and would need to be flexible enough to be applied to the varied locations and features of these sites. A group suggested that the regulations take into account the specific types and volumes of fluids that could endanger an USDW at a site, rather than impose arbitrary limits.

Public Outreach and Education

Several groups encouraged EPA to invest in strong public education and outreach efforts which are important at several stages including before the proposed regulation and during the permitting process. Public involvement and transparency could be included in the permitting requirements (e.g. informational meetings and other efforts). Audiences could include the public health and environmental communities, which have great interest in issues of climate change and air quality.

Participants emphasized that close interaction among federal and state agencies to gather and merge information will help the agencies answer the public's questions.

Scope of the Proposed Rule

Groups provided different perspectives on the scope of the regulation. Some encouraged EPA to focus solely on geologic sequestration of CO_2 under the UIC Program and protection of drinking water, while others suggested that the regulation might consider ecological and other impacts. One group noted that EPA should be comprehensive in its rule development and consider broader issues of air emissions, public health, and environmental justice.

Groups offered ideas about how CO_2 and CO_2 wells should be classified, as uncertainty exists about whether EPA considers CO_2 used in CCS a waste. One group stated that different types of capture produce different levels of purity for CO_2; therefore, EPA needs to be flexible. Uncertainty also exists about what concentration will trigger the need to handle CO_2 as a hazardous substance, which can be a significant obstacle with moving ahead with the technology. Some suggested that EPA use a new UIC well classification rather than Class I. Participants raised questions about how the regulation will affect CO_2 injection wells used to emplace CO_2 in salt come cavities that are already classified as Class I and whether EOR wells will continue to operate as Class II wells or will become a new class. One group emphasized that CO_2 should be treated as a fluid. One group cautioned EPA not to rely on the "least

common denominator" by automatically falling back on current UIC restrictions; the Agency should be careful how it transfers these current requirements into a new program.

Authorities and Resources
Participants suggested that, to accommodate the comprehensive scope suggested by some stakeholders, cooperation between EPA offices responsible for these issues will be necessary, as well as coordination with other federal and state agencies.

One group suggested that EPA clarify the relationship of the authority of states and other agencies in the regulation preamble, addressing issues such as the implications of CCS for other agencies and programs, climate change, DOE efforts, and property rights. Establishing clear authorities will also necessitate consideration of CO_2 migration between states and EPA regions. State authority and capabilities should also factor into determinations about best and most appropriate use for sinks and storage sites on a comprehensive basis.

A few groups raised the issue of the cost of regulation. One group noted that EPA should consider how the program will be funded and how the Agency can ensure sufficient resources are available to manage the program over time. The additional costs to the program for regulatory development and implementation should be balanced against uncertain risks.

Other Considerations for Regulatory Development
One group commented that the rulemaking is premature before the science is resolved and that the 30% cost of CCS is prohibitively high.

Questions about carbon credits came up in a few groups. Market issues are not within the scope of this proposed rule. Groups suggested that issues such as what happens to carbon credits if CO_2 is lost and what happens to the credits after closure need to be addressed, perhaps by legislation.

GEOLOGICAL SEQUESTRATION OF CARBON DIOXIDE: POTENTIAL MODIFICATIONS TO EXISTING UNDERGROUND INJECTION CONTROL PROGRAM REGULATIONS

Suzanne Kelly, U.S. EPA, OGWDW, reviewed regulatory and programmatic elements of the UIC Program that apply to geologic sequestration of CO_2. She outlined EPA's statutory authorities under the SDWA, well classifications, and key UIC Program elements. She detailed EPA's findings regarding how these elements may be applied in their current form, modified, or expanded to ensure safe geologic sequestration of CO_2. For example, certain existing UIC regulations may not be adequate for the AOR for a CO_2 injection well and well closure. Also, new data and techniques may need to be explored to determine the adequacy of these regulations. She added that, while existing regulations provide for public participation, these requirements could be enhanced. Ms. Kelly also summarized the rule announcement process from March 2007 through a proposed rule by summer 2008, and highlighted additional EPA activities conducted to address the subject of geologic sequestration of CO_2 including workshops and technical conferences (from 2003 through those being planned for 2008).

INTERACTIVE STAKEHOLDER PANEL: PERSPECTIVES AND CONSIDERATIONS FOR APPROACHING PROPOSED REGULATIONS FOR GEOLOGIC SEQUESTRATION OF CARBON DIOXIDE

Several stakeholders representing various interests reflected on the key themes from the workshop and shared perspectives about potential regulatory approaches. The panelists included Scott Anderson with Environmental Defense, Richard Esposito with Southern Company, Jean-Philippe Nicot of the University of Texas, Douglas Smith of Van Ness Feldman, Berry Tew with the State of Alabama and the IOGCC, and Lee Whitehurst of U.S. EPA. The panel discussed several prepared questions, and responded to questions from the stakeholder audience.

Overall Goals and Purpose of the Regulation
Panelists reiterated the theme heard throughout the workshop that the regulation needs to be simple, flexible, and clear-cut so that industry understands the process and expectations. One panelist stated that the legal objective of the rule is to prevent adverse health effects in the population. Another noted that the regulation should minimize liability on industry by specifying endpoints and post-closure procedures for liability transfer.

Another panelist cautioned that the way in which EPA describes the problems and solutions of CCS, including waste problems, will impact policy design and affect public perception.

Adaptive Approach
Several panel members agreed that adaptability and flexibility emerged as major themes during the workshop. More work and dialogue is needed to determine how to blend an adaptive approach with a desire for regulatory certainty, where regulatory flexibility is best suited, and how it would be implemented. Specific ideas for building adaptability into the process included exemption processes, "creative ambiguity," performance standards, incorporating best management practices (BMPs) by reference, and invoking a sunset process in which the rule is subject to stakeholder input and changes after a specific time or stage. A panelist suggested that incorporating BMPs into permitting allows for necessary learning during permitting and operations. Agencies can require adoption of certain BMPs or offer a library of acceptable BMPs for operators from which operators can choose.

A panelist also emphasized that agencies and industry need to have a sense of the scope of learning and change over the course of the permit so it is not too open-ended. Current general permitting practices include conditions for incorporating rule changes, remediation provisions, and requirements for further study that can be explored as models.

An adaptive approach could also be applied to AOR. The program could include a time-dependent AOR that expands as the volume of injection increases and the plume moves. This could reduce up-front costs for owner/operators and provide a method to address what could end up as very large areas.

Considerations for Specific Regulatory Provisions or Topics
Panelists reviewed and expanded on specific suggestions for EPA to consider in developing the regulation. Site characterization is recognized as a key element in understanding the geophysical

and engineering features of a site and developing an appropriate approach. Reassessment of a site may be necessary as operations and conditions may change over time. One panelist noted that site characterization could be expensive, so state agencies could implement a tiered approach for ranking different areas for CO_2 injection. Another suggestion involved incorporating risk-based monitoring objectives adapted for different phases of projects into the rule or permits.

Panelists commented that well spacing could be a significant issue that needs to be addressed in the rule. Intersection of pressure effects could have a major impact due to well density and injection volumes, particularly with the size and potential number of CO_2 projects. One suggested approach involves a first-come, first-served or non-interference principal in the regulation. Regarding a related issue, one stakeholder noted that EPA may have to deal with the issue of horizontal wells and their potential implications.

A common concern frequently identified during the workshop is the issue of CO_2 leakage, whether in the form of migration from the injection formation or leakage to the surface or into an aquifer. Some panelists suggested that allowing leakage at an acceptable amount or time-period will be difficult to enforce, and a performance-based standard is a better approach.

Panelists expanded on the suggestions for public outreach and participation offered throughout the workshop. They advocated for EPA to initiate and be actively involved in these efforts to increase understanding, perhaps using models in the energy industry, particularly hydroelectric power projects. In addition, current processes should be evaluated to see what changes could be made to address any weaknesses. One panelist cautioned that outreach does not need to extend to the whole state in which a project is located, because the most interested parties are local. Companies can also be a good source of information and tools, as they often develop their own outreach programs for employees and the community.

Coordination with Other Agencies

Panelists emphasized that geologic sequestration of CO_2 requires a comprehensive approach. EPA will need to coordinate with USGS, DOE, DOT and states to manage broad impacts and to minimize redundancy in regulation. For example, national standardized descriptions of acceptable products to put in a pipeline will need to be developed with the input of agencies at the federal and state level.

Panelists also suggested building on current state primacy relationships under the UIC Program to strengthen these relationships for CCS. States traditionally hold jurisdiction over many property ownership and liability issues that could continue for this regulation. They also cautioned that unfunded mandates could become an issue for states.

The panel also discussed additional questions from stakeholders. Regarding lessons learned from oil and gas industry experience, some panelists advised that, although some aspects of oil and gas sequestration and storage activities are relevant, CO_2 injection for sequestration differs from EOR due to leakage potential, buoyancy, and injection of larger volumes of CO_2. Panelists did not see any major impacts on traditional EOR or EOR for CO_2 with implementation of a new regulation.

One stakeholder asked about differences in policy implications for permitting saline versus coal seam sites. The panelists responded that coal seams are shallower, necessitating different monitoring programs and that some coal seams are USDWs. Good site characterization and evaluation are needed to determine whether a site is appropriate for CO_2 injection for geologic sequestration. Another question related to injection into offshore reservoirs, with panelists explaining that injection falls under SDWA, in most cases, only if it occurs within three miles of shore. Problems in offshore injection could include acidification of oceans and impact on wetlands, estuaries, and fishery resources, although more research is needed on these impacts.

Topics for Second Workshop
The panel suggested the following topics to explore in more detail at the second stakeholder workshop:

- Risk-based monitoring objectives
- Process questions, including possibly sharing a draft of regulatory text from EPA or another party to gather reactions.
- Site characterization, including the minimum elements required
- Regulatory frameworks to distinguish EOR wells from Geologic Sequestration wells
- Invite subject matter experts on each issue to talk in more detail

Final Panelists Comments
In closing, panelists urged EPA to look to other sources to inform the process, from scientific papers and industry efforts to the international community. Partnerships with industry and states will also help to improve the science of the regulation and make sure states with primacy are in a position to implement the regulation. One panelist commented that parties should keep this rulemaking in perspective as it represents a relatively small piece of what needs to be done to transform electricity generation in the U.S. Finally, several panelists commented that the meeting was both beneficial and collegial; and, they expressed support for continued dialogue on the issues.

WRAP UP AND NEXT STEPS

Stephen Heare offered closing remarks for the workshop. He praised the stakeholders and presentations, which gave EPA much to consider as the Agency moves ahead with the rule. He thanked Ben Grumbles, U.S. EPA Assistant Administrator for the Office of Water, for his attendance and support of regulatory development activities. He also thanked participants for their commitment and extensive participation throughout the workshop.

Mr. Heare summarized a number of key comments and considerations heard during the workshop. Regarding the general approach to the rule, stakeholders stressed the need for action on CO_2 and supported a consistent national regulatory framework. He heard that the rule should be easy to interpret, adaptive as more is learned, flexible for site-specific conditions, but not automatically fall to the most stringent requirements. EPA will need to deal with questions about how to implement a risk-based approach and how to set the performance standards many stakeholders favor. He also noted that site characterization emerged as the single most important activity in delineating the risk of CCS. Focus on site characterization, however, requires

balancing the cost of the activity with a level of acceptable risk. Public acceptance is also key to the rule, including broad education and strong EPA involvement.

The major technical issues for EPA to consider include measuring and responding to leaks, the role of modeling, CO_2 purity, AOR size and boundaries, well spacing, and horizontal wells. Highlights of policy issues heard were the role of state and federal authorities, the need for information and ways to incorporate new information, characterizing CCS as a climate mitigation tool rather than waste disposal, UIC Program funding, property rights, responsibilities at site closure, and long-term liability

Next Steps
EPA plans to hold a second stakeholder workshop in February 2008. Participants will be notified as details become available. In the meantime, EPA will work on developing a more focused set of discussions to invite specific input into its proposal at the next workshop.

Appendix 1: Workshop Agenda

U.S. Environmental Protection Agency
Proposed UIC Regulations for Geologic Sequestration of Carbon Dioxide
Hotel Washington
515 15th Street, NW
Washington, DC 20004

December 3-4, 2007

AGENDA

Workshop Objectives:

- **Share information about EPA's rulemaking process**
- **Provide an opportunity for dialogue between EPA and stakeholders on issues related to this proposed rulemaking**
- **Identify key questions and considerations that will help inform a regulatory framework**
- **Provide a basis for comments and possible future stakeholder dialogue on the proposed rule**

Monday, December 3, 2007

12:00 Registration

1:00-1:30 Welcome, Review Workshop Objectives, Agenda, and Ground Rules
Objective: Provide overview of the workshop and review desired outcomes, agenda, ground rules and materials for this meeting.

Cynthia Dougherty, Office of Ground Water and Drinking Water, U.S. Environmental Protection Agency

Brian J. McLean, Office of Air and Radiation, U.S. Environmental Protection Agency

Gail Bingham, President, RESOLVE, *facilitator*

1:30-2:45 EPA's Proposed Rulemaking Process
Objective: Learn about EPA's plans to propose regulations under the Safe Drinking Water Act for the geologic sequestration of carbon dioxide, including the proposed scope, process and milestones.
Process: Questions will be collected in writing to ensure as many questions are addressed as possible. Some questions may be integrated into substantive discussions later on the agenda or addressed the next morning, if additional information is needed.

Stephen F. Heare and Ann Codrington, Office of Ground Water and Drinking Water, U.S. Environmental Protection Agency *[30 min]*

Questions and Discussion *[45 min]*

2:45-3:00 Break

3:00-4:15 Presentation: Overview of CO2 Geologic Sequestration Technology

Objective: Understand current and future applications of the various technologies for the geologic sequestration of carbon dioxide, variations in geologic storage options, and factors affecting deployment of full scale geologic sequestration projects.

Panel: *[45 min]*

Charles Christopher, BP America

Clarification Questions *[30 min]*

4:15-5:30 Interactive Stakeholder Panel: Potential Risks and Technical Challenges to Protecting Underground Sources of Drinking Water for Geologic Sequestration of Carbon Dioxide

Objective: Share perspectives on what may or may not be potential risks to underground sources of drinking water associated with geologic sequestration of carbon dioxide. Discuss how a UIC regulation could address potential risks. Provide a springboard for participant discussion of questions and concerns on day two of the workshop.

Panel:

Jens Birkholzer, Lawrence Berkeley National Laboratory

Tom Curtis, American Water Works Association

Janet Henry, American Electric Power Service Corporation

Susan D. Hovorka, University of Texas

Scott Imbus, Chevron

George Peridas, Natural Resources Defense Council

Lee Whitehurst, U.S. Environmental Protection Agency

Sample Discussion Questions:

- What are the drinking water and other public health concerns from the potential affects of underground injection on drinking water that this regulation should address?
- What other challenges or risks should be considered?
- What risk reduction tools and technical approaches help address these concerns?
- Additional questions from participants, if time permits

5:30 Adjourn for the day

Tuesday, December 4, 2007

8:00 Arrival

8:30-8:45 Review Today's Agenda
Objective: Recap day one and review agenda for day two.

8:45-9:00 Respond to Questions
Objective: Provide additional responses to questions raised on day one about EPA's proposed process and approach to the rulemaking.

9:00-10:30 Participant Discussion: Questions and Considerations for the Proposed Rule
Objective: Learn about stakeholders' concerns and suggestions for what EPA should consider in developing the proposed rule.
Process: Participants will discuss the following questions in small groups [90 min]. Spokespersons from each table will share highlights from the small group discussions in a facilitated plenary session following the break. Worksheets also will be provided to capture points from individuals and from the small groups.

Suggested discussion questions:
- What are the drinking water and other public health concerns from the potential effects of underground injection on drinking water that this regulation should address?
- What other comments and suggestions do you have about the proposed regulation?
- What additional questions do you have?

10:30-10:45 Break

10:45-12:00 Reports from Small Groups: Questions and Considerations *[continued]*

12:00-1:30 Lunch (on your own)

1:30-2:00 Presentation: Modifying Existing Underground Injection Control Regulations to Address Geologic Sequestration of Carbon Dioxide
Objective: Discuss current ideas for modifying existing UIC regulations to address geologic sequestration of carbon dioxide.

Suzanne Kelly, Office of Ground Water and Drinking Water, U.S. Environmental Protection Agency *[30 min]*

2:00-3:30 Interactive Stakeholder Panel: Perspectives and Considerations for Approaching Proposed Regulations for Geologic Sequestration of Carbon Dioxide
Objective: Reflect on the key themes from the workshop and share perspectives about regulatory approaches to consider.

Panel:

Scott Anderson, Environmental Defense

Richard Esposito, Southern Company

Jean-Philippe (JP) Nicot, University of Texas

Douglas W. Smith, Van Ness Feldman

Berry H. (Nick) Tew, State of Alabama and Interstate Oil and Gas Compact Commission

Lee Whitehurst, U.S. Environmental Protection Agency

Sample Discussion Questions:

- What considerations or questions need to be addressed concerning the overall goal or purposes of the regulation?
- What concepts could be integrated into the UIC framework to create an adaptive approach to the rulemaking? What models exist in other regulations that might be useful to consider?
- What issues should be considered with respect to the interaction between this proposed regulation and other state and federal regulations?
- What other concepts should EPA consider?
- What specific topics would be of greatest interest to explore in more detail at the second workshop?
- Additional questions from participants, if time permits

3:30-4:00 Wrap up and Next Steps

Stephen F. Heare, Office of Ground Water and Drinking Water, U.S. Environmental Protection Agency

- What did we hear at this meeting?
- What will happen with the ideas discussed?
- Dates and topics for the next meeting

4:00 Adjourn

Appendix 2: Workshop Participant List

Mark Ackiewicz
U.S. Department of Energy

Scott Anderson
Environmental Defense

Allyson Anderson
Senate Committee on Energy and Natural Resources

Alex Apotsos
Office of Senator Tester

Lisa Bacanskas
U.S. EPA

Tim Ballo
Earthjustice

Mary Rose (Molly) Bayer
U.S. EPA

Howard Beard
Cadmus, Inc

Scott Biernat
The Cadmus Group, Inc.

Gail Bingham
RESOLVE

Jens Birkholzer
Lawrence Berkeley National Laboratory

Veronica Blette
U.S. EPA, Office of Ground Water and Drinking Water

Kevin Bliss
Interstate Oil and Gas Compact Commission

Don Bowie
Potomac-Hudson Engineering, Inc.

Judith Bradbury

Jay Braitsch
U.S. Department of Energy

Peter Briggs
Bureau of Oil & Gas Regulation

Wanda Burget
West Powder River Coal Company

Byron Burrows
Tampa Electric Company

Robert Burruss
U.S. Geological Survey

John Buzzone
Washoe County Department of Water Resources

Kenneth Carlson
Colorado State University

Valerie Chan
U.S. EPA

Jennifer Chavez
Earthjustice

Charles Christopher
BP
Christa Clapp
U.S. EPA

Dave Clark
Rural Community Assistance Partnership, Inc.

Ann Codrington
U.S. EPA, Office of Ground Water and Drinking Water

Sherri Comerford
U.S. EPA

Alison Cooke
BP Alaska, Inc.

Mary Jane Coombs
California Institute for Energy & Environment

Cal Cooper
ConocoPhillips

Steven Crookshank
American Petroleum Institute

Thomas Curry
M.J. Bradley & Associates

Tom Curtis
American Water Works Association

Michael Curtis
U.S. Department of Energy

Jared Daniels
U.S. Department of Energy

Jill Davidson
Archer Daniels Midland Company

Kyle Davis
PacifiCorp

Amy Dewey
U.S. EPA, Office of Public Liaison Office of Public Affairs

Adam Diamond
CF Industries

Joseph Donohue
Stratus Consulting, Inc.

James Dooley
Pacific Northwest National Laboratory

Cynthia Dougherty
U.S. EPA, Office of Ground Water and Drinking Water

William Duffy
Davis, Graham & Stubbs

Amelie DuFournet
Schlumberger Water and Carbon Services

Andrew Duguid
Schlumberger Carbon Services

Julia Dulan
Southern Company

Natalie Eades
Anadarko Petroleum Corporation

Brenda Ekwurzel
Union of Concerned Scientists

Richard Esposito
Southern Company

Bill Fang
Edison Electric Institute

Steve Feldgus
House Committee on Natural Resources

Bret Ferrell
Hunton

Aaron Fischbach
Rural Community Assistance Partnership, Inc.

Leslie Fischbeck
Ecology and Environment, Inc.

Stephanie Flaharty
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Beveridge & Diamond, PC

Steve Fries
U.S. EPA - ORD

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Shaw Environmental & Infrastructure, Inc.

Jesse Gandee
Augusta Systems Inc

John Gasper
Argonne National Laboratory

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Shaw Environmental, Inc.

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Advanced Resources International, Inc.

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Carnegie Mellon University

Mary Griffiths
The Pembina Institute

Veronica Gutierrez
Edison International

David Haines
Shell Oil

Jessica Hall
Crowell & Moring LLP

Lisa Hanle
U.S. EPA

Roy Haught
U.S. EPA

Steve Heare
U.S. EPA, Office of Ground Water and Drinking Water

Gemma Heddle
Chevron

Elliott Heide
Occidental International Corporation

Ed Helminski
GHG Transactions & Technologies

Benjamin Hengst
U.S. EPA, Office of Air and Radiation

Doug Hermann
STS

Troy Hillier
The Policy Navigation Group

Nancy Holt
Aerospace Building

Susan Hovorka
University of Texas, BEG
Harriet Hubbard
U.S. EPA

Katheryn Hubble
U.S. Government Accountability Office

Scott Imbus
Chevron Energy Technology Co.

Matt Jennings
Office of Senator Tester

Kelly Johnson
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U.S. Department of Energy

Intiaz Kalyan
U.S. EPA

Bob Kane
U.S. Department of Energy

Austin Kane

Anhar Karimjee
U.S. EPA, Climate Change Division

Raymond Kelly
Edison Mission Energy

Suzanne Kelly
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Asik Khajetoorians
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Twenty-First Strategies

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Ned Leonard
Center for Energy & Economic Development

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U.S. Department of Energy

Tim Lohner
American Electric Power Service Corporation

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Bob Mowrey
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Jim Stine
National Rural Electric Cooperative Association

Jeffrey Summers
U.S. Department of Energy

Berry H. (Nick) Tew
Interstate Oil and Gas Compact Commission

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House Committee on Energy and Commerce

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BNA's Daily Environment Report

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Roy Yang
U.S. EPA

Jill Zucker
Bryan Cave LLP

Appendix 3: Questions Not Addressed At Meeting

During the workshop, participants were invited to write and submit questions to presenters. As many questions as possible were answered during each session; however, time constraints prevented presenters from addressing all questions. This document includes written questions (not addressed at the meeting) and responses.

Questions to EPA

- *Reservoir Management/Risk Management* – Protection of USDWs requires the sound knowledge of surface aquifers, deep CO_2 reservoir knowledge (oil and gas field or deep saline) as well as knowledge of the containment overburden. Do you plan to include (in the forthcoming regulation) the requirement to proceed through a complete slate of dynamic characterization of the complete reservoir within the operation of a risk management process including assessment and optimization through mitigation?

    - A thorough site characterization and analysis of the Area of Review (AoR) are critical components of existing UIC Program regulations. In developing new regulations for geologic sequestration, EPA is carefully considering these critical components of a robust site characterization as well as the unique properties of CO_2. EPA intends to seek public comment on the components of site characterization/AoR to better refine requirements for CO_2 injection for geologic sequestration.

- *Plume Monitoring* – Will monitoring using wells be required or will other techniques (e.g., seismic) be allowed?

    - EPA is evaluating and exploring a range of monitoring technologies and approaches. EPA will seek comment on these approaches as they apply to the unique challenges posed by the geologic sequestration of CO_2.

- *Injection into USDWs* – Does EPA anticipate that injection of CO_2 into a USDW will require that the aquifer be "exempted" as a USDW? Is there a process for exempting aquifers for injection via Class V wells?

    - The overall mission of the Underground Injection Control Program is to protect USDWs from contamination and we don't anticipate making any changes to the Aquifer Exemption requirements in this rule-making. However, we will evaluate the applicability of the Aquifer Exemption criteria as they apply to the geologic sequestration of CO_2.

- *Grandfathering Existing Projects* – Will EPA be considering provisions to "grandfather" sequestration projects pursued prior to the promulgation of final federal regulations, should they be permitted prior to the establishment of final federal regulations? There may be some projects that will be initiated (or at least would like to be initiated) prior to the proposed 2010 target date for the final regulations.

- EPA recognizes that projects may come online before the final rule is promulgated and we therefore intend to look at the impacts of finalizing the regulation after full-scale projects have been permitted. Furthermore, throughout the regulatory process EPA will analyze impacts of this regulation to owner-operators and the final rule will reflect these analyses.

- *Scope* - How much larger would the UIC program be – volume, numbers of wells, number of permits, etc. as a result of GHG sequestration? What are the resource implications for EPA and the states?

  - Geologic sequestration partnerships in coordination with DOE have done work to estimate the number of wells and the scope of geologic sequestration activities. EPA will use projections as a part of their analysis of the impacts that regulations will have on owner operators and the states.

- *Regulatory and Impact* - Does EPA consider CO_2 a hazardous waste? Has there ever been a documented case of environmental impact associated with EOR activities?

  - Pure CO2 is not a hazardous waste and is, in fact, used in food manufacturing.
  - To date, according to rule-making research, we know of no cases of CO_2 being used for EOR where the CO_2 has impacted a USDW. However, EPA will be soliciting comments and data on this issue as we move to rule finalization.

- *Status of CO_2* – What is the state of consideration of CO_2 as a commodity, waste, or hazardous waste?

  - EPA has statutory authority under the Safe Drinking Water Act to regulate all fluids (with the exception of natural gas and some hydraulic fracture fluids) under the UIC program regulations whether the fluids are identified as a commodity, waste, or non-hazardous waste.

- *EOR and Geothermal/new technology* – Will the proposed rule apply to injections of fluid for EOR or enhanced or engineered geothermal systems, or are they already covered? If the latter, how similar are they to CO_2 injection?

  - This rule applies to geologic sequestration, not EOR/EGR activities.

Appendix 4: Day 2 Worksheet Comments

On day 2 of the workshop, participants met in small groups to discuss three questions:

1) What are the drinking water and other public health concerns from the potential effects of underground injection on drinking water that this regulation should address?
2) What other comments and suggestions do you have about the proposed regulation?
3) What additional questions do you have?

While one representative from each group kept a summary sheet and shared the group's thoughts with the rest of the participants in a full group discussion, all participants were welcome to submit worksheets with individual comments on each question.

This document is a summary of comments submitted via summary sheets and individual worksheets.

1. *What are the drinking water and other public health concerns from the potential effects of underground injection on drinking water that this regulation should address?*

Contamination of drinking water

- Release into the air, release into drinking water – exceeding Maximum Contaminant Levels (MCLs), and release into surface water
    - Releases are very unlikely given a strong risk based program and if they [leaks] happen are easily managed via existing technologies and don't let it happen in the first place with strong risk-based program.
- Risk of CO_2 polluted water migrating into potable water
- Contamination of aquifers by UIC operation; potential mitigation if there is a release.
- Contamination of drinking water (by metals)
- How will EPA deal with ground water impacts that may not have MCLs, such as iron, increased salinity, and pH?
- Changes in water chemistry resulting in violations of primary drinking water standards
- Saline contamination
- EPA's regulations should protect against having contaminants enter USDWs at concentrations that would prevent a public water system from complying with national drinking water standards or at concentrations that would survive treatment to cause other health concerns and should not impose any absolute prohibitions on fluids entering USDWs without endangering.
- Intrusion into current USDWs v. potential future USDWs
    - Desalinization appropriate treatment
    - Analogous to unmineable coal seams
    - CO_2 capture from water treatment
- Protection of USDWs, long term. Mixing of "bad water" with "drinkable water". Can't fix this once it happens – resources gone! E.g. brine displacement.
- Trace element leaching and brine displacement.
- Existing "saline" aquifers may become the vital drinking water supplies for future generations. Consider allowing CO_2 sequestration into only "highly saline" (>30,000

mg/L TDS) aquifers, or very deep (>10,000 feet) aquifers. Regulations should include a requirement for an evaluation of "sustainable" ground water supplies available for existing and future use. Sequestration should not be allowed in geologic formations above the deepest USDW.

Site Characterization

- Recommend extremely rigorous geologically-based site characterization
- Site-selection is critically important
- If mitigation is not feasible, site characterization must be emphasized in conjunction with monitoring. But not so great as to compromise the integrity of the sink/reservoir.

Flexibility

- Recommend performance based standards
- "Performance standard" based : application to specific reservoirs demands flexibility (example: define reservoir lining and set "non-degradation standards"
- Focus on performance standards, should be flexible (might not need level of detail)
- Monitoring and adaptation; behavior of CO_2 – Need to be flexible because this CO_2 load will be coming from power plants, etc.
- Site specific effects (potential effects may be site specific rather than occurring at every site)

Public perception

- Address even low probability hazards to help address public perception of risk
- Develop public education programs by EPA to address public concerns
- Factor public transparency into the permitting requirements of the rule: Include/require the applicant to hold an informational meeting in the area as well as public hears into the public process for siting.
- Public perception issues: EPA needs resources for outreach beyond "technical issues."

Purity

- Purity of injected CO_2, i.e., M_2S.
- Do you need to require a specific purity? Will this reduce:
    - mobilizing heavy metals?
    - surface migration?
    - blow-outs during the injection process?
- Contaminants from carbon capture? How pure will CO_2 have to be? (10 GLC originally called for 95% purity)

Liability

- Long-term liability issues – who pays to fix problems that occur, in the short-term and long term?
- Monitoring and liability issues must be considered thoroughly in the rule development; Also make sure mineral rights are considered

Water (general)

- Displacement of drinking water?
- Availability of water might be an issue
- Interested in the link between drinking water and lakes; Who protects and regulates?
- Impact to lakes – sensitive ecosystems
- Link between ground water and surface water
- Protect USDWs
- Impact to drinking water

Pressure

- Over-pressure
- Increased pressure through unknown pathways (brine movement to freshwater supplies)

Co-Contaminants

- There may be some pollutants from power plants where there is a strong economic motivation to co-sequester (with CO_2). This needs to be considered in regulations.
- Transport of co-contaminants (H_2S)

Seismic activity

- Induced seismicity
- Earthquakes/seismic activity
- Include specific seismic performance requirements in site characterization as part of the rule. This is true both with respect to local seismic conditions and induced seismicity related to CO_2 injection.

Leakage

- Leakage
- Immediate concern – leaks through artificial penetrations, faults, pressure impacts (brine displacement)
    - Leaks would move both CO_2 & brine into formation water
- CO2 releases

Miscellaneous

- Over-saturation effects from full-scale implementation.
- Displaced fluids may pose a greater risk than CO_2 migration except for migration through discrete conduits
- The area of influence is much larger when Gigatons (Gts) of CO_2 are injected than what has been done [injected] before. We don't truly know how stable Gts of CO_2 actually are. We suggest a stepwise regulation – 1st regulate EOR, then brine areas, then analyze resultant data and revamp regulations to address problems.
- Please don't forget to take into account the lessons learned from the MTBE case. Make sure you factor in all issues related to the quality of CO_2, implications for movement of contaminants that are either in the ground (because of EOR, for example) or that are in the CO_2 stream

- Concern: Scale of injections
- Uplift/Subsidence leading to property damage, change in water distribution
- Carbonic acid impacts to geologic materials and metals mobilization
- Possibly a very low risk, but asphyxiation should be addressed
- Must focus on risk (probability X impact)
- Characterization should focus on pathway integration
- The permitting requirements should look like Class I requirements.
- States have laws that aren't allowed to be more stringent than EPA
- What about whether the UIC program should apply if no drinking water?
- Property rights
- Possible remediation, corrective action needs
- How will monitoring requirements in the USDW over the CO_2 footprint be addressed? These could be significant costs.
- CO_2 does not itself pose any new public health concerns
- Will the next set of proposed regulations cover injection into coal or basalt? They represent very different challenges compared with saline/petroleum projects.
- Please don't look at this with water-only blinders on – please don't think of this as an "industrial waste" and consider only the water-related issues of injection in your regulatory development. Bring in the air folks, the EPA folks who do public health issues generally, the Environmental Justice folks – also make sure the rule development occurs with input from the Department of Energy (DOE) and the Department of Transportation (DOT) on pipelines.
- Terrorism (and vulnerability) of transport system

2. *What other comments and suggestions do you have about the proposed regulation?*

<u>Flexibility/Adaptability</u>

- Adaptive performance standards on injection pressures; look to previous info on oil/gas hydro-fracturing.
- Make sure there is flexibility, that the rules are adaptive.
- Performance based post closure – presumption of achievement of performance standard at closure. Don't want to count molecules for carbon credits
- Not prescriptive: dynamic management approach
- Performance-based versus prescriptive standards
- Consider the establishment of a dynamic vs. static approach to Area of Review (AOR) evaluation.
- Site-specific vs. performance-based standards?
- Regulations need to be flexible but effective
- Don't specify technology but specify standards in the regulation.
- Regulation needs to be flexible enough to allow tailoring of permit conditions to storage sites – the standard should be performance based to avoid over-regulating the best sites.
- Adaptive regulation important to avoid restriction of advances

- If there is an adaptive regulation, you should ensure that there are evaluations of information gathered from projects.
- Make sure that adaptability is reflected in specific requirements of the rule to factor in new data as you get information – periodic review of permits and performance requirements. No "grandfathered" permits.

Risk

- Risk management with performance standards and risk mitigation
- There are different risk assessment approaches being investigated; need best practices guidelines.
- EPA should consider a risk based regulatory approach similar to those for nuclear waste
- The insurance industry should be consulted as to its capability to accept long-term risks of Carbon Capture and Storage (CCS), e.g. the 30 years vs. 10,000 years duration of risk.

Economic Considerations

- 30% energy cost is too high to justify.
- Compressing gas is energy intensive.
- Funding for regulatory implementation is critical and the current funding for the UIC program is wholly inadequate to meet the needs.
- Clarify financial assurance requirements.
- There should be a legislative solution for post-closure financial assurance.

Liability

- All regulations should address small rural communities and long-term liability. If an injection well/power station is located near a rural community 50 years in the future and there is a problem – who is watching out for the small community? Contingency fund?
- Long term liability transfer/funding to a government "caretaker"
    - The concept offered by 2016 report makes sense rather than leaving long-term oversight with private sector.
    - Costs of transfer should be defined before permit regulations are put in place
    - Allow EOR projects to go forward first and develop the science/knowledge base for the development of broad regulations in the future. Also note, reservoir boundaries will cross state lines and involve multiple state jurisdictions.
- If there was a CO_2 incident (well after the fact), how would the responsible party be determined?
- Address liability and property rights issues
- The regulations will need clear federal direction for post-closure liabilities

Inter- and Intra- agency coordination

- Clarify the interplay/authority of other states and agencies in the regulatory scope/preamble of broader carbon capture and storage: DOT, EPA Office of Air and Radiation (Climate Change), DOI (property rights), OSHA (security)
- Coordination with the Office of Air? Assume that regulations, while protective of drinking water, also address the need to sequester CO_2.
- Involve the EPA National UIC Technical Workgroup in developing any future regulations. EPA should include Regional Office UIC experts in the process as well.
- EPA must engage with DOT and any other agencies early in RM development
- Do not require multi-agency permitting – allow all UIC agencies to grant CCS permits.

Public

- Public education and outreach: Not just around water issues, but link this to climate change and air quality
    - Don't call it a waste.
    - Engage with public health and environmental groups to help you – message: this does not preclude renewables.
    - People need an answer to questions related to potential seismic activity and risks.
- Public education/perception – address

Information Needs

- The rulemaking is premature if the science & economics are not adequately resolved.
- Have real data.
- Provide incentives for sharing research information (public, agencies, industry).

Climate Change

- Because of climate change issues, do we need to begin large-scale CCS before those issues are resolved?
- Building something into this program so that it is "credit" ready?

Property Rights

- Property rights – how to address?
- Maybe EPA should look at pore space ownership.

Permitting/Siting

- Need to look at all areas that will be occupied by ultimate CO_2 plumes
- Be very clear and strict regarding requirements for site characterization. Our experience with other programs (Superfund, RCRA, radioactive waste) is that site characterization is very important but often neglected due to cost considerations.
- CCS projects should be permitted and reviewed on the basis of an entire reservoir to optimize storage capacity.
- Thorough process needed for site characterization, modeling, risk assessment

Scope of Regulation

- Need clarity in co-sequestration issue on class/standards
- What about off-shore injection in state and federal waters. Will UIC permits apply and cover? If not who will?
- The rule should focus on existing experience – EOR type, rather than moving into saline reservoirs.
- How will EPA address other impacts that may not directly affect groundwater quality, e.g. methane, radon releases, ecological effects of CO_2?
- How will EPA address issues of permanence, acceptable levels of leakage?
- Establish a tiered/measured leakage response system that relies on good baseline USDW analysis and quantitative action limits for specific constituents.
- Don't fall back on current UIC restrictions such as fracturing of injection zones without evaluating the affects/unintended consequences.
- How much MMV will be required in the rule as well as the guidance document?
- Keep in mind and emphasize in the rule that CO_2 is not a hazardous material in this context.

Miscellaneous

- This should not be permitted as a Class I activity (not a waste!). Perhaps a new classification should be created.
- Texas & Lawrence Berkley Framework expected in Q1 2008 will address the full program (well, strata, vadose zone, etc.) Also see EU CCS Directive.
- Mitigation, performance optimization & risk management is needed.
- Large formations – how to design the system?
- Volume and gas might be different than UIC has previously seen
- UIC program has small [limited] resources – not a lot of manpower to address the program; staffing; but, this might not indicate their ability to handle CCS
- Programmatic support will be critical
- What if the CO2 displaces other substances (brine, etc.)?
- Monitoring techniques?
- Address project as a whole.
- UIC mandate – protect USDWs and maintain CO_2 sequestration ("stays put") – opportunity to mandate monitoring to ensure performance beyond individual wells (entire site)
- Performance-based (creativity on industry for methods)
- Require large # of wells (or injection points) to work

3. *What additional questions do you have that EPA should consider in developing the proposed regulation?*

Liability

- Clarify post-closure requirement to limit industry liability. i.e., monitoring requirements, post closure care.

- EPA needs to define how to transfer liability at closure.
- Long-term liability?
- What about liability relief?
- How will EPA deal with long-term liability issues in the proposed regulation?
- How should long-term stewardship and liability issues be addressed and how does this affect the regulatory scheme?
- Need a legislative remedy that allows for a presumption of compliance if all permit requirements are achieved. Specifically, as an example, concerns over common law, nuisance suits, toxic torts, future generations.
- If something goes wrong (CO_2 leaks) what are the realistic options (fines, SEPs, mitigation)?
- Will the rule insist on contingency planning for failures?

Flexibility/Adaptability

- Need to cover formations beyond EOR and saline. For example, desert [sands] and coal seams. Can such flexibility be included?
- Be flexible – we will learn a lot after the final regulation.
- The regulation needs to be adaptive
    - May not be a model to avoid litigation/uncertainty (legislation could avoid)
    - Any existing adaptive regulation models to use?

Jurisdiction / Coordination

- How will states administer this rule? A comprehensive perspective is also needed. Multi-state aquifers and reservoirs pose special challenges.
- Access rights to the states: who will have to pay for it?
- If EPA's proposed regulations do not address liability and property rights issues, how does EPA propose to coordinate its activities with other governmental (state) agencies that may be involved with those issues?
- Cross state lines for Siting and Monitoring?
- Consider interstate migration of CO_2 – how will the rules address the migration underground:
    - Between 2 EPA regions?
    - Between 2 states with primacy?
    - Between one state with primacy and an EPA region?

Public Perception

- This program must consider how to communicate the risks – public perception issues
- Education for the public by EPA/DOE?

Carbon credits

- Should this program address the broader issue of the carbon trade?
- How will carbon credits factor in? (outside UIC scope)

Economic cost

- 30% energy cost seems too high – can't we get everyone to conserve instead?

- Economic considerations are not well settled; if 30% of power is consumed by sequestration, economics may not support technology at all.
- States with primacy need financial resources and technical assistance from the EPA regions.

Links with Current System

- Will the new rule affect [injection into] existing CO_2 domes? (currently permitted Class II UIC facilities)
- Must address all media in this program. Address Clean Water Act and Clean Air Act and Comprehensive Environmental Response, Compensation, and Liability Act (if needed). Must be coordinated. When a permit is received, the owner/operator must know what is needed for all media.
- EPA should function within the current limitations of the SDWA and not expand into non traditional areas such as property rights and long-term liability.
- Need for more authority – SDWA or new mandate from legislation?
- NEPA can be a stumbling block (as in California). This is another likely legislative issue.
- Are the current bonding/post-closure systems adequate to address CO2 injection?

Classification

- Program: distinguish between EOR and CCS
- Whether there should be two permitting processes for EOR and CCS: 1) EOR plus CCS or 2) CCS -what needs to be different?
- Should CO_2 be classified as a pollutant?
- What purity of waste stream will allow classification as a CO_2 waste as opposed to another waste like a hazardous waste?
- EOR continues to be Class II? Or will you include new EOR in Class VI?

Permitting/Siting

- How would a higher incidence of seismic activity be factored into a permit? What metric would be used?
- Would you disqualify a site or have different construction and/or financial responsibility requirements for a site with a high incidence of seismic activity?
- Does EPA have expertise to certify sites?
- Permits
    - Frio – Class I worked but scales were small
    - Additional constraints for large volume, long time?
    - Permit application and certification contract have obligation, but who certifies them?
    - Who certifies contract? Who evaluates sites as part of application?
    - Class I – associated with waste, bad for Public relations
- Size of area of review: Will it be the pressure plume of CO_2 plume?

Data/Modeling

- Could modeling of the CO_2 plume be integrated into a permit? How reliable is it?

- Integrity testing data? Well integrity?
- Will they require different data pre-permitting?

International Programs

- We encourage EPA to look at international programs
- Look at Australia & EU, other models for regulation/legislation.

Miscellaneous

- Coal seam issues
- Post closure must be reasonable
- Balance: Regulation structure should be measured, not overwhelming and acknowledge benefits of capture vs. atmospheric release.
- Maybe where there are already oil and gas fields you can inject sensors in the retired wells
- How will EPA ensure that it will have the resources over the long-term to:
    - Factor in new information as it is received?
    - Do the monitoring or be sure it is done?
    - Satisfy public health concerns in the future?
- Agency control of GS? -Single or multiple with defined domains
- Concern that regulations may limit development of data and technology
- 10 GLC – uses subsurface as resource (quantity pending)
    - Ownership of pores
- EOR conversion
- Limited experience / number of both on-site & professionals for Research & Development