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

February 26-27, 2008

Meeting Summary*

TUESDAY, FEBRUARY 26, 2008

WELCOME AND OPENING REMARKS

Gail Bingham, meeting facilitator from RESOLVE, opened the meeting by welcoming participants to the workshop. Ms. Bingham then introduced Stephen Heare, Director of the Drinking Water Protection Division within U.S. EPA's Office of Groundwater and Drinking Water (OGWDW). Mr. Heare welcomed participants and provided an overview of the workshop purpose and format. He noted that this workshop was designed to build on the December 2007 stakeholder workshop and obtain more specific stakeholder input on EPA's proposed rulemaking for the geologic sequestration (GS) of carbon dioxide (CO_2).

Robert Brenner, Director of the Office of Policy Analysis and Review within U.S. EPA's Office of Air and Radiation (OAR), highlighted the cross-media nature of carbon capture and storage (CCS), and the importance of interagency coordination in addressing issues related to climate change. He said that the three major sectors that the federal government must consider when addressing climate change are power generation, transportation, and the rest of industry and society. Dr. Brenner noted that action on the issue in the transportation sector and rest of society is already recognizable. He then pointed out that most energy analysts believe coal energy technology must be part of the United States' energy future; therefore, how to deal with emissions is a critical question. Dr. Brenner explained that CCS is a lynchpin of the United States' overall climate change strategy, noting that the challenge lies in determining how to make it a viable strategy. He said that collaboration across sectors is the key to meeting the challenge of making CCS viable.

Mr. Heare then reviewed the regulatory context of the GS rulemaking, explaining that the EPA has authority under the Safe Drinking Water Act (SDWA) to protect underground sources of drinking water (USDWs) from underground injection of fluids, including CO_2. He also reviewed the potential U.S. deployment of CCS-enabled power generation systems, the estimated CO_2 storage capacity in the U.S., and the basic process for CCS. Mr. Heare mentioned that the U.S. Congress is very interested in CCS and that stakeholders have expressed a desire for a management framework. He also noted that EPA's 2006-2011 Strategic Plan highlights CCS. Mr. Heare reviewed EPA OGWDW activities aimed at developing a regulatory framework for

* This document is a summary of the February 26-27, 2008 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.

GS, which EPA's Underground Injection Control (UIC) Program will administer. These activities include release of UIC Class V Experimental Technology Well Guidance in March 2007; review of UIC permit applications for GS projects; technical and stakeholder input workshops; and collaboration with EPA's OAR, U.S. Department of Energy (DOE), U.S. Department of Transportation (DOT), Bureau of Land Management (BLM), and United States Geologic Survey (USGS). Mr. Heare also explained that EPA has formed an internal workgroup focused on the rulemaking, and that a proposed rule for commercial scale GS of CO_2 will be released during Summer 2008.

All presentations from the workshop can be found here:
http://www.epa.gov/safewater/uic/wells_sequestration.html

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

- Provide updates on EPA's rulemaking process;
- Share EPA's current thinking and have a dialogue with stakeholders on the proposed regulation; and
- Discuss issues related to public participation, financial assurance for long term site care and monitoring, site characterization / area of review, monitoring, UIC well construction, and other topics related to the proposed rulemaking.

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

OVERVIEW OF DECEMBER 2007 WORKSHOP AND UPDATE ON SUBSEQUENT ACTIVITIES

Ann Codrington, Chief of EPA OGWDW's Prevention Branch, provided an overview of the December 2007 UIC Program stakeholder workshop. Ms. Codrington said the goal was to update stakeholders on activities since the previous workshop, and provide a bridge to the current meeting. She reminded participants that the EPA UIC Program regulates underground injection of all fluids (liquid, gas, or slurry), and that the UIC Program provides a regulatory framework for the GS of CO_2.

Ms. Codrington said that the purpose of the December 2007 stakeholder workshop was to inform stakeholders about the GS rulemaking process, and to identify and discuss stakeholder issues, questions, and considerations related to the proposed rulemaking. Building on the outcomes of that workshop, the February 2008 meeting was meant to update stakeholders on the rulemaking process and how their concerns are being taken into consideration by EPA. EPA also identified specific issues based on the December meeting to discuss with stakeholders at the February meeting.

The December 2007 stakeholder workshop involved over 250 participants from industry, environmental and public interest groups, government, and the general public. Topics covered included the following:

- The proposed rulemaking process;
- Existing UIC regulations;

- CO_2 GS technology;
- Ideas about how to approach regulation of GS of CO_2; and
- Potential challenges related to GS of CO_2 and protection of USDWs.

The following challenges were identified at the December workshop:

- Technical challenges: Area of Review (AoR) determination, site characterization, and monitoring.
- Policy challenges: the relationship between primacy states and federal authorities, property rights, surface access, pore space ownership, and post-closure care.
- Overarching challenges: public education and outreach, flexibility, adaptability, and identifying cost and benefits of GS of CO_2.

Ms. Codrington explained that, subsequent to the December 2007 workshop, EPA reviewed stakeholder input and the EPA internal GS workgroup deliberated. She said EPA is addressing information in the context of the following categories of information:

- Geologic Siting Criteria;
- Area Of Review;
- Well Construction Standards;
- Mechanical Integrity Testing;
- Operation and Monitoring Requirements;
- Well Closure and Post-Closure Care, and Financial Responsibility; and
- Public Participation and Communication.

Ms. Codrington also reviewed recent activities related to the rulemaking including a January 16, 2008 technical workshop on measurement, monitoring, and verification; preparation of cost analysis, options development, and background documents; ongoing data collection and analysis; and increased coordination with DOT, BLM, and USGS. Ms. Codrington concluded by presenting the following table of rulemaking milestones:

Activity	**Milestone**
Data Collection and Analysis	Ongoing
Two Stakeholder Meetings	December 2007/February 2008
Interagency Review of Proposed Rule	Late May - Early June 2008
Administrator's Signature of Proposed Rule	July 2008
Public Comment Period for Proposed Rule	July – October 2008
Notice of Data Availability (if appropriate)	2009
Final UIC Rule for GS of CO2	Late 2010 / Early 2011

PRESENTATION: OVERVIEW OF EPA'S CURRENT THINKING ON APPROACHES TO SITE CHARACTERIZATION, AREA OF REVIEW, WELL CONSTRUCTION, WELL OPERATION AND MONITORING, FINANCIAL ASSISTANCE FOR LONG-TERM SITE CARE AND MONITORING, CLOSURE & POST-CLOSURE CARE, PUBLIC PARTICIPATION, CLASS V EXPERIMENTAL WELLS, AND CLASS II ENHANCED OIL RECOVERY AND ENHANCED GAS RECOVERY

Lee Whitehurst, EPA OGWDW, presented brief background information on elements of EPA's proposed rule development for GS of CO_2, with the goal of setting the stage for stakeholder input during the breakout sessions on Day 2 of the workshop. In the first segment of his presentation, Mr. Whitehurst provided an overview of EPA's current thinking on approaches to site characterization, AoR, well operation, and mechanical integrity testing. The second part of his presentation covered well operation and monitoring, financial assistance for long-term site care and monitoring, closure and post-closure care, and public participation. Mr. Whitehurst concluded by covering two topics not slated for breakout sessions at the meeting: Class II Enhanced Oil Recovery / Enhanced Gas Recovery (EOR/EGR) and Class V experimental wells.

Mr. Whitehurst began by noting again that the proposed rule will be limited to authorities under the SDWA, and that the proposal will not address climate implications (i.e., carbon credits or releases to the atmosphere). He said that EPA is committed to taking an adaptive approach to regulation and intends to incorporate new information over time. Mr. Whitehurst also pointed out some special considerations for GS of CO_2 that the EPA UIC must take into account in developing each element of the proposed rule, including the potential large volumes that may be injection, and the buoyancy, viscosity, and corrosive properties of CO_2 in the subsurface. He then went over the basic requirements in current UIC regulations, key questions and considerations, and potential approaches to addressing major elements of the proposed rule. Meeting participants provided input on the key questions during sessions on Day 2 of the meeting.

Site Characterization
Mr. Whitehurst explained that the basic requirements for site characterization in the current UIC regulations include an injection zone that can accept fluids, and a confining zone (system) above the injection zone that contains all fluids. EPA sought stakeholder input on the question of whether a secondary containment / confining system (SC/CS) be required for GS projects.

Mr. Whitehurst noted several potential approaches to addressing this question, including 1) not requiring SC/CS; 2) leaving this decision to the UIC Program Director's discretion for each GS site; 3) requiring SC/CS where local geologic conditions allow; and/or 4) mandatory identification of SC/CS. Key considerations related to SC/CS are that 1) it could provide enhanced protection in case of leakage; 2) it would provide an additional zone for monitoring; 3) a well characterized primary CS could be sufficient; and 4) it may not be possible in certain geographic areas.

Area of Review
The current UIC regulations for AoR require delineating the AoR, identifying all artificial penetrations and evaluating features that may allow upward migration, determining if artificial penetrations and geologic features provide an adequate seal, and corrective action of artificial

penetrations as necessary. The key question on which EPA sought stakeholder input was whether periodic re-evaluation of the delineation of the AoR should be required.

The range of approaches presented by Mr. Whitehurst included 1) requiring re-evaluation of AoR; 2) leaving the decision to the UIC Program director's discretion for each GS site; 3) setting a fixed time interval for re-evaluation; 4) re-evaluating upon significant operational changes; and/or 5) a combination of approaches. Key considerations related to re-evaluation of AoR include that it 1) allows better understanding of the plume/pressure front location and movement; 2) provides opportunity for phased corrective action of artificial penetrations; and 3) could be time and cost intensive.

Well Construction

The basic deep well requirements in the current UIC regulations state that wells must be cased and cemented in a manner that prevents movement of fluids into a USDW. Mr. Whitehurst noted that EPA is seeking stakeholder input on whether corrosion resistant construction materials should be required. Potential approaches include 1) no requirement for corrosion resistant materials; 2) leaving the decision to the UIC director's discretion for each GS site; 3) establishing a performance standard; or 4) prescribing specific well materials. Mr. Whitehurst noted that impurities in the CO_2 stream may be corrosive, and that CO_2 itself can be corrosive when mixed with water.

Well Operation and Monitoring

For well operation and monitoring, the current UIC regulations require that injection not fracture the confining zone; monitoring of injection pressure, flow rate, and volumes; monitoring the nature of the injected fluid; and performing injection well mechanical integrity tests. The key questions on which EPA sought stakeholder input was whether tracers should be used in the CO_2 stream and if surface air/soil gas monitoring should be required.

Potential approaches include 1) having no requirement for tracers and surface air/soil gas monitoring; 2) leaving the decision to the UIC director's discretion for each GS site; 3) requiring it as part of a comprehensive monitoring plan developed by the owner/operator; or 4) detailing specific monitoring requirements in the regulation. Key considerations regarding tracers and soil surface air/soil gas monitoring include the following: 1) surface air/soil gas monitoring is the final opportunity for leak detection; 2) detection of CO_2 in surface air could provide a side benefit of public health protection; and 3) it can be difficult to connect the location of detected CO_2 in surface air or soil gas to the location of the leak in the subsurface. There is also uncertainty about cost of additional monitoring requirements versus proposed benefits, and the impact of increased monitoring on public perception of GS sites.

Well Closure and Post-Closure Care

Under existing UIC regulations, wells must be closed in a manner that protects USDWs from endangerment. The owner/operator must demonstrate and maintain financial assurance in order to close and abandon the injection operation, and liability stays with the owner. The key question on which EPA sought stakeholder input was whether the owner/operator should be required to demonstrate and maintain the financial assurance for corrective action, remediation, and post closure monitoring in addition to well closure, and if so, for what timeframe.

Potential approaches include 1) leaving the decision to the UIC director's discretion for each GS site; 2) requiring financial assurance for a fixed time period after site closure; 3) requiring it for timeframe set as some multiple of the operating life of a GS project; 4) requiring it until plume and pressure front no longer pose endangerment to USDWs; or 5) requiring it until reservoir pressure returns to pre-injection levels. Key considerations noted by Mr. Whitehurst included the following: 1) CO_2 projects could pose a threat to USDWs well beyond the injection phase; 2) a lengthy post-closure care period may be unrealistic; and 3) the transfer of owner/operator liability is outside the scope of the SDWA and the UIC Program rulemaking.

Public Participation
The basic requirement for public participation under existing UIC regulations is to provide a note of a pending permit action via newspapers, posting, and mailings, and in some cases a public hearing. Mr. Whitehurst posed two key questions for stakeholder input on public participation requirements, asking whether the notification process be adapted to incorporate new technologies (e.g., websites, discussion boards), and whether stakeholders be engaged earlier in the permitting process (e.g., during site evaluation/selection).

Class V Experimental Wells
Mr. Whitehurst reviewed recent UIC Program activities related to Class V experimental wells. He noted that EPA Guidance from March 2007 classified experimental GS projects as Class V wells, and that EPA has permitted a number of experimental wells and will permit more before the new rule is finalized. Mr. Whitehurst also said that Class V GS projects are currently being built to deep well (e.g., Class I) construction standards. The key question on which EPA sought stakeholder input was whether the well construction of existing Class V experimental wells should be "grandfathered." Proposed approaches include not allowing them to be grandfathered, grandfathering by rule, or leaving the decision to the director's discretion.

Class II EOR/EGR Wells
Mr. Whitehurst then discussed options for permitting existing Class II EOR/EGR wells that an owner/operator wishes to transition to a GS project. He said most existing Class II wells are authorized under a separate section of the SDWA and are typically regulated by "oil and gas" agencies. He said that these Class II UIC Programs must demonstrate effectiveness. The key question on which EPA sought stakeholder input about Class II EOR/EGR wells was at what point should a Class II EOR/EGR well formally transition to a GS well and therefore be subject to requirements in the proposed rule.

The range of approaches to determine the appropriate time for this transition include 1) establishing a performance standard (e.g., once the primary purpose is no longer production); 2) developing an economic algorithm (e.g., CO_2 costs outweigh production revenue); and 3) preserving the Class II status of EOR/EGR wells as long as the field is producing any oil and gas. Mr. Whitehurst noted that transitioning a Class II well to a GS well can be administratively complex and technically challenging. He also said that EOR wells may not meet the new GS well construction standards, and that current UIC requirements mandate that Class II wells not endanger USDWs.

QUESTIONS AND ANSWERS

During Mr. Whitehurst's presentation, participants were invited to write and submit questions. After each set of presentations, EPA staff offered the following responses to participants' questions.

EPA Coordination and Proposed Rulemaking

The Agency is working to coordinate with other agencies to identify potential overlap or gaps in regulatory responsibilities related to GS of CO_2. The EPA Office of Water (OW) and OAR have been partnering since 2003 and are currently working closely together on risk and economic assessments, with OAR providing perspective on climate change policy. The EPA's internal working group on GS of CO_2 meets regularly and has been working together since 2004. Director-level EPA staff also meet regularly with DOE and the two agencies are co-funding efforts.

Adaptability for the Proposed Rule

EPA can also write the rule so that the director of the state UIC program has a good deal of discretion, allowing for the rule to be adaptable over time. EPA may also accept new data for consideration after the rule is written through the notice of data availability (NODA). EPA welcomes additional stakeholder input on how to ensure the adaptability of the new rule.

EPA plans to complete the final rule by 2011 and may incorporate new information during the process through the NODA. EPA did receive additional funds in FY2008 to work on the GS rulemaking. EPA cannot comment on the FY2009 budget.

Site Characterization and Area of Review

The issue of whether to require a SC/CS is a key issue on which EPA is seeking stakeholder input. EPA is considering key factors that could cause CO_2 to migrate and potentially contaminate USDWs, as well as prevention opportunities through comprehensive site characterization, specific construction and operation requirements, and detailed monitoring plans. EPA suggested focusing on an excellent primary containment system, and then if the geologic zone allows, considering a secondary system. The SC/CS would provide a 'block and bleed' zone, that would impede movement of fluid that may have leaked through the primary CS and dissipate pressure build up. In addition, the SC/CS would provide a designated monitoring zone.

EPA is seeking stakeholder input about whether the proposed rule should address public access issues and the potential need to purchase sub-surface mineral rights. EPA is also considering whether the rule will allow for multiple injection wells in one field under the same permit.

EPA has not decided whether to require injection below the deepest USDW. The Agency recognizes that some sites could be precluded if that were the requirement.

Well Construction and Integrity

EPA has already held a number of meetings on well construction and integrity and will be developing a synopsis of the results from these meetings that will be included in the preamble of

the proposed rule. EPA also welcomes further input from stakeholders on this and related issues. The Agency plans to refine well construction requirements based on new data when it becomes available.

The DOE Regional Carbon Sequestration Partnerships have been conducting research on the impacts of CO_2 on well cement. Ongoing research on this issue is one of the reasons EPA wants to make sure it has the flexibility to incorporate new information. There are currently many wells injecting hazardous materials with no wholesale failures to date. Given the success of EOR wells for over 25 years, EPA is optimistic about developing a safe approach for GS sites.

Monitoring
EPA does have authority under the SDWA to require soil and air monitoring as long as it is meant to protect USDWs. If surface monitoring is the final option to determine whether CO_2 is escaping, then EPA can require it. However, EPA believes project owners/operators should have a range of monitoring options to demonstrate compliance with UIC requirements, which may include subsurface and surface monitoring.

EPA is considering requiring monitoring for the life of a GS project as well as for some post-closure period. EPA recognizes that extensive baseline monitoring may be needed to establish a comparative basis for a monitoring program. Surface air and soil monitoring is a new frontier for the UIC Program as it is not required for any well types currently regulated by the program. EPA welcomes stakeholder input on this topic. EPA agrees that surface monitoring is part of a suite of available monitoring options, including subsurface monitoring. Surface monitoring could serve as a last line of defense and could spur corrective action, even if USDWs are already affected. EPA welcomes stakeholder input on this topic.

EPA is just starting to look at options for use of tracers in the CO_2 stream to aid in monitoring. EPA is concerned about the potential for some tracers to bioaccumulate or cause unintended contamination, but also recognizes that there are different types that have less impact. The use of odorants may not be feasible because they have a tendency to break down. If EPA determines that the potential dangers of tracers to public health outweigh the benefits they provide, than EPA will consider that information.

Long-Term Liability and Financial Assurance
Liability issues may have important implications for future GS projects. EPA will discuss liability in the preamble of the proposed rule and request public comment on related issues. EPA noted that a state may choose to take over responsibility for GS wells, but EPA cannot require that under the SDWA.

USDW Protection and Remediation
By regulation, EPA is required to protect any USDW that contains less than 10,000 mg/L total dissolved solids (TDS) from endangerment that would impair its potential use as a drinking water resource. EPA may define what is meant by endangerment in a number of ways. For GS of CO_2, this definition will probably be based on not causing an exceedance of a drinking water standard. There is currently no drinking water standard for CO_2. However, EPA is also considering defining endangerment of USDWs based on pressure changes, or increases in the

concentration of metals, co-contaminants, brine, or CO_2. EPA's expectation is that adequate site characterization will prevent leakage of large volumes of CO_2 into USDWs.

For remediation of contamination resulting from a GS site, EPA understands that a pump and treat approach may not work considering the large volumes of water and expansive areas. The more likely action would be that the local water supplier would have to implement additional treatment methods to deal with metals or other contaminants in the drinking water.

EPA is focusing on reducing threats to drinking water, such as potential introduction of co-contaminants, CO_2 mobilization, and movement of saline fluid into a USDW. Under certain circumstances, CO_2 can have corrosive properties and potentially contribute to the release of metals into USDWs. CO_2 migrates due to differences in density (i.e., buoyancy) and in response to pressure differentials. CO_2 is very mobile in the subsurface due to a small viscosity compared to aqueous fluids. EPA welcomes further input from stakeholders on migration issues. EPA is also considering the immiscibility of CO_2 in the proposed rule.

EPA has a great deal of experience with injection of different types of fluids. CO_2 is not novel in terms of the timeline, as there are other regulated injected substances that can also pose a long-term threat. Though the current proposal for confinement assumes conventional reservoirs, EPA's internal workgroup suggested the Agency consider scenarios with unique reservoirs (e.g., basalt).

Transport of CO_2 to the injection site

The transport of CO_2 to well sites for injection is somewhat outside the purview of EPA's authority under the SDWA. However, the U.S. Department of Transportation has information about how it is regulating materials related to climate change issues and EPA plans to mention this in the preamble of the proposed rule.

Class II EOR/EGR Wells, Class V Wells, and Pilot Programs
EPA has not decided how to handle permitting existing Class II EOR/EGR wells that an owner/operator wishes to transition to a GS project. EOR/EGR wells are currently permitted as Class II. EPA is also permitting some GS wells as Class V experimental wells, though less than five GS wells are currently classified in this way. The Regional Partnerships are running about 25 pilot projects, most of which are EOR/EGR wells.

States can permit pilot projects under Class V experimental regulations. States have the ability to propose their own regulations, however the state regulations would have to meet minimum federal regulations. EPA's advice to states in terms of retaining primacy is to wait until EPA completes the final rule.

Climate Change Policy and Carbon Trading
The UIC Program and the proposed rule do not focus on the accounting of greenhouse gas (GHG) emissions or the carbon credit trading system, However, OW and OAR are working

together to evaluate how UIC regulations may be relevant to the US GHG inventory. The preamble to the proposed rule will outline these issues. If a decision is made about carbon credits in the future, and a GS site changes, then EPA might consider addressing the issue.

Research and development of alternative energy sources such as geo-thermal, and climate mitigation technologies, are key components of U.S. climate change policy. However, the UIC rulemaking will not address alternative energy sources as it is outside the scope of the SDWA.

New Technologies
EPA is trying to evaluate innovative GS technologies, including horizontal wells. EPA welcomes stakeholder input on new technologies.

Risk Assessment
EPA and its partners are working on the issue of risk assessment, but this meeting will not cover the topic.

GS Site Closure
EPA's current approach does not include a site certification framework that would allow owners/operators to negotiate closure terms for GS projects with the director during the permitting process. However, the Agency is willing to consider such an approach and welcomes input from stakeholders.

WEDNESDAY, FEBRUARY 27, 2008

WELCOME AND OPENING PLENARY

Gail Bingham, meeting facilitator from RESOLVE, opened Day 2 of the meeting by welcoming participants to the workshop. She explained that EPA decided to dedicate the opening session of Day 2 to hearing stakeholder insights, ideas, and concerns about EOR/EGR wells and Class V Experimental Wells. Ms. Bingham invited participants to engage in a facilitated roundtable discussion in front of the plenary audience. Participants self-selected and offered their insights, ideas, and concerns about EPA's questions on Class II EOR/EGR wells and Class V experimental wells. Below is a summary of key points from the roundtable about these two topics.

How should Class II EOR/EGR wells injecting CO_2 be distinguished from GS wells?

Stakeholders expressed a range of views on this topic. One person suggested that EPA frame the question to account for the fact that an effective EOR well used to drive oil out is also expected to sequester CO_2 and conserve it as a commodity for reuse, so EOR and GS of CO_2 are not necessarily distinct. A second participant supported a dual approach for EOR/EGR and GS of CO_2, explaining that drawing a strict distinction between EOR and GS wells could cause the development of many unnecessary wells. Another approach offered was to design EOR projects from the outset so that they are positioned to be effective GS projects in the future.

At the same time, stakeholders noted several differences between EOR and CO_2 wells for EPA to consider when preparing the proposed rule, such as increased pressure build-up. One person shared that, unlike GS sites, there is very little or no localized pressure build-up at an EOR site because of regular withdrawals. Design, monitoring, and closure may be affected by pressure build-up. A stakeholder suggested that EPA compare EOR and GS wells to identify the differences and develop guidance for transitioning from EOR to GS projects before operators begin designing new types of wells.

Another suggestion was for EPA to set up a structure where owners/operators can get credits for storing CO_2, which would create an incentive for owners/operators to design EOR projects to transition to GS eventually. If EPA mandates enhancements for GS wells compared to typical EOR wells, owners and operators of GS sites can begin designing wells that can eventually be converted to GS. A stakeholder encouraged EPA to approach the rulemaking in a way that is flexible and supports experimentation so that EOR projects can contribute to knowledge about GS.

Participants raised other considerations such as project size, noting that large-scale EOR operations could require more wells and infrastructure than a GS project. GS projects will probably require fewer wells, but the scale depends on how much CO_2 one is trying to inject and store.

One participant expressed that EOR is not a long-term answer for dealing with CO_2 emissions, but it is something that industry can do now. A stakeholder related the sentiment that oil and gas

regulators at the state level and industry have a strong track record of protecting USDWs. Industry representatives were concerned that regulation will raise the cost of EOR/EGR projects if they must comply with new regulations for GS wells.

Should the well construction of existing Class V experimental be "grandfathered?"

Stakeholders expressed a range of views on the topic of grandfathering Class V GS wells. Some noted that grandfathering should be allowed, as permitted Class V wells already had to meet construction requirements for Class I, and that operators might be discouraged from using Class V wells if they are worried about being able to use them under the new UIC regulations. Others suggested that grandfathering may not be a feasible approach, as creative well design is necessary to make GS cost effective and realistically manage large volumes of CO_2. Another idea was that EPA could issue permits issued according to the volume of CO_2 an operator aims to inject and require them to alter well construction if they want to increase the volume.

OVERVIEW OF BREAKOUT SESSIONS

Following the roundtable discussion, participants dispersed into four different breakout sessions on key aspects of the rulemaking process. The sessions included a panel of experts who provided insight on the focal topic and fielded questions from participants. Facilitators ran two sessions on each topic (morning and afternoon) so that participants had an opportunity to provide input to EPA on two of the four topics. Below is a summary of the overview presentations, and key themes and points raised during the breakout sessions. Please note that the proceedings of the morning and afternoon sessions have been integrated for the purposes of this meeting summary.

SITE CHARACTERIZATION / AREA OF REVIEW BREAKOUT SESSIONS

The following experts served as panelists for the Site Characterization / Area of Review breakout sessions:

- Jens Birkholzer, Lawrence Berkeley National Laboratory (afternoon session)
- Neeraj Gupta, Battelle Memorial Institute
- Curt Oldenburg, Lawrence Berkeley National Laboratory
- Rajesh Pawar, Los Alamos National Laboratory (morning session)
- Iain Wright, BP

Lee Whitehurst, EPA OGWDW, went over key aspects of his earlier presentation on site characterization and AoR. He also provided the following discussion questions for consideration by the expert panel and participants:

1) What are the advantages and disadvantages of requiring the identification of a secondary containment/confinement system (SC/CS) for GS sites? How should a SC/CS be defined/identified?
2) What are the advantages and disadvantages of requiring periodic Area of Review reevaluations? How can this approach be implemented and enforced?
3) What are the advantages and disadvantages of allowing for phased corrective action for wells in the Area of Review? How can this approach be implemented and enforced?

4) How could site characterization and monitoring data be used to reevaluate the AoR?
5) What other comments or questions do you have concerning the issues discussed?

The theme of flexibility for the regulator and regulated community was discussed throughout the sessions. Participants highlighted the importance of striking a balance between requirements and flexibility, to allow adaptability and learning, while at the same time giving enough guidance to owners/operators that may need more prescription (particularly for small projects) and also ensuring there are sufficient requirements in place to be protective. Another theme that applied to several topics was the need for the proposed rule to clarify definitions and criteria.

The following key themes also emerged during the facilitated discussion about site characterization and AoR:

Advantages and Disadvantages of SC/CS
Panelists and participants noted potential advantages of a SC/CS, including enhanced security and leakage mitigation strategies, particularly in leaking areas. Many expressed that SC/CS should not necessarily be a regulatory requirement. One panelist noted that a SC/CS is a good goal, but it is not always practical, as there may be suitable sites where SC/CS is not available.

Many emphasized the importance of thorough site characterization, which would then dictate monitoring and other safety measures needed based on geology, USDWs, and other features of the site. Site characterization provides an opportunity to identify risks and potential leakage routes, and from there determine the best possible confinement system and mitigation options. A participant supported adaptability for a fully characterized site, as there are opportunities to benchmark results against expectations; with increased confidence in performance, there could be a reduced need for a SC/CS.

One participant asked whether EPA would consider requiring multiple confining layers at the discretion of the director, if the system warrants. A panelist pointed out that definitive confinement system is different than a system with high and low permeability layers that, as a whole, can trap CO_2. Another shared a concern that a director may err on the side of caution because of desire to be conservative, causing some potential GS sites to be not used.

Participants also urged EPA to be clear about definitions of terms, as there could be different interpretations of primary and secondary confinement. For example, a participant asked if there would be depth requirements for confinement systems, to ensure CO_2 remains in a supercritical state. One panelist suggested that a better framing of these terms would be around the definition of a "storage region"; as long as CO_2 remains within the storage region, there would not be any concept of leakage.

Advantages and Disadvantages of Periodic AoR Reevaluation
Many expressed interest in and support for AoR reevaluation, or optimization, urging EPA to include it as part of a holistic approach to an overall GS plan negotiated early in the permitting process. One panelist also noted that it would be important to compare predicted and actual plume movement early on, so if there are discrepancies between the two, the project should be reevaluated and strategies can be modified. He said that an advantage is that a reevaluated AoR

is seen as a change in strategy and accommodates uncertainty, rather than being perceived as a project failure. Others agreed, stating that reevaluation is fundamental because of project dynamics; after injection, pressure will drop and a re-equilibration will begin. Given that pressures decline, the AoR may become smaller, which would be an advantage to the owner/operator.

A panelist noted that a possible disadvantage of reevaluation is increased burden on the owner/operator. Another said that, particularly for large scale projects, owner/operators may prefer to meet with regulators to decide on the AoR early on, due to a desire for regulatory certainty up front rather than a mid-project reevaluation. He explained that if injection increases, the AoR and monitoring should be expanded, but otherwise he would prefer to begin with a large AoR and reduce it as more is learned. A participant echoed this comment, questioning the value of reevaluated the AoR in the absence of operational changes. Another participant noted that reevaluation could diminish public confidence, as public acceptance is tied to certainty.

Again noting a need for flexibility, a panelist suggested a process of AoR "optimization" rather than evaluation, due to competing needs for pore space among nearby projects. A participant agreed, suggesting a focus on pressure and project overlap; when a smaller project is near a larger project, it is important to revisit the AoR to understand complexity of interacting sites. Another said it would be important to explore how to define or set criteria for AoR based on the location of the plume and pressure front.

Participants also discussed how site characterization and monitoring data could be used to reevaluate the AoR. A panelist suggested using "operational" rather than "monitoring" data, and to look at the process as an optimization of models and other technology to maximize pore space for the project.

Stakeholders discussed the use of monitoring wells for analyzing pressure, and possibly for use as a trigger for a reevaluation of the AoR. A panelist agreed that factor for reevaluation could include new projects or activity in the AoR picked up by monitoring wells. One concern with this approach would be the cost of monitoring wells and the fact that having more of these wells may not necessarily yield useful information. Another panelist added that there is much data and experience from existing projects to help guide future placement and use of wells. Another pointed out that the use of monitoring wells is a site-by-site consideration based on site evaluation, and they may not be necessary or useful in all cases.

A panelist noted the 4D seismic (3D seismic plus time) evaluation could be a useful technique, depending on the site geology, but it is not fully quantifiable due to the many variables involved.

Advantages and Disadvantages of Phased Corrective Action

Participants noted several potential advantages of phased corrective action. A panelist suggested that a phased approach can account for the fact that AoR may be off by as much as 50% due to uncertainty in models. The advantage is that you can remediate all wells or as the plume grows, an owner-operator can react to the plume (in a phased manner). Another panelist agreed, sharing that a phased approach allows a more "performance based" approach. Several noted that phased

corrective action can also account for change in technology over time, such as improved desalinization techniques making it possible to access water that is currently considered non-viable as a water source. EPA could be able, with the phased-corrective action approach, to build in consideration for future technologic advances into the proposed rule.

Participants also discussed disadvantages and challenges of phased corrective action, including owner/operator bankruptcy and property rights access issues. Several highlighted the importance of an early determination that the owner/operator has both financial and technical competence. One suggestion was that the corrective action plan, approved as part of the permitting process, should include financial assurance. Needs for surface and mineral rights should also be outlined in the plan. To manage a high degree of concern or uncertainty about a site, the regulator could also require corrective action from the outset.

Another participant expressed that there may be little value in phased corrective action, given the speed with which pressure fronts move.

Additional Issues Discussed
Other issues raised included the following:

- Public Participation and Acceptance: A number of participants noted the link between AoR and public participation and confidence. One stakeholder encouraged EPA to take an adaptive approach, with initial projects meeting a higher standard and increased monitoring due to the likely high degree of public interest in early projects. Participants also discussed the importance and challenges of explaining risk to the public, possibly through comparing risks of GS projects with activities that are more familiar to the general public.
- Pore Space: A number of participants stressed the importance of understanding pore space needs to both owner/operators and regulators. While no regulatory text will be available on pore space and other issues, given the compressed timeframe for proposed rule, related issues will be discussed in the preamble.
- Monitoring Tradeoffs: With better site characterization, less monitoring may be required. This will vary depending on the site. For example, well characterized EOR sites may have strong predictive modeling and certainty in the AoR. For saline aquifers, this may not be the case, and more flexibility or a reevaluation option may be the best approach. A future activity could be to prioritize monitoring activities, understanding that there are also tradeoffs for monitoring costs.

MONITORING BREAKOUT SESSIONS

The following experts served as panelists for the Monitoring breakout sessions:

- Jens Birkholzer, Lawrence Berkeley National Laboratory (morning session)
- Sue Hovorka, Texas Bureau of Economic Geology
- Rajesh Pawar, Los Alamos National Laboratory (afternoon session)
- T. S. Ramakrishnan, Schlumberger-Doll Research

Bruce Kobelski, EPA OGWDW, reviewed key aspects of Lee Whitehurst's earlier presentation on monitoring. He also provided the following discussion questions for consideration by the expert panel and participants:

1) What are the advantages and disadvantages of requiring surface-air and soil-gas monitoring for GS projects, as a final barrier to USDW protection?
2) What are the advantages and disadvantages of requiring the use of tracers in the injected CO_2 stream? What tracers are most appropriate for CO_2 monitoring?
3) How might the EPA/UIC programs raise public awareness about the use and value of tracers?
4) What other comments or questions do you have concerning the issues discussed?

The following themes and points emerged during the facilitated discussion about monitoring.

Tracers, Soil-Gas, Surface-Air Monitoring
The general feedback among participants was that EPA should not require surface-air or soil gas monitoring, or the use of tracers. These types of monitoring are still in the research and development stages and are not yet commercially applicable. One participant noted that the overall value and effectiveness of tracers, soil-gas, and surface-air monitoring methods is not clear because the way they function is complex, and the results of numerous studies are not yet available. Specific disadvantages of soil-gas and surface-air monitoring noted by participants were the difficulty in distinguishing between background noise and signal, and the costs associated with monitoring across large areas. Participants also noted several disadvantages connected with tracers, including financial costs, the possible environmental impact from accumulation of tracers in USDWs or the atmosphere (some tracers are potent greenhouse gases), and the potential that sensitive tracers could detect a minor leak and cause the unnecessary shutdown of a project. Some suggested that although tracers may be useful in some instances, they should not be universally used for leak detection.

While a number of concerns were raised, some participants shared potential advantages of these monitoring methods, including public assurance, supporting a carbon credit system by detecting and accounting for stored and re-emitted CO_2, and allowing operators to tag CO_2 so they can tell whether any leaks detected are coming from their wells. Use of tracers, soil-gas, and/or surface-air monitoring would be useful in comparing modeling predictions to actual operations and identifying effective remediation measures. For any of these methods to be valuable, however, operators would need to need excellent site characterization and baseline information.

Additional Issues Discussed
Other issues raised included the following:

- Flexibility: Some participants suggested that EPA gather more information about monitoring methods and build in flexibility to allow operators to draw from a suite of methods that may apply under different circumstances.

- Pilot Projects: Participants suggested examining DOE pilot GS projects as well as experience from the oil and gas industry to learn more about how to apply different monitoring techniques.
- Geophysical Monitoring: Some participants suggested that geophysical monitoring methods could be useful to detect certain types of changes in GS projects. However, these methods have many limitations and many participants did not think EPA should require them in the proposed rule. Time-lapse 3-D seismic surveys possess potential for use as a regulatory tool, but EPA should first review their success rate in the oil and gas industry.
- Public Perception: Participants recommended careful public education and outreach to manage public perceptions around monitoring methods, since this monitoring has the potential to cause more concern than it alleviates. Members of the public tend to get anxious when monitoring systems are set up as they may imply danger, particularly if described as a last line of defense. Handling false positives could be a tough public perception challenge.

FINANCIAL ASSURANCE FOR LONG TERM SITE CARE BREAKOUT SESSION

The following experts served as panelists for the Financial Assurance for Long Term Site Care breakout sessions:

- Ann Codrington, Prevention Branch, Office of Ground Water and Drinking Water, U.S. EPA
- Richard Esposito, Southern Company Services
- Lindene Patton, Zurich North America
- George Peridas, Natural Resources Defense Council
- Chiara Trabucchi, Industrial Economics

Ann Codrington, EPA OGWDW, presented an overview of the UIC Program's current financial responsibility requirements. EPA asked for input from panelists and participants on the following questions:

1) Who should bear financial responsibility for long-term care/monitoring? For how long?
2) What financial assurance options are available to cover the costs of long-term care/monitoring?
    a. What are examples of financial instruments?
    b. What are advantages/disadvantages of various financial assurance options, when considering GS projects?
3) When does closure/post-closure end, and long-term care/monitoring begin?

The following themes emerged during the facilitated discussion about financial assurance for long term site care and monitoring.

Clarify Terms
Panelists highlighted the importance of clarifying terms, observing that there is significant confusion regarding the terminology that stakeholders and EPA are using to discuss financial

assurance. Several participants asked for clarification about the scope and scale of financial assurance EPA is considering in the proposed rule and noted the need for clear definitions of terms such as liability, indemnity, and long-term care or stewardship. For example, one participant noted that EPA and others should not use the terms liability and long-term care interchangeably. Another participant called for "disciplined dialogue" among stakeholders about how to define engineering and financial assurance terminology.

Learn from Other Financial Assurance Models
Participants suggested that EPA draw on lessons from the successes and failures of a number of financial schemes used in other situations that might be applicable to the issue of financial assurance for long-term care of GS sites, and noted several potential models. One panelist noted that there are numerous federal indemnification models, many of which have not been thoroughly evaluated. One option could be a public-private hybrid in which there is a fund attached to a particular site with eventual transfer to a state or federal authority. However, EPA will need to be sensitive to statutes in different states. She also mentioned the Trans-Alaska Pipeline Liability Fund (TAPLF), and subsequent Oil Spill Liability Trust Fund (OSLTF) models may provide useful insights into the development of a similar framework for GS long-term care. However, development of this type of long-term framework would require Congressional approval. She also cited the uranium mills tailing program as a potential model for the UIC Program, because the post-closure period is up to 1000 years and contains a significant engineering component. Another panelist noted that the trust fund model has performed well historically. The pharmaceutical industry could also offer a good model for liability treatment.

A participant suggested that the best approach from the industry perspective is market-driven solutions combined with incentives for good behavior. EPA could also consider a post-closure process where operators undertake different activities with set costs. In choosing its financial instrument for long-term care, participants urged EPA to use a model that does not distort costs or encourage bad behavior.

Multiple panelists and participants highlighted that estimating the cost of risks and engineering responses is a key task. One participant noted that traditional financial assurance mechanisms, such as the one in place for the Resource Conservation and Recovery Act, have a residual risk, and that no model has absolute guarantees. She supported industry mutual instruments, because of the commonality of the risk profile and resulting incentive to act responsibly. Most federal "backstop" mechanisms are instituted as a reaction to a failure in cost estimate, typically instituted after large-scale events that overwhelm private sector models. A panelist supported the quantification of residual risk and potential impacts of EOR and CCS injection. Another participant suggested that financial instruments be phased so that they match evolving risk profiles. Another participant emphasized that EPA should consider incorporating a trigger to re-price as variables evolve.

Several participants referred to European Union's (EU) regulatory proposal for CCS as a potential model for EPA. One participant characterized this approach as flexible, providing performance standards with which insurance companies, courts, and owners/operators can work. He added that nations, not companies, have the ability to establish financial structures at the scale necessary to deal with the longevity of the risks associated with CCS. Another participant

added that the EU proposal is a directive, not a law, and that member states will be able to tailor the approach. However, there is currently no guidance to member states to assist with the development of long-term frameworks.

Define Risk
Several participants commented that EPA should be clear about how it defines risk. Risk analyses must define risk in engineering, environmental, and financial terms, and integrate these different aspects. Participants also noted the need for UIC regulations to be flexible enough to allow solutions that are efficient from a public perspective.

One panelist emphasized that EPA and stakeholders must parse different risks associated with CCS, and develop a common understanding with its stakeholders about what types of risk are being modeled so that financial responsibility is attached to the right place. For example, one participant noted that owners and operators do not perceive a difference in risk between EOR and CCS, while EPA does. One option for assigning financial responsibility is to attach a fee on a proportional basis, so an owner / operator drawing from a fund has to pay back the fund, thus minimizing the incentive to file for damages.

In response to a participant question about whether separate coverage for each risk might be offered by the insurance industry, a panelist noted that this could be an inefficient approach.

Flexibility
Participants generally agreed that EPA should incorporate flexibility into the regulations so that long-term financial assurance and site care practices can be adapted to evolving markets and policies.

Additional Issues Discussed
Other issues raised included the following:

Financially Responsible Party: A stakeholder suggested that if EPA establishes a mechanism providing for closure and a system for removing responsibility for long-term care, industry can work toward this and it will be a benefit to society. Another noted that, at some point, customers will have to help bear the cost of long-term financial responsibility. Another participant noted that some major and minor corporations are comfortable with the concept of assuming the manageable risks related to CCS without liability relief or indemnity clauses and in accordance with current financial assurance models.

End of Closure/Post-Closure vs. Beginning of Long-Term Care/Monitoring: Participants supported adaptive solutions to address closure, post-closure and long-term care. For post-closure care, EPA could establish a performance-based system that is flexible and rewards operators for proper site characterization, and sound operation and monitoring. An understanding of what monitoring requirements would be needed during site operations, during closure, and associated with post-closure would help understand long-term liability and financial assurance requirements. EPA could establish a phased approach that assigns financial responsibility to parties according to their role in different post-closure and long-term care activities, and reduces requirements over time. Another approach would be for EPA to establish a fixed timeframe for

cases of well abandonment. Another participant urged EPA to assume that CO2 may be underground and persist much longer than the corporations that injected it initially intended.

PUBLIC PARTICIPATION BREAKOUT SESSIONS

The following experts served as panelists for the Public Participation breakout sessions:

- Janet Henry, American Electric Power
- Jeffrey McDonald, U.S. EPA Region 5
- Paul Schwartz, Clean Water Action
- Sarah Wade, AJW, Inc. *[morning session only]*

Jeff McDonald provided an overview of current EPA UIC public participation requirements. Sarah Wade delivered a presentation on best practices for public participation used by the DOE Regional Carbon Sequestration Partnerships. EPA asked for input from panelists and participants on the following questions:

1) How can EPA strengthen its public involvement requirements, particularly taking advantage of the advances in modern technology?
2) What examples under the current regulations or other public participation programs might offer useful models or lessons learned for GS projects?
3) What existing public education approaches provide models for how best to educate the public about geologic sequestration in the context of a permit application? What types of information can be made available to increase the public's confidence in the process and understanding of the proposed project?
4) What other concerns or issues should be considered with respect to public notification, education and participation, and what approaches might help address these issues or concerns?

The following key themes emerged during the facilitated discussion about public participation.

Best Practices Guidance and Useful Models for Public Participation
Participants generally agreed that EPA should develop best practices guidance for permit applicants that complements the public participation requirements outlined in the rulemaking. For example, guidance could encourage public information meetings, which are more interactive than public hearings. The guidance could also encourage project proponents and regulatory agencies to collaborate on initial public education about GS, before providing specific information about proposed projects.

Stakeholders cited a number of potential models that could be used by the UIC Program, such as the Electric and Magnetic Fields (EMF) Research and Public Information Dissemination (RAPID) Program, coordinated by the National Institute of Environmental Health Sciences and DOE. Another model is in Ohio, where the public is notified when a project proponent submits a permit application, instead of waiting until the permitting agency makes a decision. In addition, a

successful public meeting in Gaylord, Michigan, incorporated interactive models and demonstrations that were staffed by knowledgeable people. Similar to Superfund or EPA Watershed Assistance Grants, EPA could issue technical assistance grants to help communities understand CCS and articulate their concerns. Permit applicants could also sponsor public open house meetings at the outset of the application process to help establish realistic stakeholder expectations regarding the permit process.

Public Education and Outreach
Participants and panelists generally agreed that EPA and its partners should make an effort to educate the public generally about the purpose, process, and risks associated with GS projects. At the same time, participants noted that EPA's primary role is to regulate rather than to promote GS projects, and encouraged the Agency to design the public participation requirements and best practices guidance so that information and data remains objective and trustworthy in the eyes of the public. EPA should also make a distinction between cases in which the purpose of the public participation process is to inform stakeholders about GS projects and answer their questions, versus engaging the public in a collaborative decision-making process (i.e. task force or working group).

Participants suggested that broad public education would go beyond specific sites and permitting requirements to raise awareness about CCS via mass media outlets such as television and the internet. Specific ideas about education approaches and information types included establishing a visitors' information centers at GS project sites, conduct broad education on a regional rather than site-specific basis (i.e. DOE Regional Partnerships), developing a traveling demonstration that the Partnerships could use around the nation, and avoiding lengthy presentations.

Flexible Site-Specific Approach
Participants recognized that each GS project will have unique site-specific characteristics and generally recommended that EPA incorporate flexibility into the permit requirements for public participation. For example, communities will have varying populations and demographics. The characteristics of the geology and USDWs will also be different across sites. Therefore, project proponents should have flexibility to develop outreach strategies and informational materials that are appropriate for their proposed GS project.

Interactive Tools
Participants raised a number of ideas about the use of new tools for public participation, education, and outreach. A key theme was that these tools should be able to evolve and incorporate new information over time. While participants raised a number of ideas about technology, stakeholders also advocated for maintaining a balance between conventional public participation methods and the use of new technology.

Specific ideas about technology to involve the public included using webcasts of public meetings and/or archiving proceedings on the internet (audio and/or video), using public access channels to advertise and/or televise public meetings, and allowing for ongoing opportunities for public comment and inquiry through on online system. One example of technologies that could be used during meetings was interactive, multi-layered geographic information system maps. These maps could then be posted on the internet for exploration by the public.

Applicants could also establish links between the relevant UIC program website and other CCS websites, and websites that members of the public are more likely to frequent. For example, public meeting activities or notices could also be linked to community listserves and other online social networking sites. Public notices of permit application could also be made available on CD or DVD at local libraries.

Translating Technical Information

The issue of literacy was a recurring theme throughout the public participation sessions. One participant noted that there are varying types of literacy, including functional (reading, writing), technical (science, technology, internet), process (regulations, opportunities for public input), and language (non-English speakers). Participants discussed various ways in which permit applications could help ensure that members of the public understand technical and regulatory dimensions of GS. One key concept that came up repeatedly was the idea of having technical resource people available at public meetings. These people should possess the ability to explain the science of GS projects, and UIC regulations, in lay language. These people should also be accessible at meetings so that the public is able to approach them and ask questions in an informal manner.