Geologic Sequestration of Carbon Dioxide: EPA Rulemaking*

Bruce J. Kobelski[1], Molly Bayer[1] and Sean Porse[1]

Search and Discovery Article #80108 (2010)
Posted October 14, 2010

* Adapted from an oral presentation at AAPG Annual Convention and Exhibition, New Orleans, Louisiana, USA, April 11-14, 2010

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Abstract

In July 2008, the U.S. Environmental Protection Agency (EPA) issued a proposed rule to address Geologic Sequestration of CO_2. EPA took a number of steps to support and inform the proposed rulemaking. The Agency sponsored research by national laboratories; coordinated with the U.S. Department of Energy (DOE); and monitored international GS projects. For several years, EPA consulted with technical experts, states, tribes, utilities, industry, and others through technical workshops and public stakeholder meetings. The proposal is part of an adaptive approach that is necessary to allow regulatory development to move ahead in time to meet the anticipated demand for GS permits, while recognizing the need to continue to gather data from pilot projects and other research as it becomes available.

EPA proposed the new federal requirements for the geologic sequestration (GS) of carbon dioxide (CO_2) under the authority of the Safe Drinking Water Act (SDWA). EPA proposed a new class of underground injection well, Class VI, to address the unique nature of CO_2 injection for GS and ensure protection of underground sources of drinking water (USDWs) from injection-related activities. The elements of the proposed rule build upon the existing Underground Injection Control (UIC) regulatory framework established under the SDWA. The relative buoyancy of CO_2, its corrosivity in the presence of water, the potential presence of impurities in captured CO_2, its mobility within subsurface formations, and large injection volumes anticipated at full-scale deployment warrant specific requirements tailored to this new practice. The tailored requirements include:

- Geologic site characterization to ensure GS wells are appropriately sited;
- Requirements to construct wells with injectate-compatible materials and in a manner that prevents fluid movement into unintended zones;

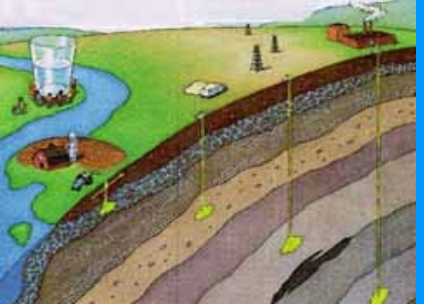
- Periodic re-evaluation of the area of review around the injection well to incorporate monitoring and operational data and verify that the CO_2 is moving as predicted within the subsurface;
- Testing of the mechanical integrity of the injection well, ground water monitoring, and tracking of the location of the injected CO_2 to ensure protection of USDWs;
- Extended post-injection monitoring and site care to track the location of the injected CO_2 and monitor subsurface pressures; and
- Financial responsibility requirements to assure that funds will be available for well plugging, site care, closure, and emergency and remedial response.

The final rule, anticipated in 2011, will apply to owners and operators of wells that will be used to inject CO_2 into the subsurface for the purpose of long-term storage.

Geologic Sequestration of Carbon Dioxide EPA Rulemaking

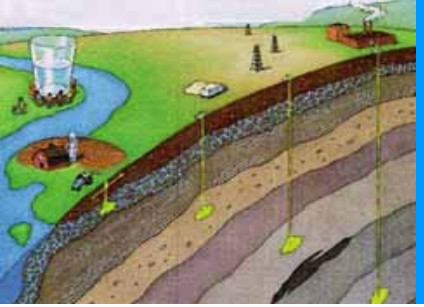
2010 AAPG Annual Convention & Exhibition

Bruce J. Kobelski*, Molly Bayer and Sean Porse
U.S. Environmental Protection Agency
Office of Ground Water and Drinking Water
April 13, 2010



Presentation Outline

- UIC Program Background
- EPA's GS Rulemaking
  - Process, Goals, and Approach
  - Select Proposed Technical Requirements
  - Notice of Data Availability (NODA)
  - Schedule
  - Technical Guidance Development
- Continuing Research Efforts



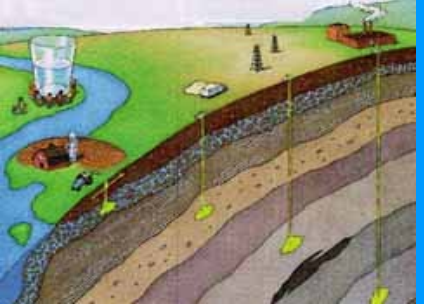
UIC Program Background

Click to View Notes by Presenter

- 1974 Safe Drinking Water Act (SDWA; Reauthorized in 1996)
  - Federal regulations for protection of Underground Sources of Drinking Water (USDWs)
  - USDW defined:
    - Any aquifer or portion of an aquifer that contains water that is less than **10,000** PPM total dissolved solids or contains a volume of water such that it is a present, or viable future source for a Public Water Supply System
- UIC Program regulates underground injection of *all* fluids – liquid, gas, or slurry
  - Designation as a commodity does not change SDWA applicability
  - Some natural gas (hydrocarbon) storage, oil & gas production, and some hydraulic fracturing fluids exempted
- Existing UIC program provides a regulatory framework (baseline) for the Geologic Sequestration of CO_2

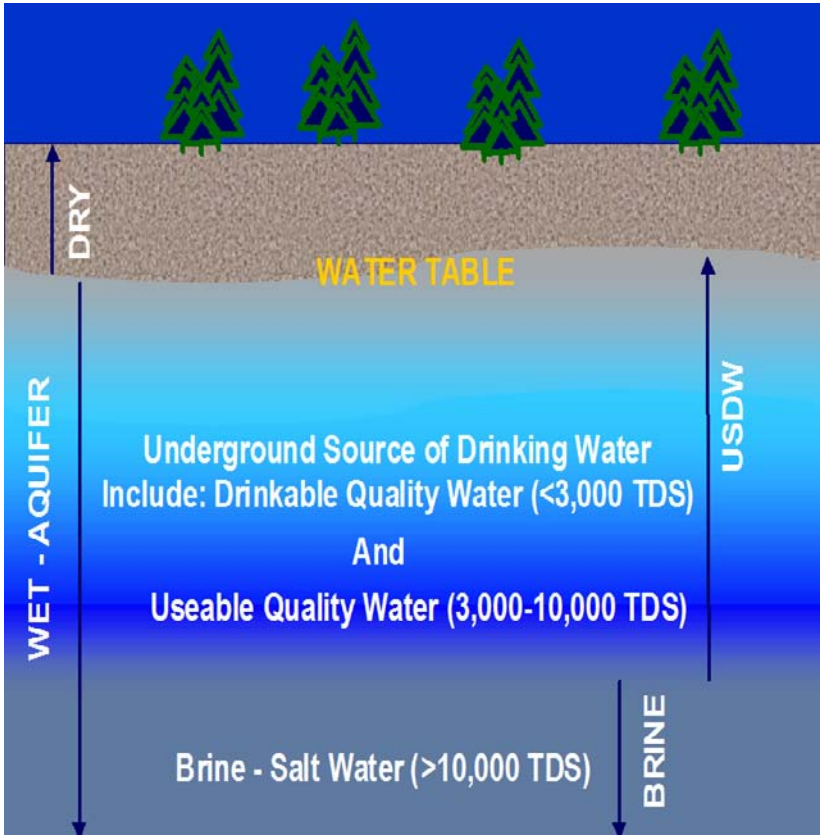
Notes by Presenter (for previous slide):

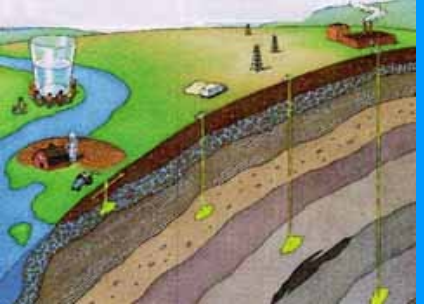
- The UIC Program was developed in 1974 under the authority/mandate of the SDWA to protect USDWs
- The UIC Program regulates all fluids (liquid, gas or slurry) injected underground, including CO2
- Existing UIC program requirements provide a regulatory framework for the GS rule development



Safe Drinking Water Act (SDWA) Overview

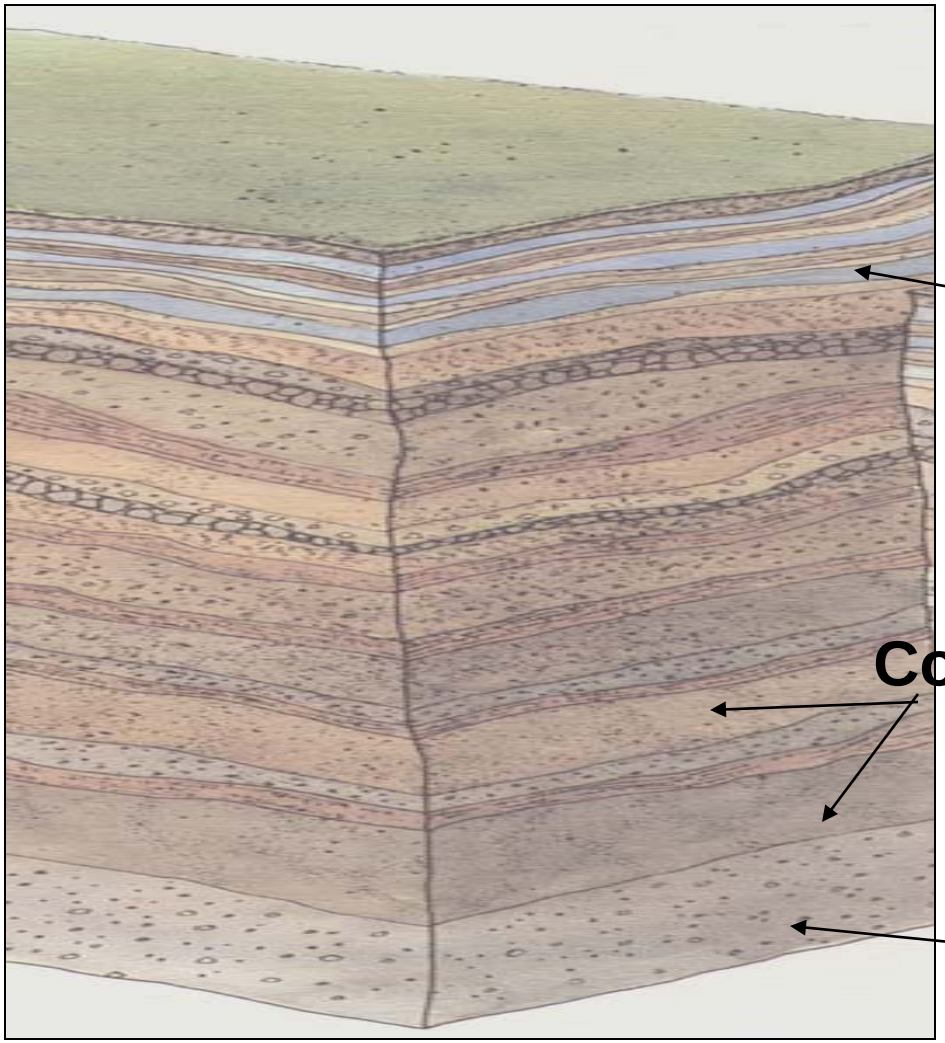
- SDWA (1974) required that EPA determine need to protect underground sources of drinking water (USDWs).
- Established a process for approving primary enforcement responsibility (**primacy**) to States and Tribes.
- Authorizes EPA to give grants to States and Tribes to support essential UIC program functions.
- Provides States with flexibility to establish effective Class II (oil and gas) Programs.

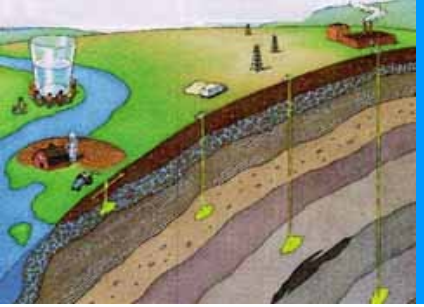




UIC Program Background

USDWs, Confining & Injection Zones



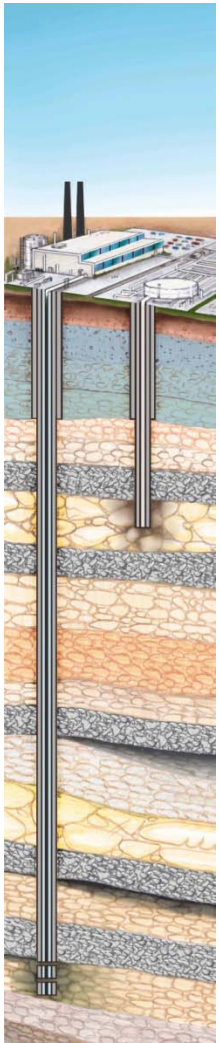


UIC Program Background

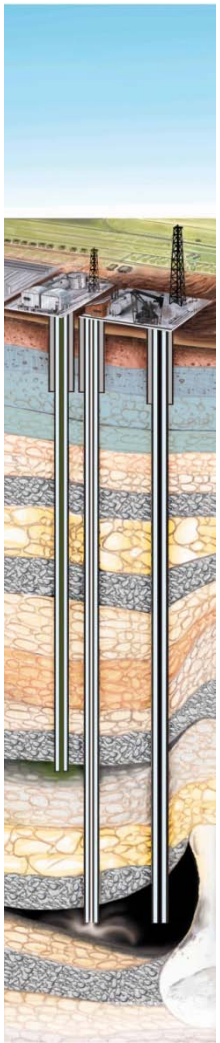
Well Classes

Click to View Notes by Presenter

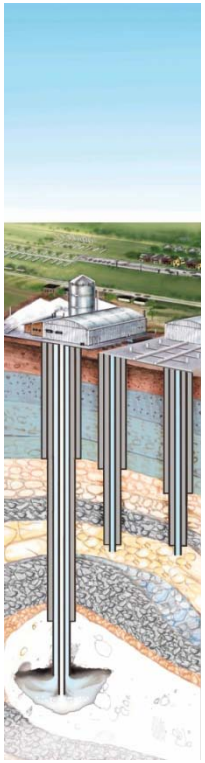
Class I



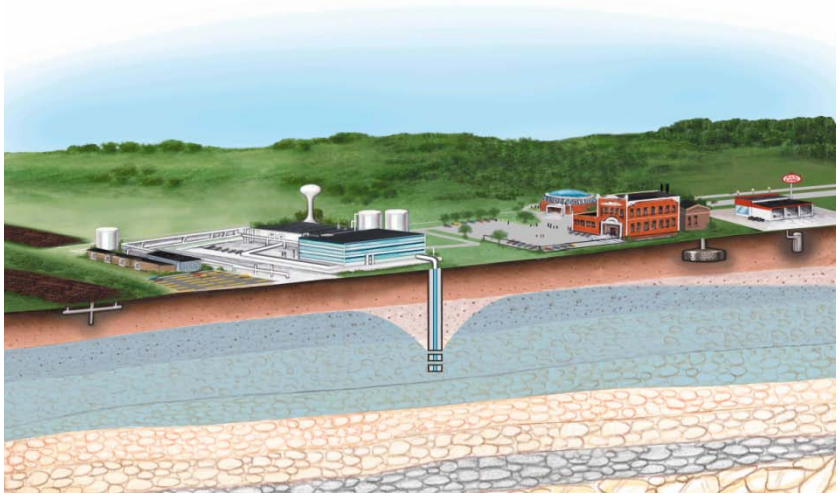
Class II



Class III

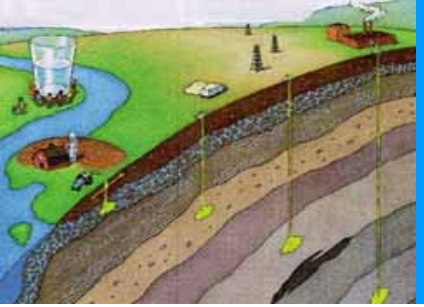


Class V



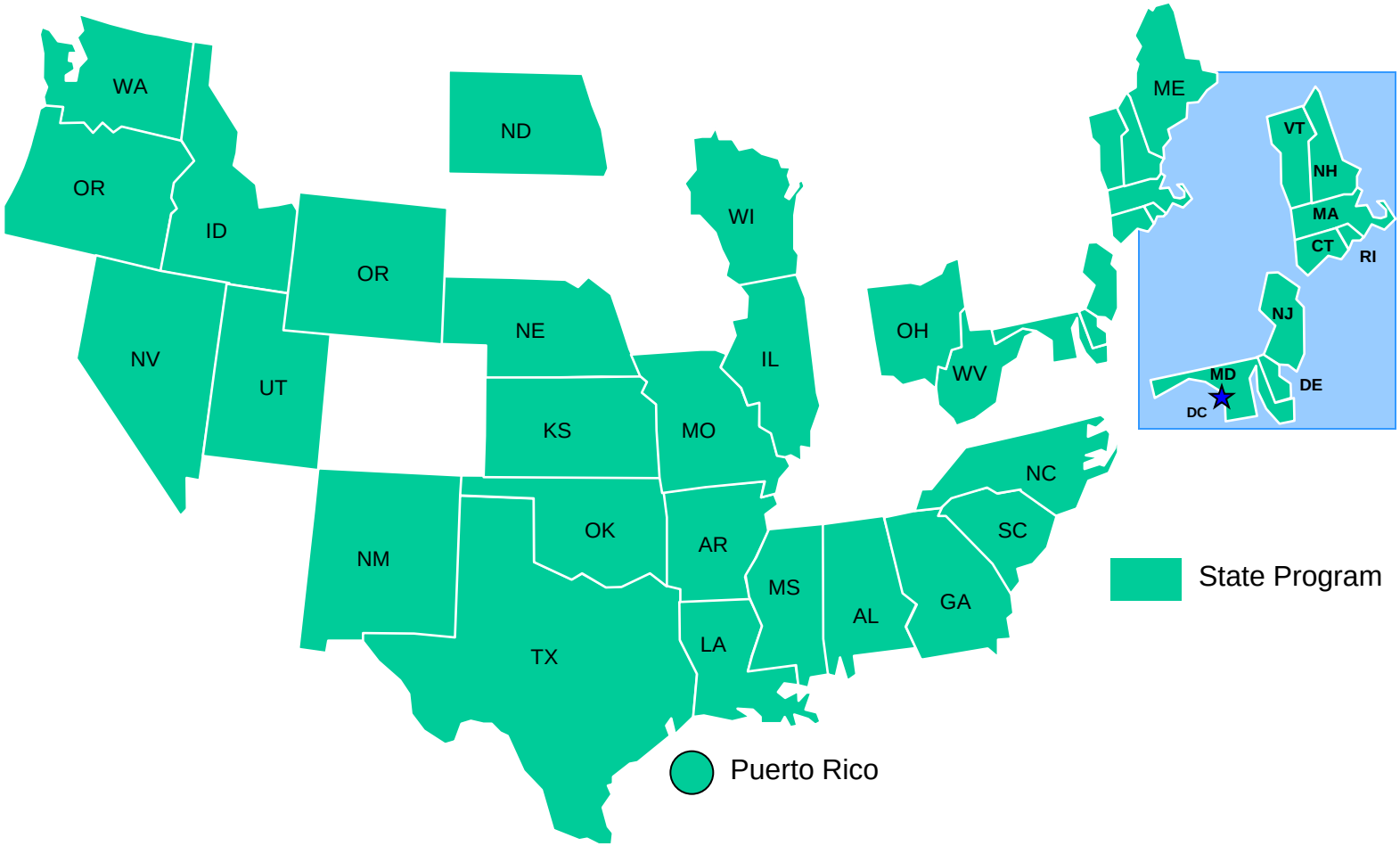
Notes by Presenter (for previous slide):

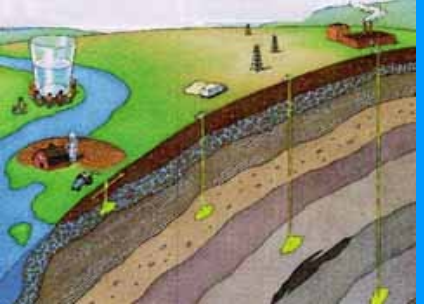
Class I – Technically sophisticated deep injection wells used for industrial, municipal, and hazardous waste injection (500-600).
Class II – Wells used for oil and gas production related fluids; these include CO_2 injection for enhanced oil and gas recovery; and hydrocarbon storage (several hundred thousand).
Class III – Wells are mining related injection wells (utilizing solvents to dissolve minerals) (e.g., extraction of uranium, copper, and salts) (30,000).
Class IV – Wells used in state or EPA approved ground water clean-up sites (to inject hazardous or radioactive waste into or above a USDW) (banned).
Class V – are injection wells that do not fit into the other well Classes I to IV; typically these are shallow disposal wells used to discharge a wide variety of fluids –included in this category are initial GS pilot projects permitted as Class V experimental wells.



UIC Program Background

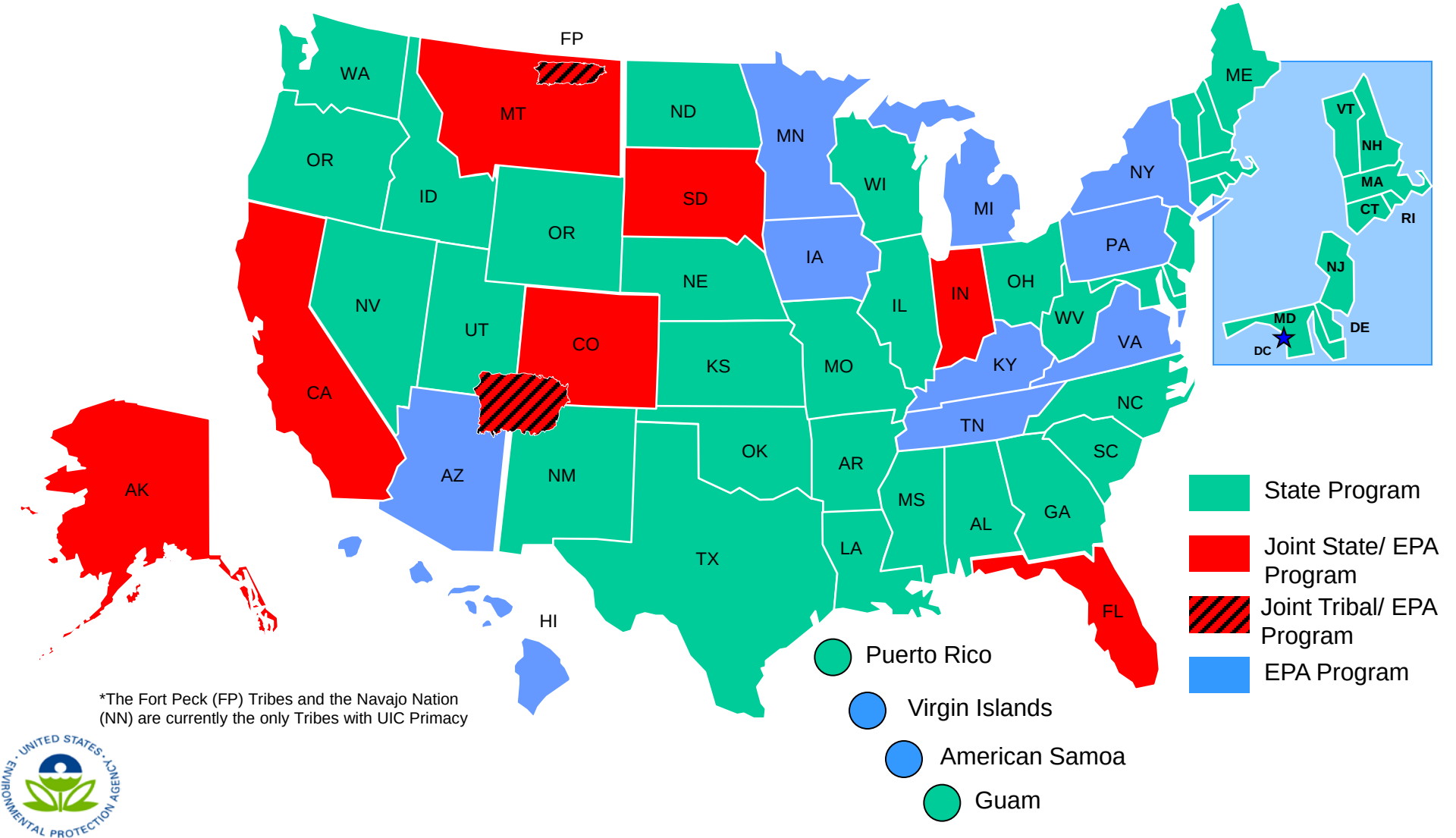
UIC Primacy



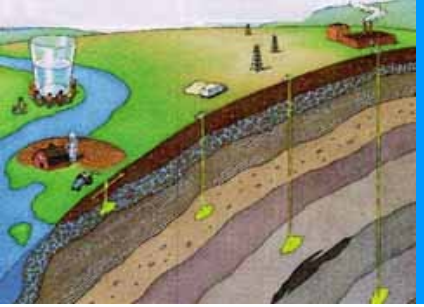


UIC Program Background

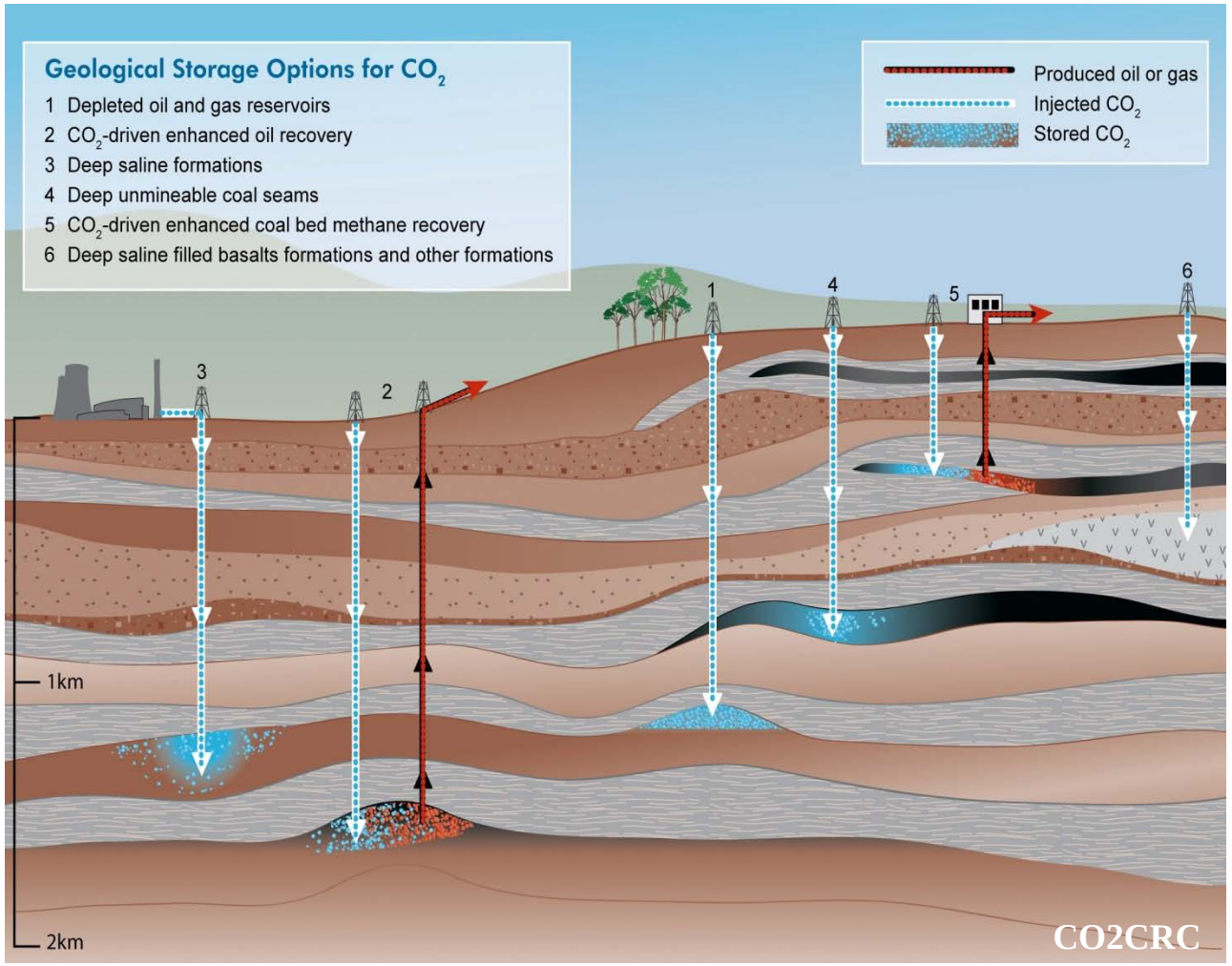
UIC Primacy

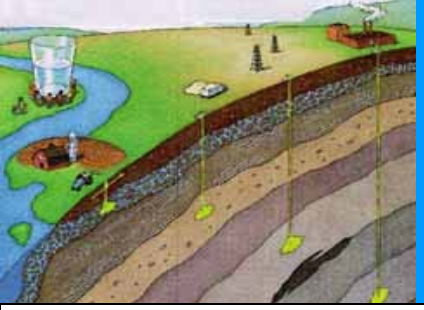


*The Fort Peck (FP) Tribes and the Navajo Nation (NN) are currently the only Tribes with UIC Primacy

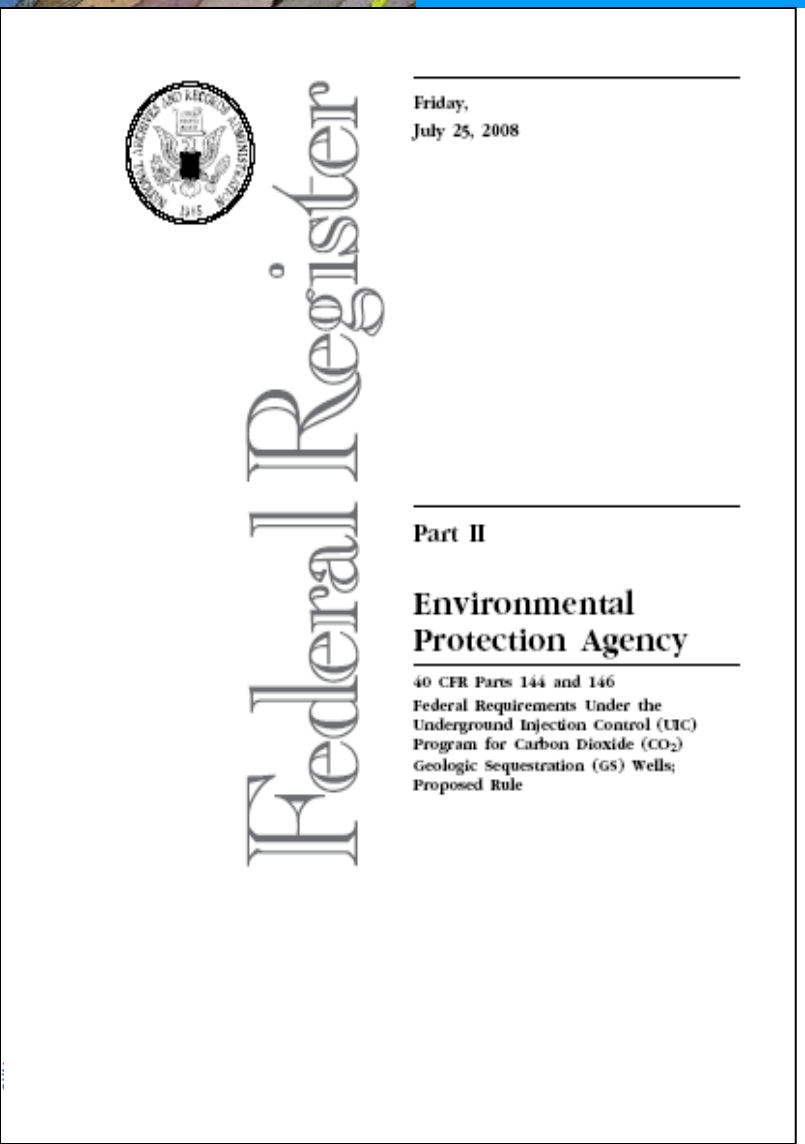


Geologic Sequestration of CO_2





EPA's GS Rulemaking
Rule Development Process


Federal Register

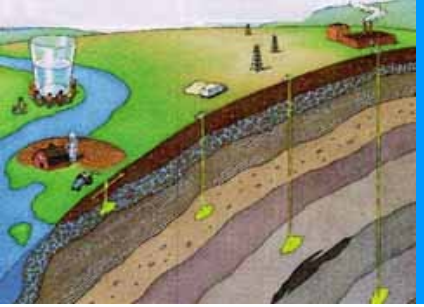
Friday,
July 25, 2008

Part II

Environmental Protection Agency

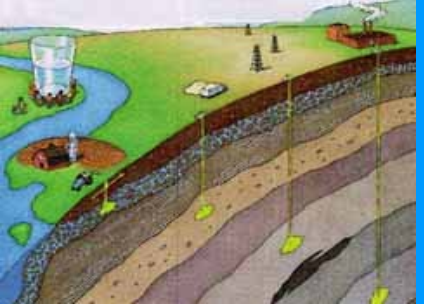
40 CFR Parts 144 and 146
Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells; Proposed Rule

- **Proposed Rule** for GS of CO_2
  - Announced by Administrator: October 11, 2007
  - Signed by Administrator: July 15, 2008
- Basis of rulemaking: SDWA Authority to prevent endangerment of USDWs
- Proposal revises Underground Injection Control Program criteria and standards to address Geologic Sequestration



EPA's GS Rulemaking
Goals of the Rulemaking Process

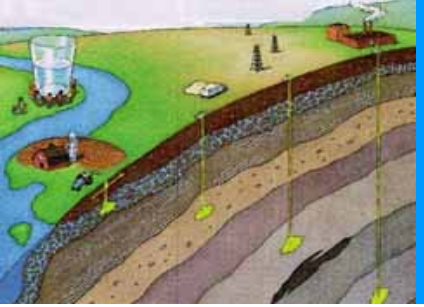
- Clear and transparent process
- Allow development of a promising CCS technology and ensure protection of USDWs
- Capitalize on many years of EPA and State UIC program experience
- Use "adaptive approach"
- Involve, inform, and educate the public



EPA's GS Rulemaking
Approach to Rulemaking

Special Considerations for GS

- Large Volumes
- Buoyancy
- Viscosity (Mobility)
- Corrosivity



EPA's GS Rulemaking
Approach to Rulemaking

Click to View Notes by Presenter

Special Considerations for GS

- Large Volumes
- Buoyancy
- Viscosity (Mobility)
- Corrosivity

Develop new well class for GS – Class VI

UIC Program Elements

- Site Characterization
- Well Construction
- Well Operation
- Site Monitoring
- Area Of Review
- Post-Injection Site Care
- Public Participation
- Financial Responsibility
- Site Closure

Notes by Presenter (for previous slide):

As indicated in the previous slide, one of our goals was to use the existing structure of the program and to tailor it for the purpose of GS… The proposed rule is an outgrowth of the existing UIC requirements tailored for GS … Given that

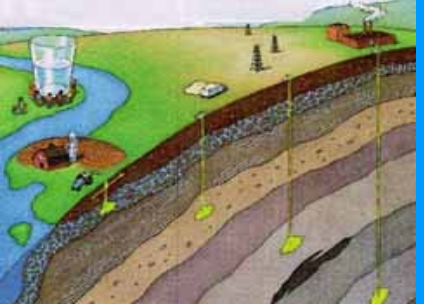
- Anticipated large volumes of CO_2 injected
- It is relatively buoyant – in comparison with other injected fluids
- It has a low viscosity – which means it will be more mobile in the subsurface
- And, it is corrosive in contact with H_2O…

This slide simply illustrates our approach in developing the proposed requirements…

Considering these characteristics, the GS program elements were tailored…

Right: major program elements (the requirements to be considered in applying for a permit, constructing, operating, maintaining, and eventually closing a site).

Left: the unique properties of CO_2 that were the catalysts for the way in which the existing requirements were tailored for CO_2.

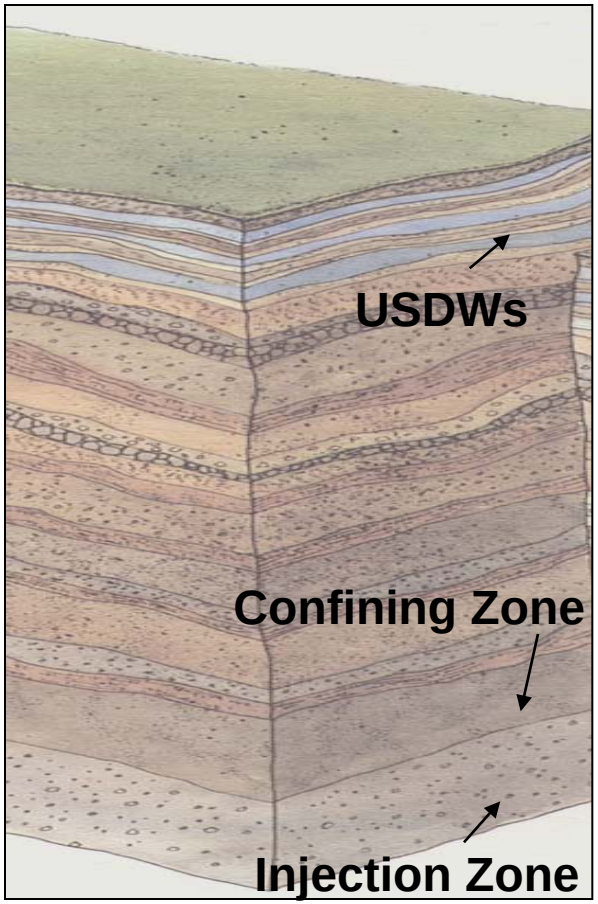


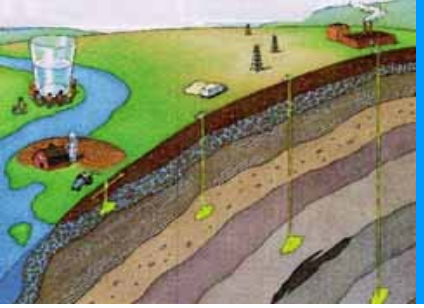
EPA's Proposed GS Rule

Site Characterization

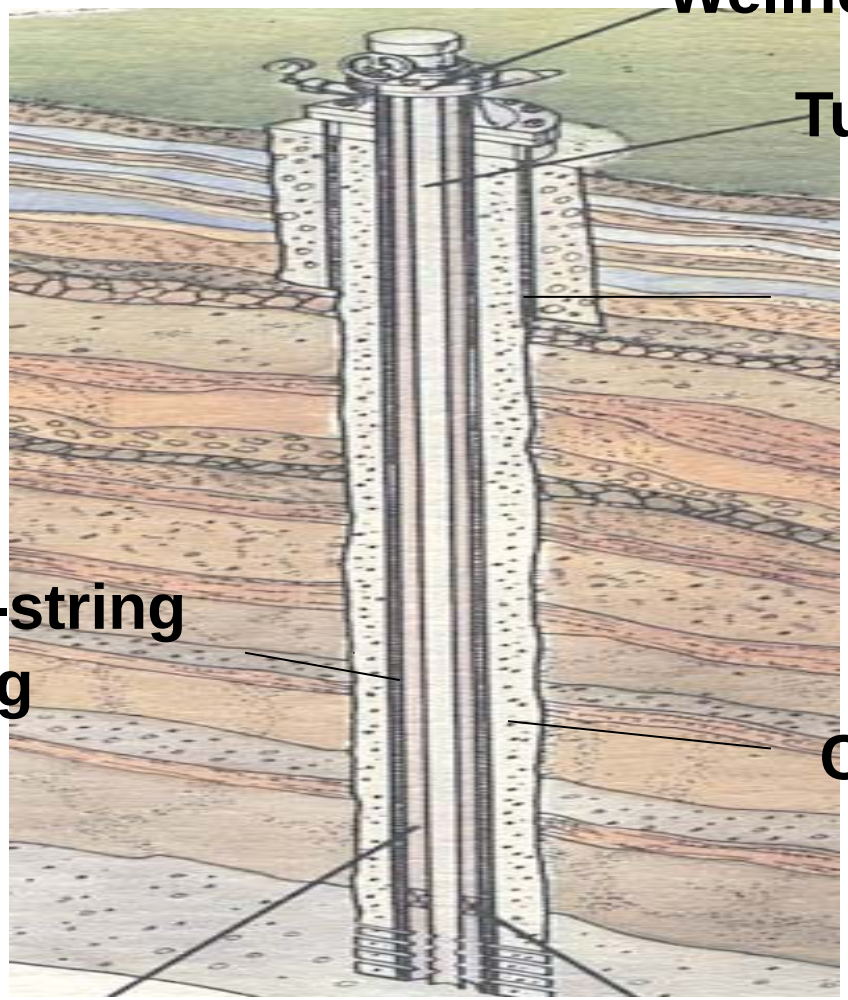
Site Selection

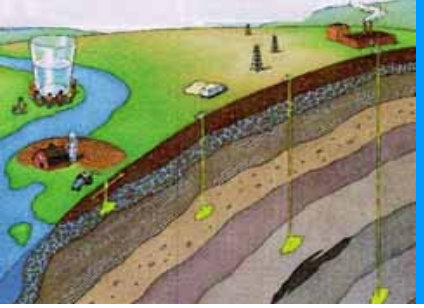
- Injection zone that accepts fluids
- Confining zone (system) above the injection zone to contains all formation fluids
- Information on structural geology, stratigraphy, seismicity and geochemistry
- Identify and evaluate artificial penetrations and features that may allow migration of fluids
- Plug and/or remediate abandoned wells as appropriate
- Use computational modeling for AoR
- Reevaluate Area of Review every 10 years





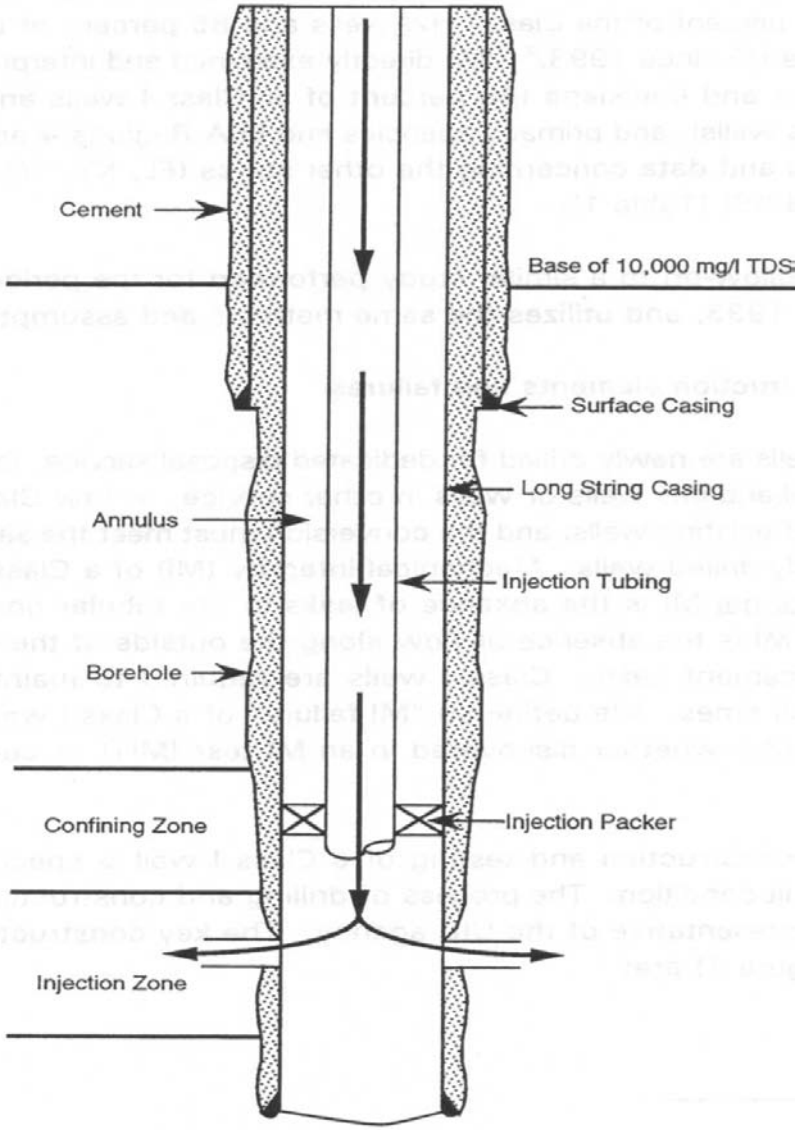
EPA's Proposed GS Rule
Well Construction

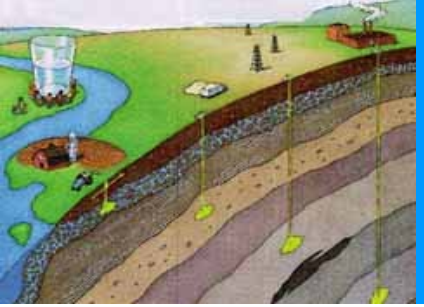




EPA's Proposed GS Rule
Mechanical Integrity Testing (MIT)

- Internal: to demonstrate no significant leak in the casing, tubing, or packer
- External: to demonstrate no significant fluid movement into USDW through channels adjacent to injection well bore

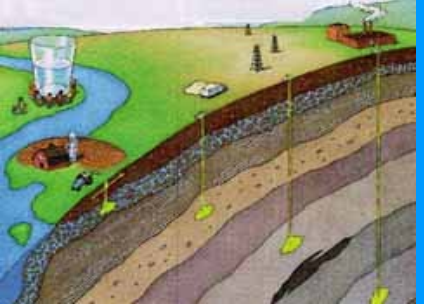




EPA's Proposed GS Rule
Well Testing and Operation

Proposed Approach

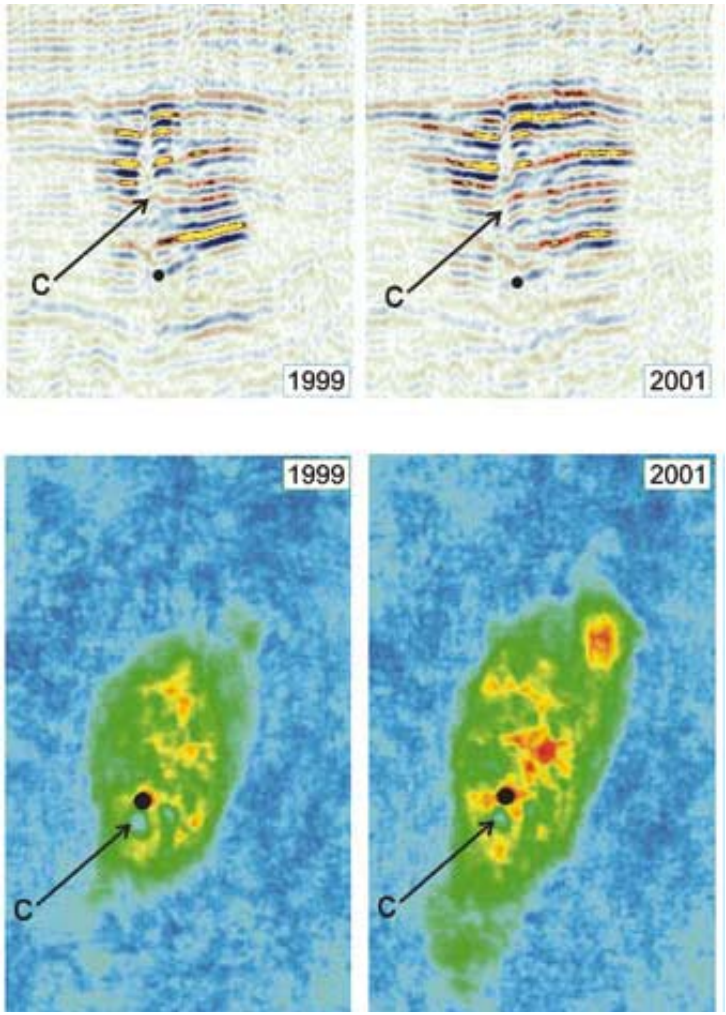
- Continuous internal well mechanical integrity tests (MIT) and annual external MITs
- Injection pressure should not exceed 90 percent of fracture pressure in the injection zone



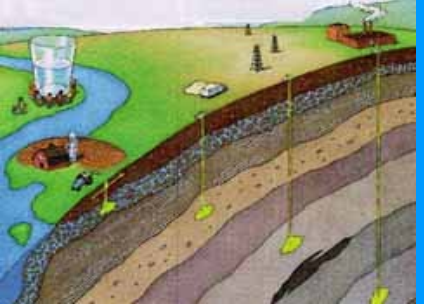
EPA's Proposed GS Rule
Site Monitoring

Proposed Approach

- Determine extent of CO_2 movement and associated area of pressure (pressure front)
- Tracking of the plume and pressure front is required, but techniques, frequency, and spatial resolution are not specified
- Surface-air and soil-gas monitoring are at the Director's discretion



Seismic Monitoring Results, Sleipner

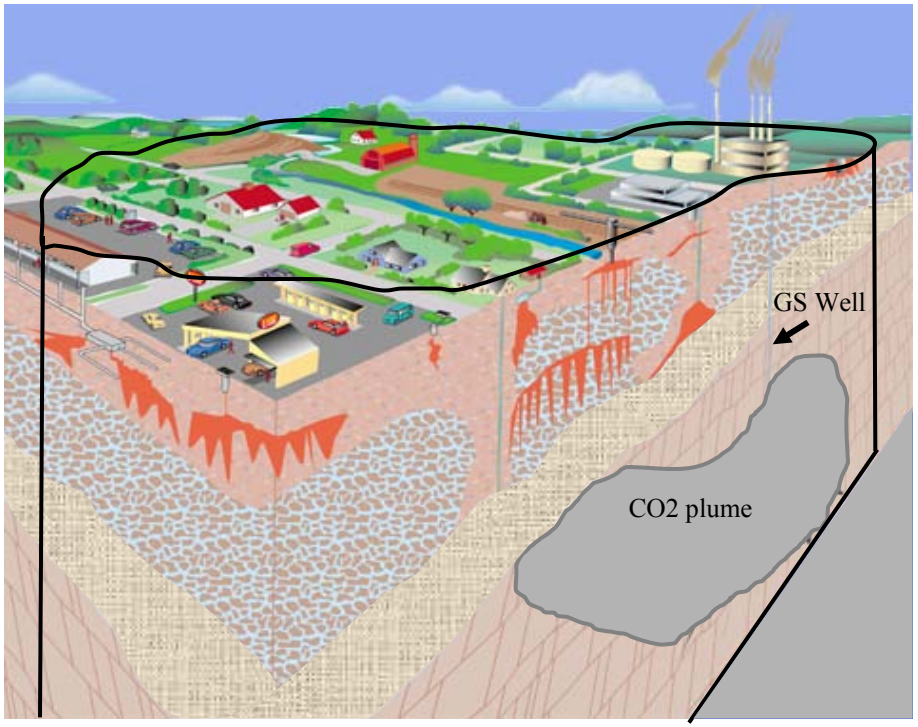


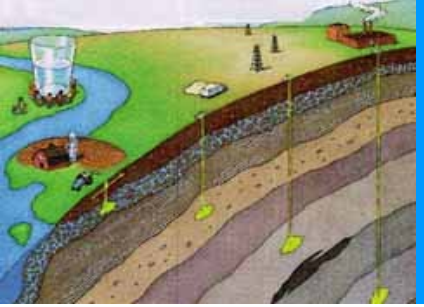
EPA's Proposed GS Rule
Area of Review (AoR)

AoR: The region surrounding the project that may be impacted by injection activity

Basic Requirements

- Delineate the AoR
- Identify and evaluate all artificial penetrations and other features that may allow upward migration of fluids
- Plug and/or remediate as appropriate

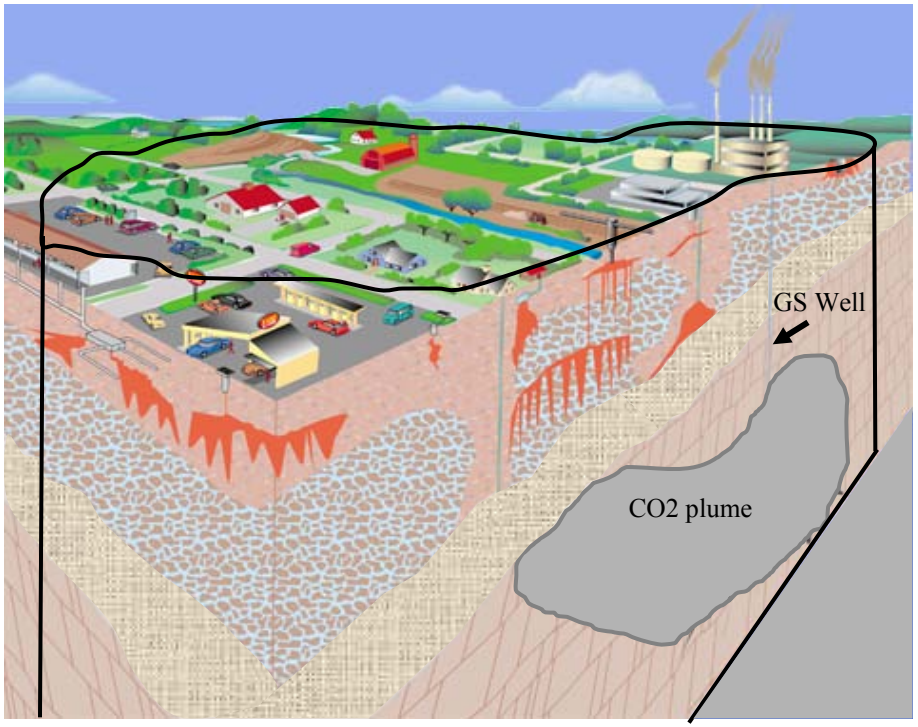


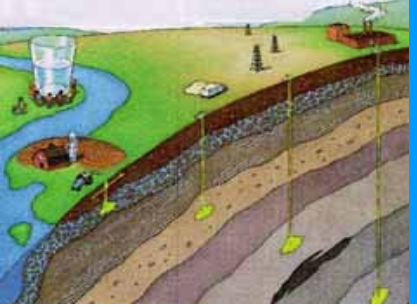


EPA's Proposed GS Rule
Area of Review (AoR)

Proposed Approach

- Use computational modeling
- AoR reevaluation at a minimum of every 10 years



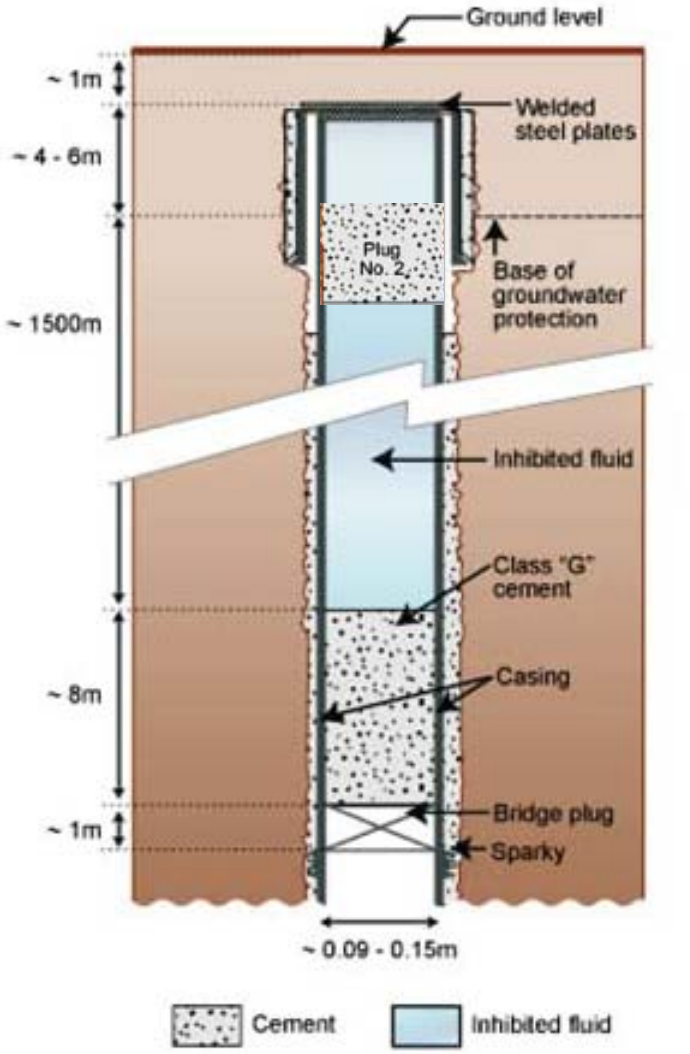


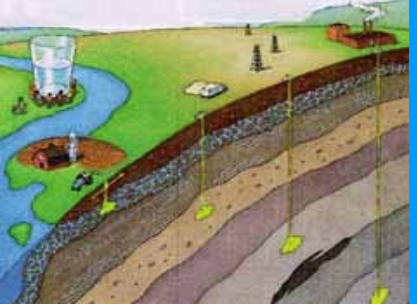
EPA's Proposed GS Rule

Well-Plugging and Post-Injection Site Care

Basic requirements

- Appropriate well-plugging, monitoring and other actions following cessation of injection
  - Wells must be closed in a manner that protects USDWs from endangerment
  - Owner/operator must demonstrate and maintain financial assurance to close and abandon the injection operation
  - Liability stays with owner/operator



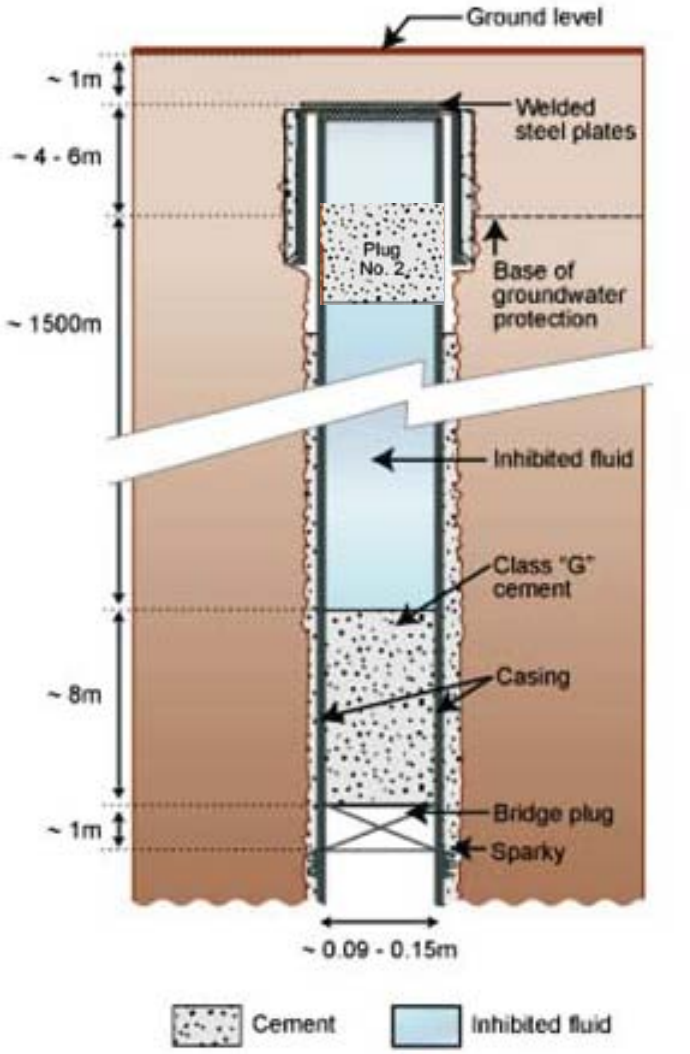


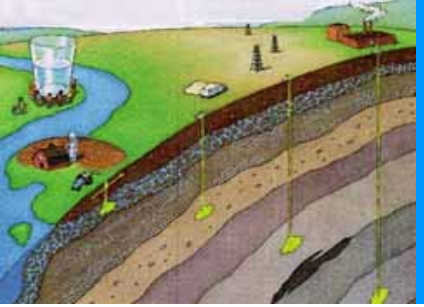
EPA's Proposed GS Rule

Well-Plugging and Post-Injection Site Care

Proposed Approach

- Well-plugging materials must be compatible with CO_2 stream
- Post-injection site care is set at 50 years; however, it may be modified with a demonstration that the plume has stabilized and the pressure has dissipated sufficiently
- The owner or operator must demonstrate financial assurance through the end of post-injection site care



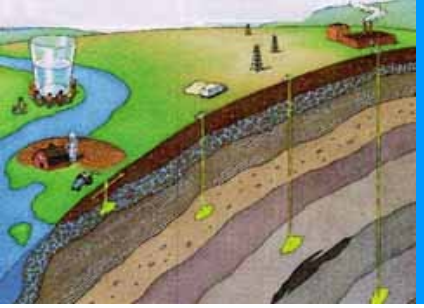


Notice of Data Availability

Background

- Notice of Data Availability (NODA)
  - Developed in early 2009
  - Published August 31, 2009
  - 45 day comment period: August 31st – October 15th, 2009

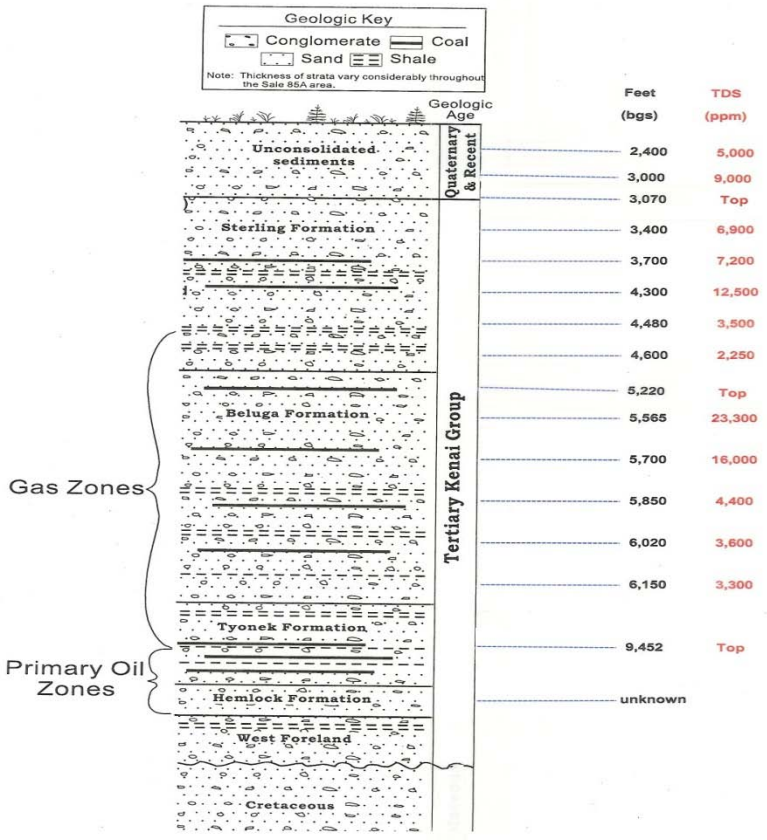
- Developed to seek comment on:
  - Research findings and DOE Regional Partnership project data
  - Potential approach that would allow injection above or between underground sources of drinking water (i.e. waiver process)
  - Comprehensive Framework (SDWA, CAA, RCRA)



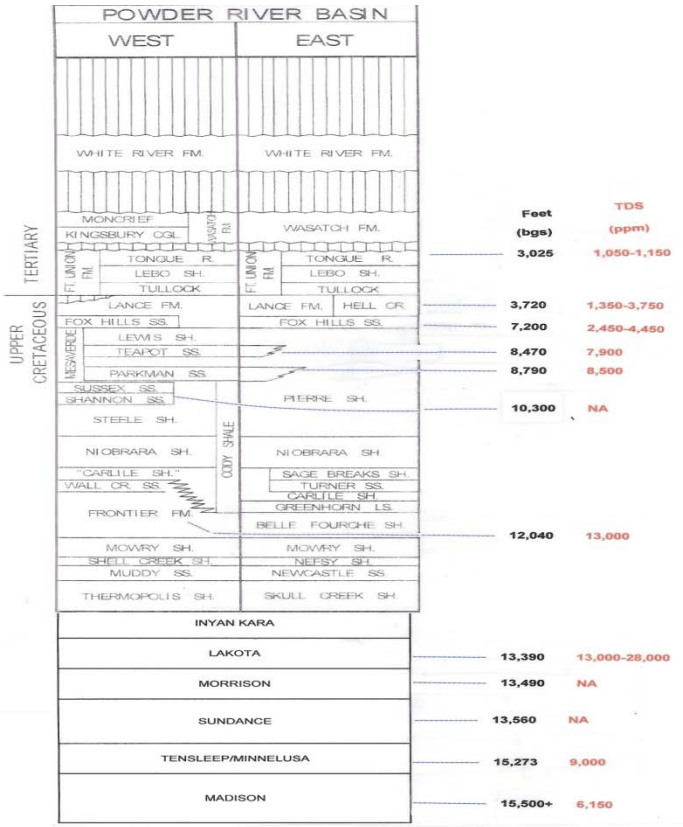
Notice of Data Availability

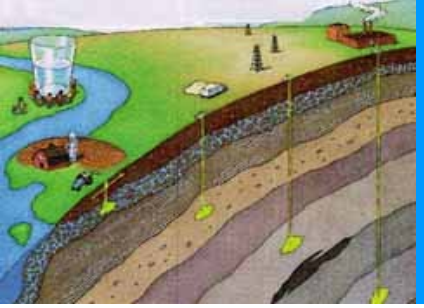
Waiver Process: Cross Section Examples

Region 10 (Alaska)



Region 8

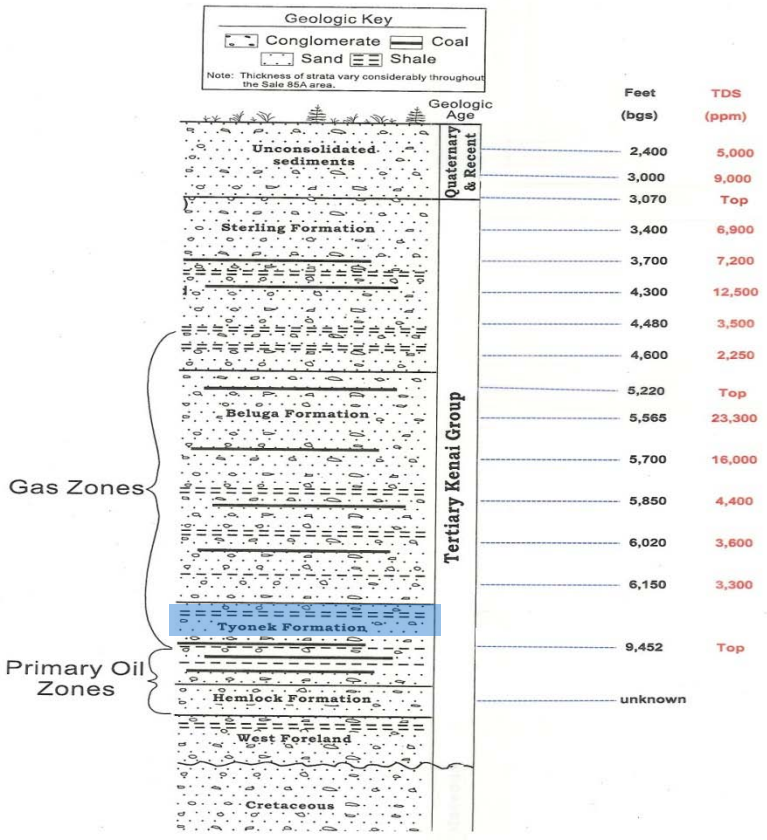




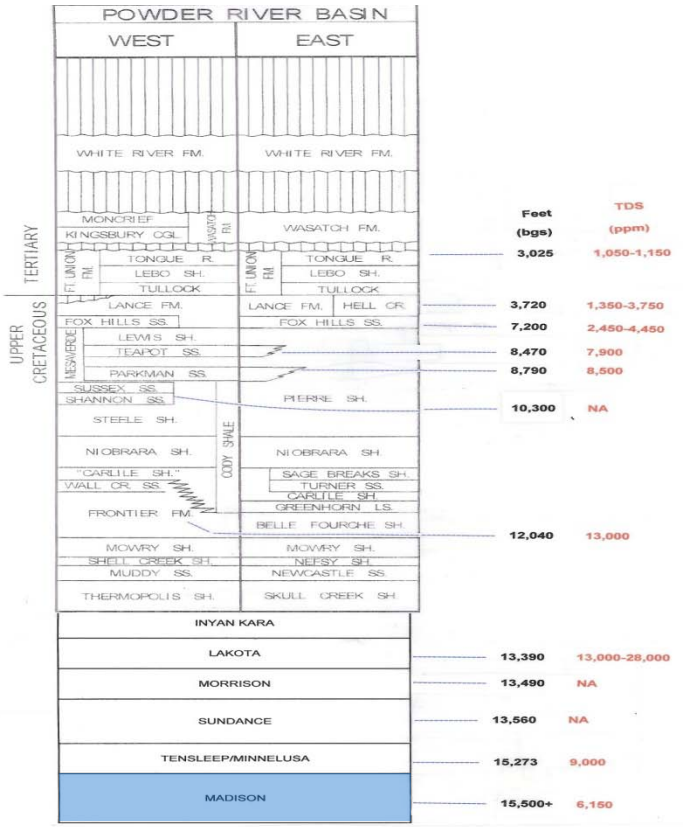
Notice of Data Availability

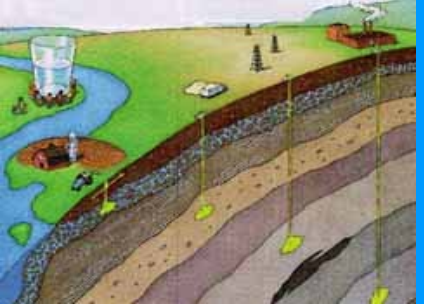
Waiver Process: Cross Section Examples

Region 10 (Alaska)



Region 8





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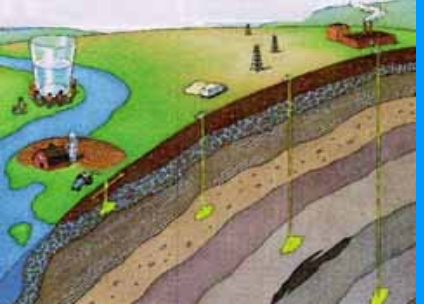
Injection Depth Waiver Process

The waiver process goals are to:

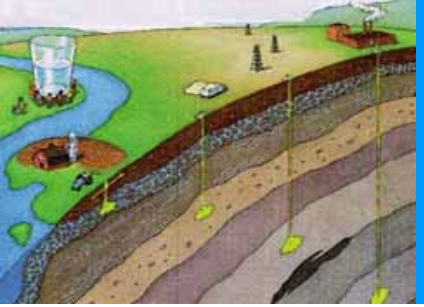
- Accommodate injection into different formations at varied depths
- Consider the concept that injection above and/or between the lowermost USDW, under specific circumstances, can be equally protective of USDWs
- Provide flexibility and respond to storage capacity concerns resulting from limiting injection below the lowermost USDW
- Ensure consideration of community drinking water resources by requiring coordination between the UIC Director and the PWSS Director



EPA's GS Rulemaking

Schedule

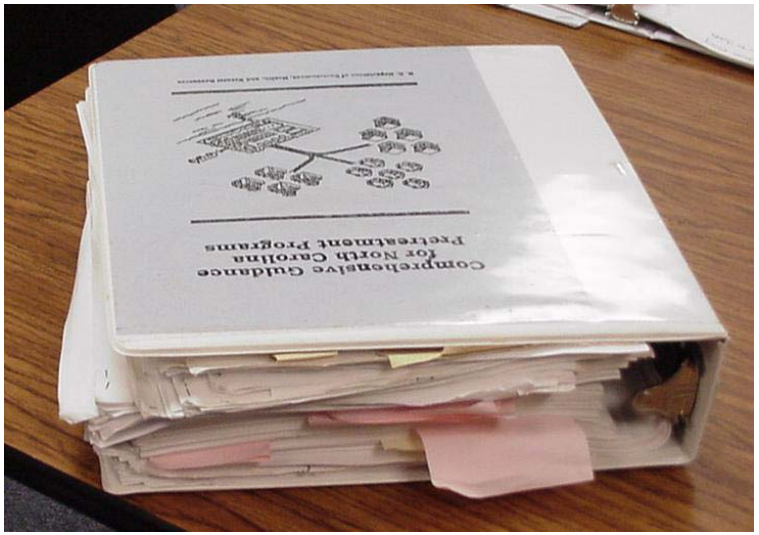
Activity	Timeframe
Technical Workshops & Data Collection	Completed
Stakeholder Meetings	December 2007/February 2008
Administrator's Signature of Proposed Rule	July 15, 2008
Notice of Data Availability	August 31, 2009
Final UIC Rule for GS of CO_2	Late 2010/Early 2011
Implementation of UIC Rule for GS of CO_2	Post-rule publication

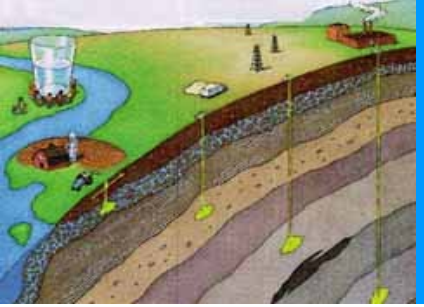


EPA's GS Rulemaking

Technical Guidance

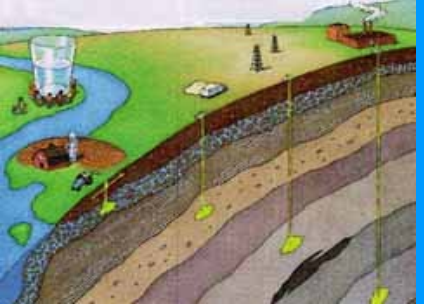
- EPA will eventually produce 12 Technical Guidance documents and/or manuals on subtopics within the GS rule designed to assist owners and operators as well as regulators
- The first Technical Guidance documents and/or manuals will cover the following areas:
  - Site characterization
  - Area of Review
  - Monitoring and Testing
  - Well Construction
  - Financial Responsibility
  - Implementation and Class VI Primacy
  - Plan Development





Continuing GS Research

- Lawrence Berkeley National Laboratory (LBNL) Interagency Agreement
  - EPA is funding work by LBNL to integrate experimental and modeling efforts with objective of evaluating the potential consequences of CO_2 leaks from GS operations into ground water resources
- EPA Office of Research and Development (ORD)
  - Continues to research site characterization, monitoring, and modeling topics related to GS through EPA's National Labs
- EPA Science to Achieve Results (STAR) Grants
  - ORD awarded 6 Science To Achieve Results (STAR) grants to major universities and institutions. The awards to projects focused on the *Integrated Design, Modeling and Monitoring of GS of Anthropogenic CO_2 to Safeguard Sources of Drinking Water*



Thank you!

More information about the UIC Program

- EPA Geologic Sequestration of Carbon Dioxide Website – http://www.epa.gov/safewater/uic/wells_sequestration.html

- Code of Federal Regulations: Underground Injection Control Regulations 40 CFR 144-148 – http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?sid=d6ee71a544eca89c533c825135913f13&c=ecfr&tpl=/ecfrbrowse/Title40/40cfrv22_02.tpl