Water-Quality Issues Related to Uranium In Situ Recovery Sites

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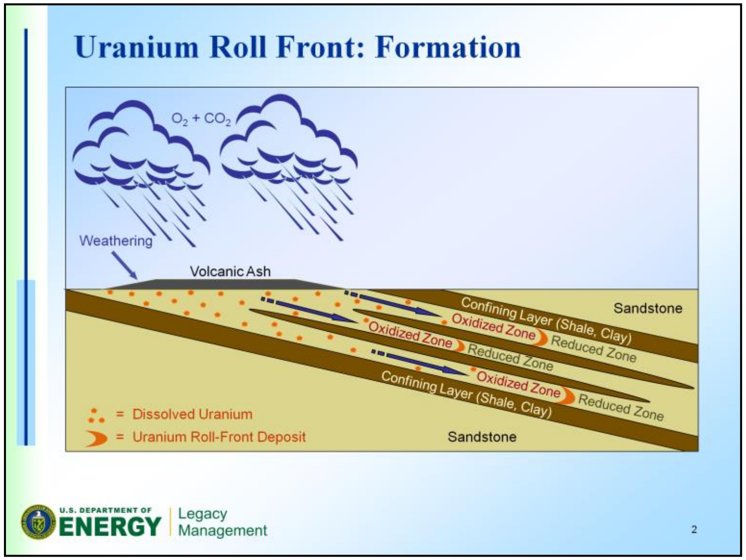
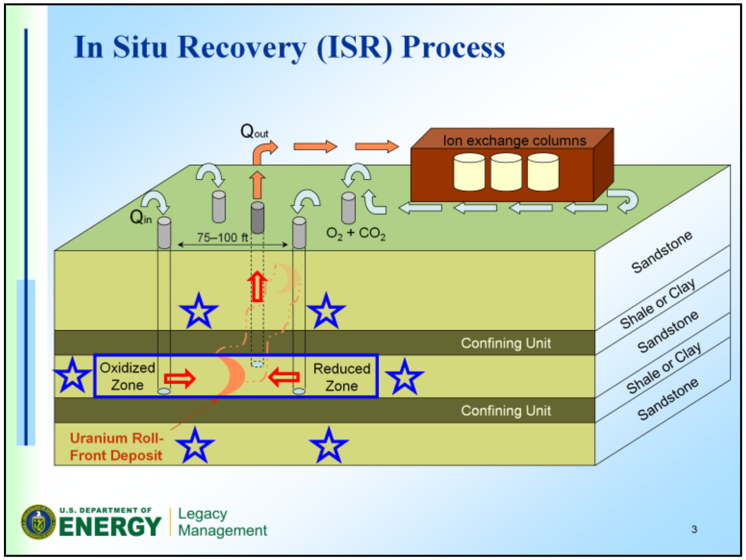
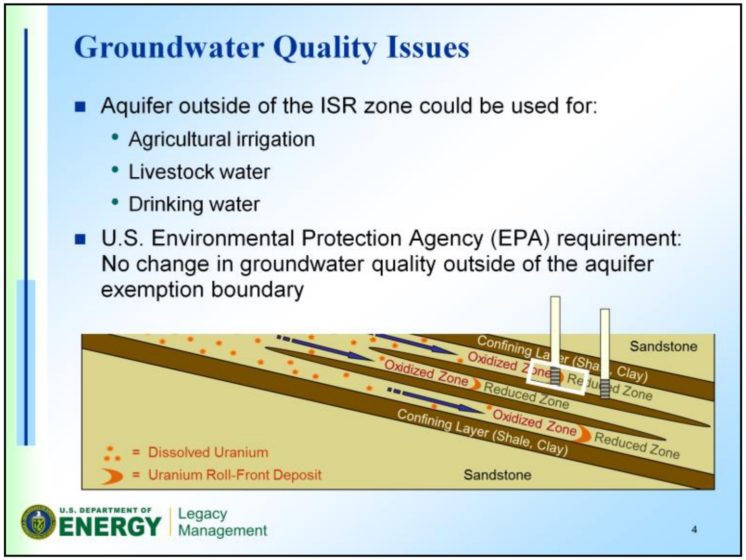


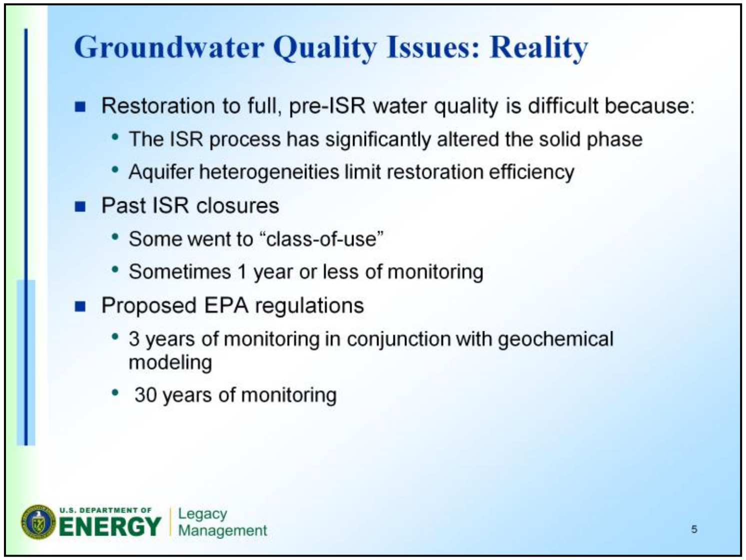
- Oxygen and carbon dioxide are key components in mobilizing uranium from source material, including volcanic ash.
- Uranium precipitates at redox boundaries, which moves down-dip or downgradient at centimeters or less per century, depending on groundwater flow velocities, oxygen content, and carbon content at the redox boundary.
  - This redox boundary becomes an enriched uranium deposit over geologic time.



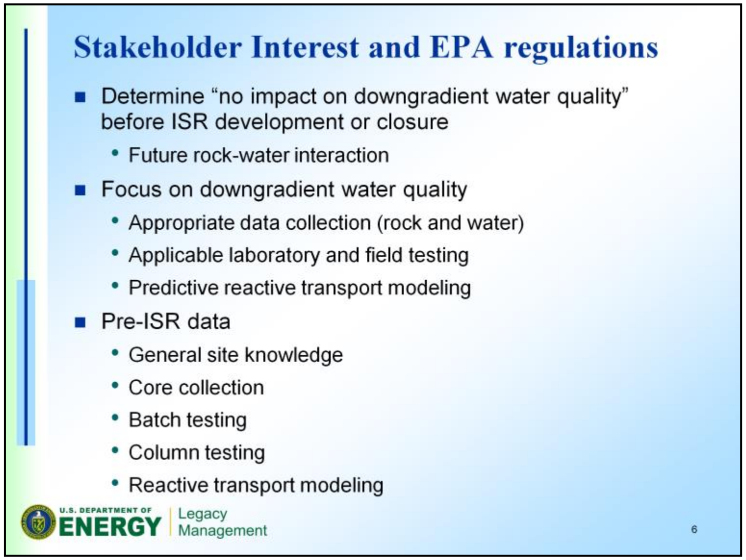
- The addition of oxygen and carbon dioxide reverses the depositional processes and keeps uranium in solution.
- Uranium is pumped from a central well to ion exchange columns at the surface, where uranium is removed, and the water is re-injected.
- The blue box is an aquifer exemption boundary that is issued by the U.S. Environmental Protection Agency to allow the ISR process to proceed in this localized area.
- The stars are nearby monitoring locations.



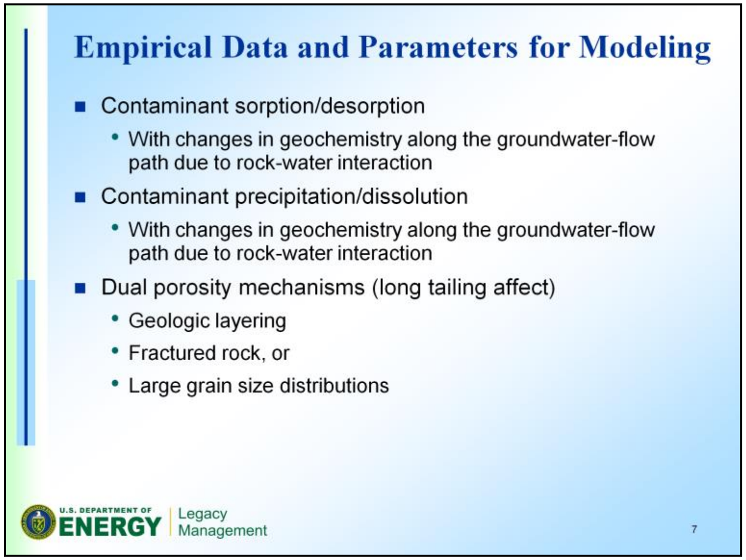
- White box indicates aquifer exemption boundary with ISR wells within that boundary.
- Aquifer exemption boundary recognizes the presence of the uranium ore body, and that the groundwater within that ore body is not suitable for drinking water (often high uranium and/or radium concentrations).
- The well outside of the white box is a downgradient user of the groundwater.
    - Determining the ISR influence on groundwater outside of the aquifer exemption boundary is the focus of this talk.



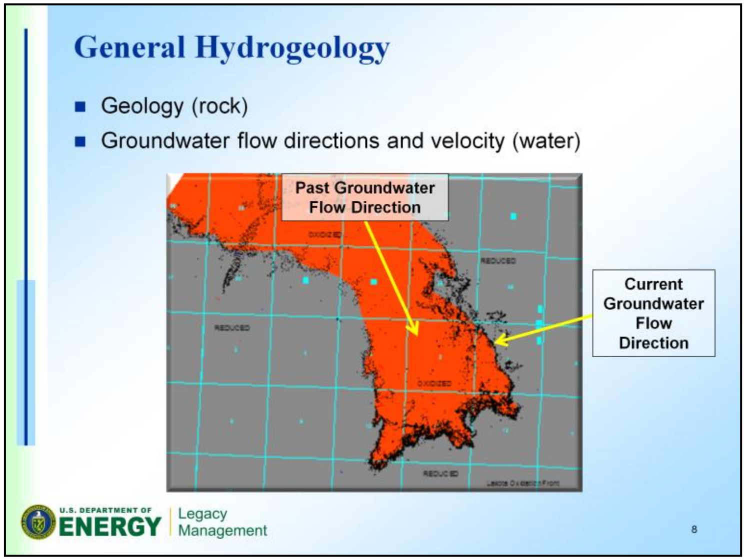
- Reductants are often used in the restoration process
  - Not going to get into all the restoration techniques
- One year of monitoring is probably not sufficient
  - New proposed regulations might require up to 30 years of monitoring
- “Class-of-use” argument is not recognized by the Nuclear Regulatory Commission (NRC)
- With typical groundwater flow rates, any downgradient impacts will be decades in the making



- Before an ISR facility is closed, it is not easy to determine whether or not the downgradient water quality will be impacted given slow groundwater flow rates, thus need to know the downgradient rock-water interaction and points in the second main bullet.
- Mention DOE as a stakeholder, with remediated uranium mill sites that are near and/or downgradient from current and/or proposed uranium ISR sites. ISR facilities do not transfer to DOE.
- Mention that once an ISR facility is "closed" through Nuclear Regulatory Commission approval, groundwater can again be used for purposes that are consistent with the state's class-of-use designation.

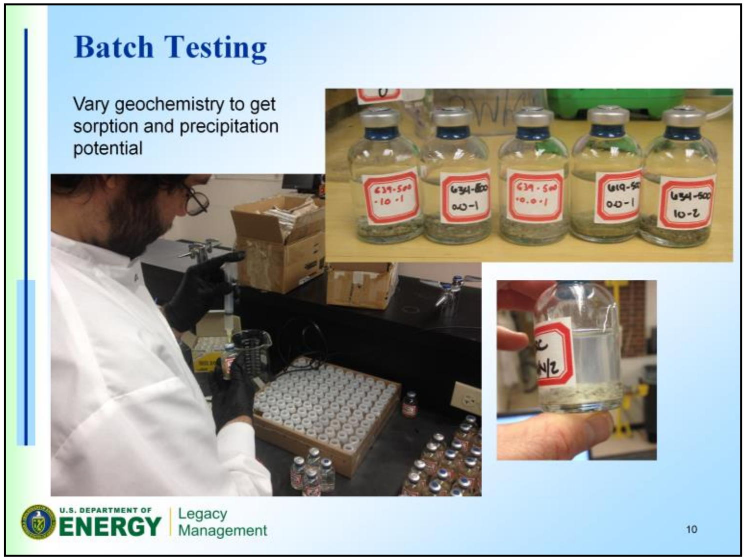


- Key items of interest before getting into testing details

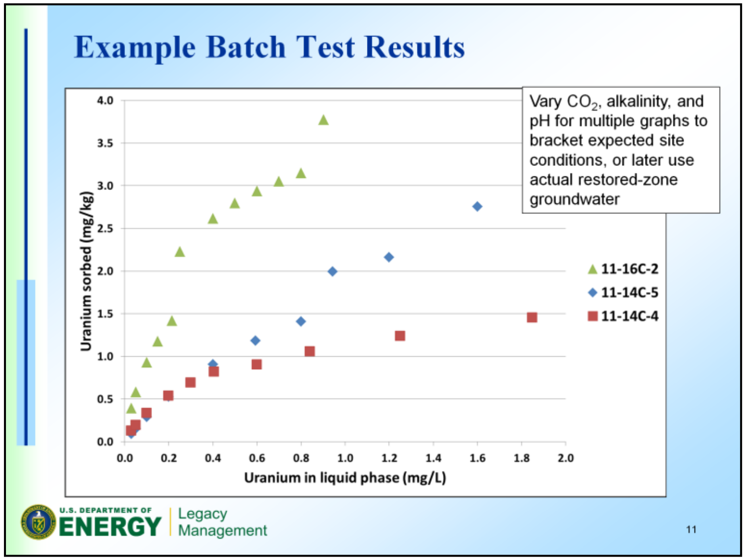


- General hydrogeology is part of the initial permitting process, but complexities need to be fully understood.
  - Example: Dewey Burdock site in southwestern South Dakota, where the groundwater flow direction has changed a full 90 degrees through geologic time.
    - This situation creates an area where oxidized solid phase material occurs downgradient from the ore zone. Note that the ore occurs along the boundary of the oxidized (red) and reduced (grey) zones.

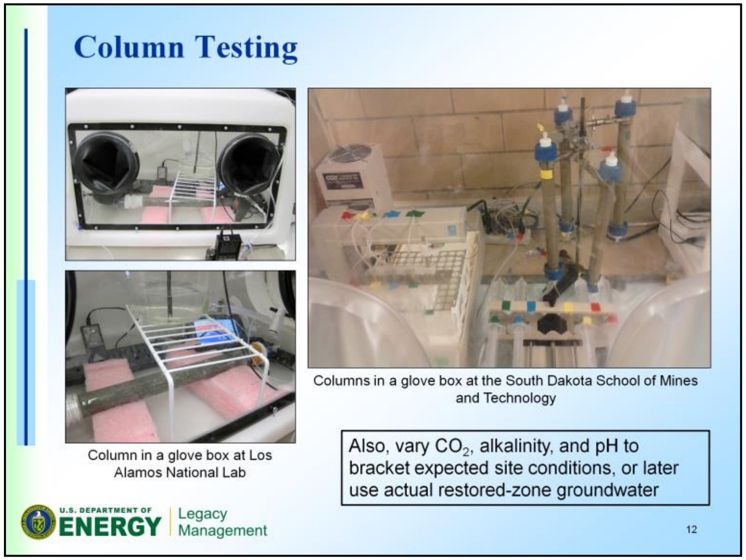
- Some examples of oxidized core, ore zone, and reduced zone core.
- Cannot begin to do any future predictions without knowing the solid-phase mineralogy.



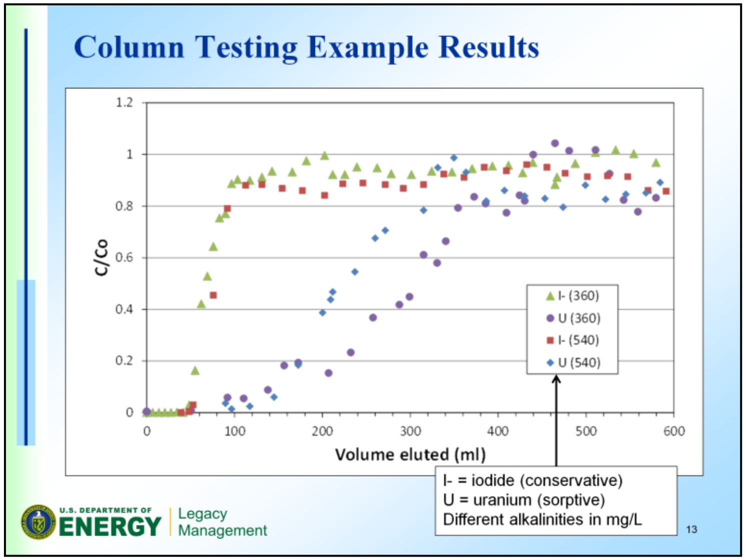
- Each vial is a batch test of rock-water interaction for uranium sorption and/or precipitation.
    - Generally, vary the uranium concentration, alkalinity, and pH to test the influence on uranium sorption.



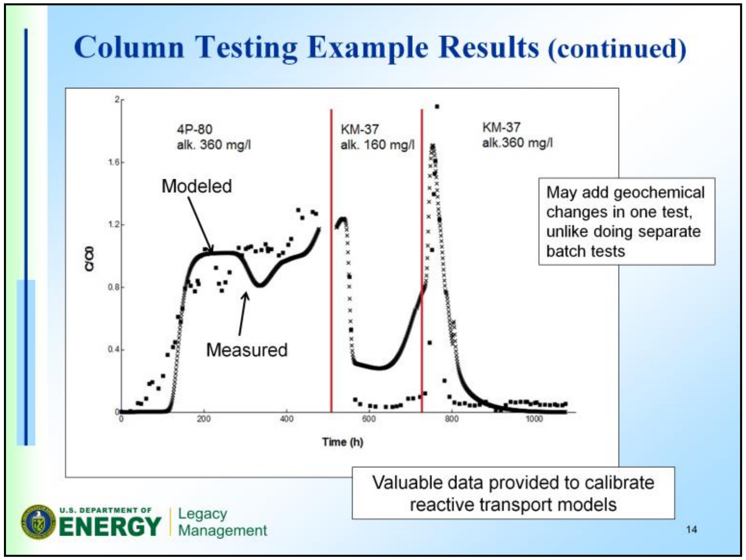
- Explain that these results show equilibrium sorption; thus, given an added amount of uranium, the graph shows the measured amount of uranium sorbed to the three different solid-phase samples.
- Precipitation could also be important, thus the importance of maintaining reducing conditions (sealed vials in previous slides and glove boxes for column work).
- Time scale for reducing conditions to occur appear to be important. Batch tests are relatively short time frames that may not allow for uranium precipitation to occur under reducing conditions.



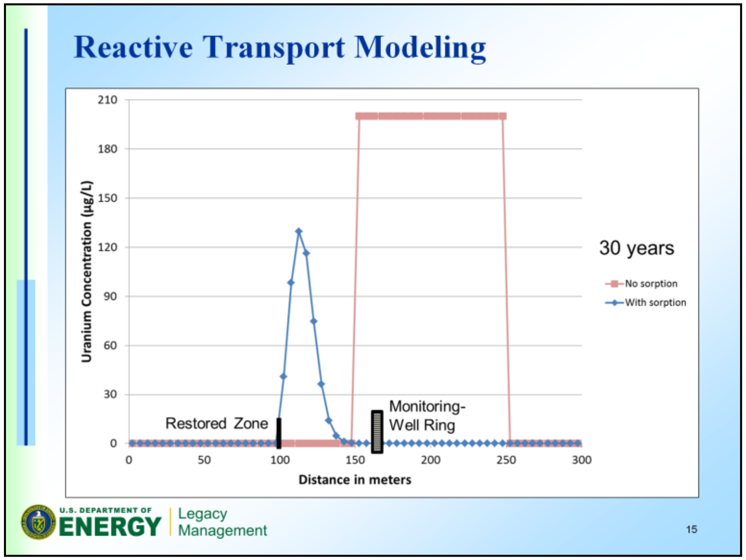
- Pictures show column testing being done in anaerobic glove boxes to maintain reducing conditions. Thus, allowing for uranium precipitation, if it has the potential to occur. Again, the short lab time frame could be an issue.



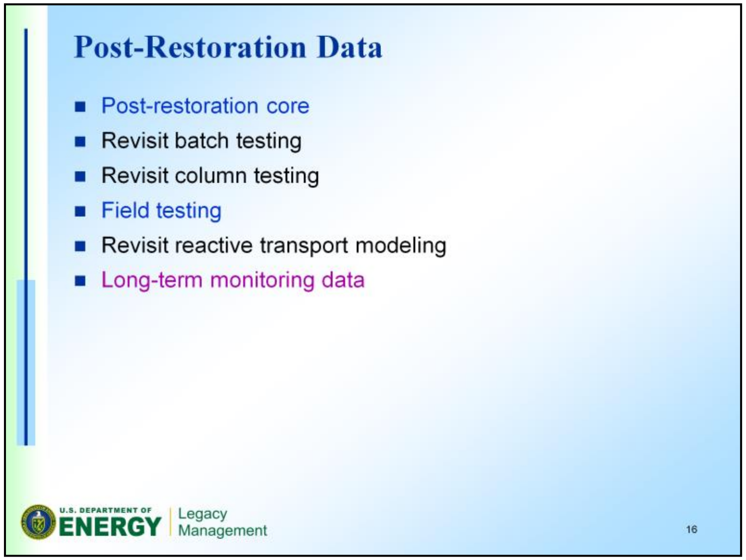
- Iodide shows conservative behavior and uranium shows sorption to the solid phase.
    - The sorption, and thus natural attenuation, is increased when the alkalinity is lowered.



- 4P-80 is unrestored ISR groundwater and KM-37 is background groundwater.

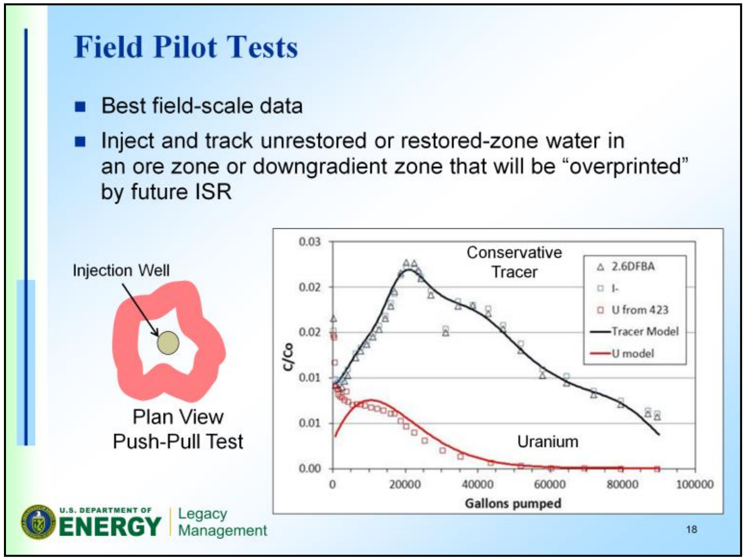


- Data from batch and column tests can be used as input parameters for reactive transport modeling that accounts for geochemical changes and rock-water interaction.
- Example shows a prediction at 30 years, showing strong natural attenuation of uranium.
    - This example shows that the monitoring well ring location is okay for conservative elements, but too far out for adequate detection of uranium over the next 30 years. Closer monitoring wells may be needed for earlier detection.

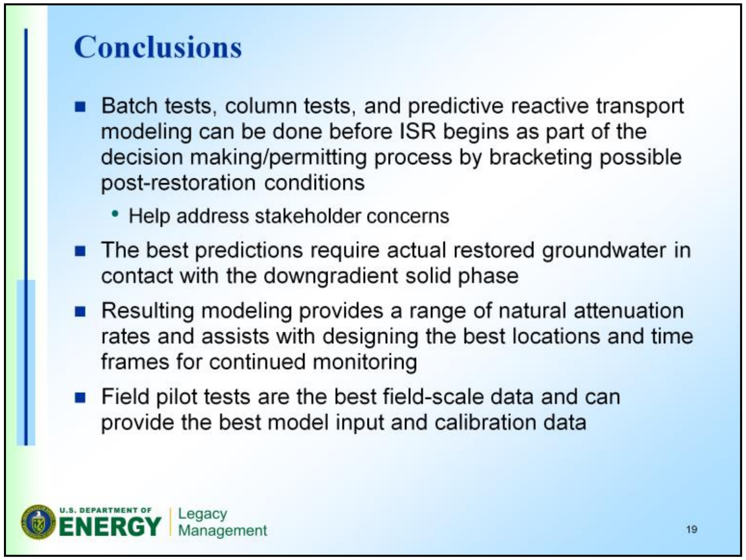


Long-term monitoring data is good to have, but does not help with shorter-term need for a decision on closure.

- First point gets at the very long-term geochemical stability of the restored zone
    - The geochemistry of an "evolved background groundwater" may be different from the current background groundwater due to rock-water interaction
- Inset provided to point out groundwater locations
    - Point out that the predictive reactive transport modeling is very sensitive to small changes in geochemistry (especially pH); thus, the use of the final groundwaters will provide the best predictions



- Main idea: To test the natural attenuation of uranium at the field scale in a much shorter time frame than natural flow rates
    - Currently being done at the Smith Ranch-Highland site where restored and unrestored ISR units are close to newly installed ISR units
    - Push-pull test is one example
    - A cross-hole test is being completed



- Mention that point one is a dilemma for stakeholders who want assurance of “no impacts” even before ISR work is conducted
    - Thus, the importance of having a modeled “range of reasonable possibilities” beforehand