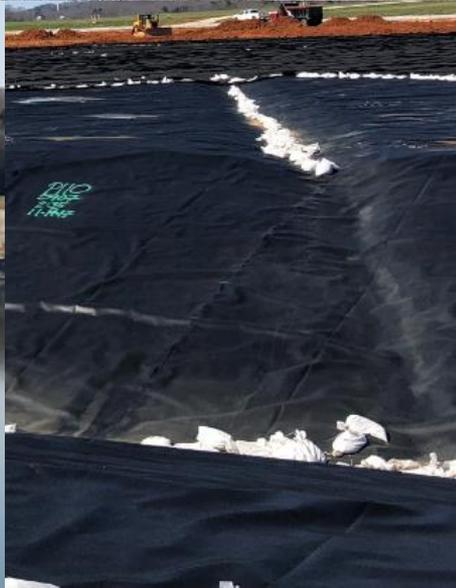


HDR



Challenges Facing Simulation of CCR Impacts with Groundwater Models

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01 Background

02 Some Sources of Uncertainty ...
(and how to deal with them)

03 Roadblocks and Detours

04 Discussions (and Questions)

01

Background

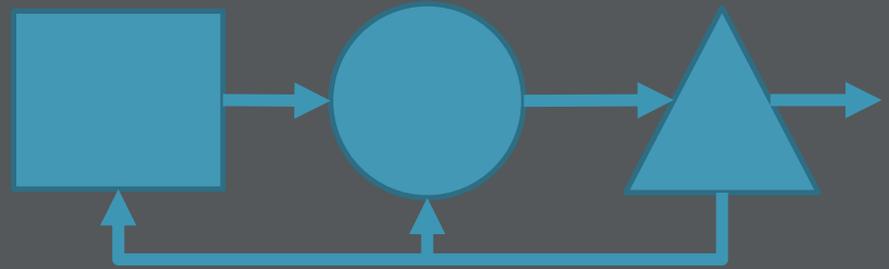
Groundwater Models as Tools to Evaluate CCR Storage Facilities Potential Impacts on Groundwater

- The CCR Rule has brought groundwater assessment forward as a necessary task
- Detection Monitoring and Assessment Monitoring prescribed by the rule focus on the CCR facility (not the flow system)
- Questions can arise from these programs that require understanding the system where the facility exists...
- **Groundwater modeling is an effective way to put data, analyses, and questions into the 'system' context**



Ideal Phases of Groundwater Modeling

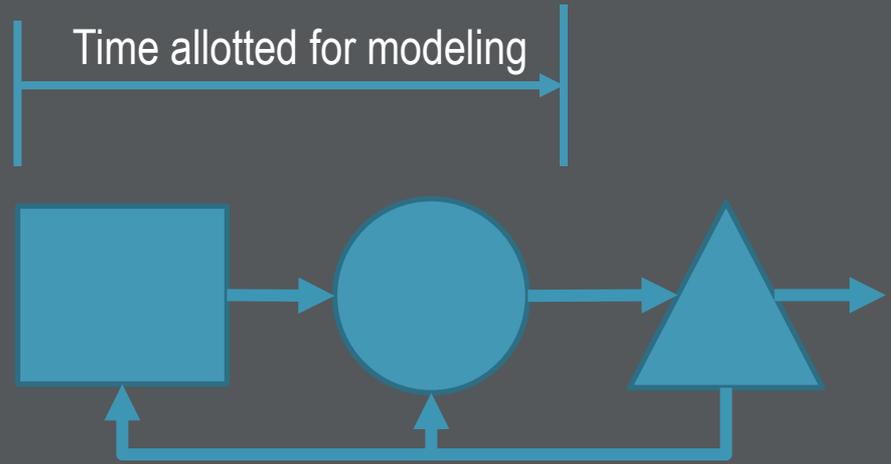
- Conceptual Site Model
 - Choosing the domain
 - Boundary Conditions
 - Temporal Considerations
- Groundwater Flow Model
 - Development
 - Calibration
 - Sensitivity Analyses
 - Predictive Simulations/Particle Tracking
- Fate and Transport
 - Model Development
 - Calibration
 - Sensitivity Analyses
 - Predictive Simulations



Each phase is iterative and can inform a previous phase..

What Really Happens...

- Conceptual Site Model
 - Model domain is prescribed and data limited
 - Very little existing data on boundary conditions
 - What happened yesterday is not known, so considering something from 1956 is just out
- Groundwater Flow Model
 - Development – as quick as you can from literature-based assumptions
 - Calibration - usually no stream flows, only heads at the site, maybe an old pumping test
 - Sensitivity Analyses – done in arrears
 - Predictive Simulations/Particle Tracking – yep!
- Fate and Transport
 - Little data to support anything other than advective transport



Each phase is iterative and can inform a previous phase.

Why do we need more data? We've collected so much!

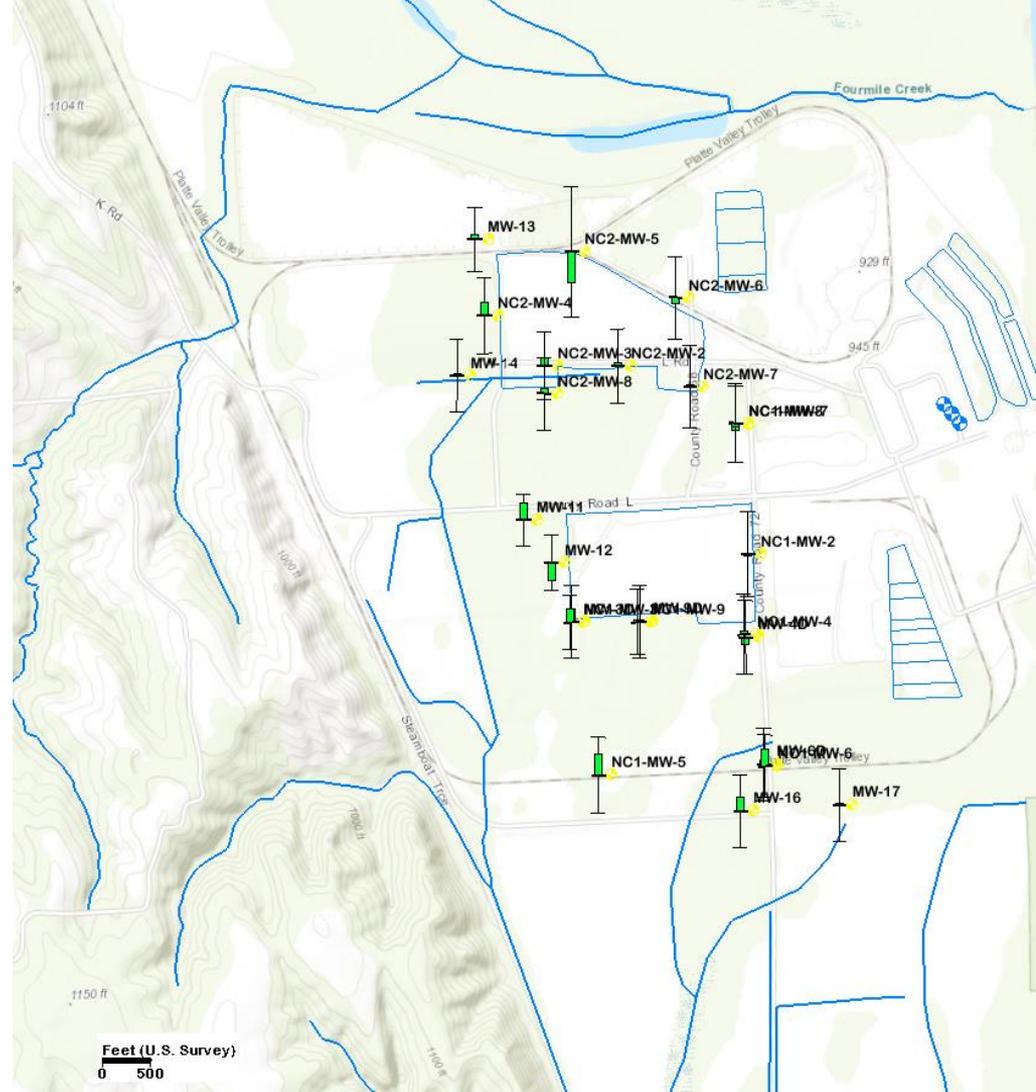
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Some Sources of Uncertainty...

(and how to deal with them)

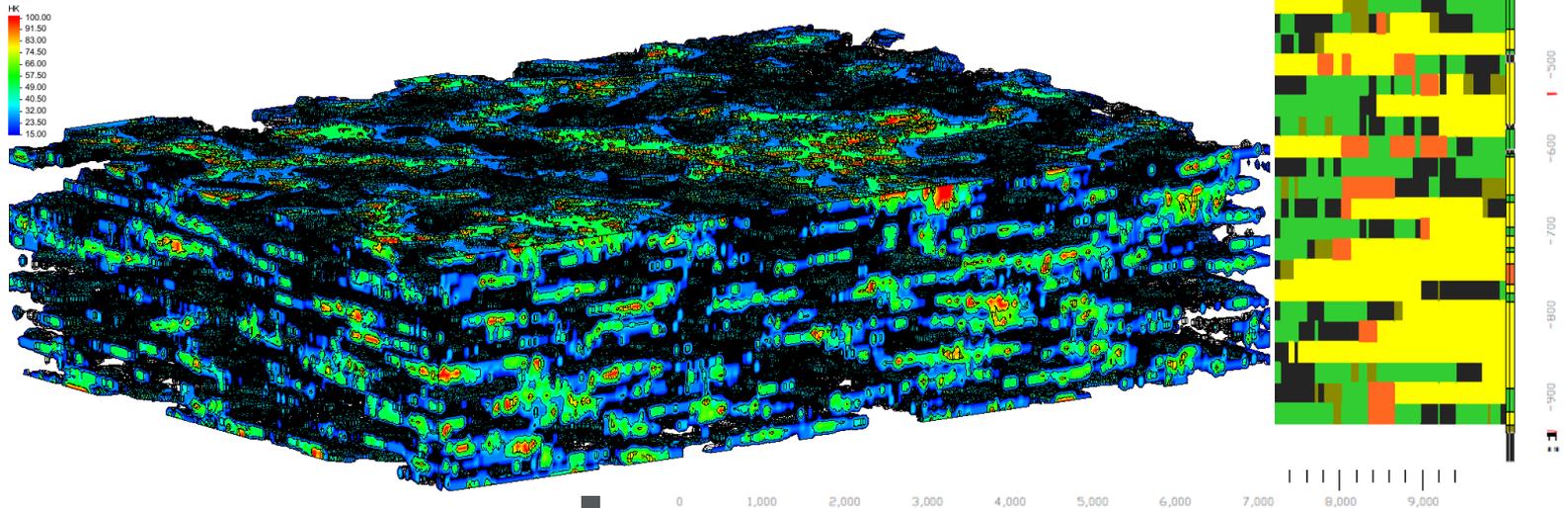
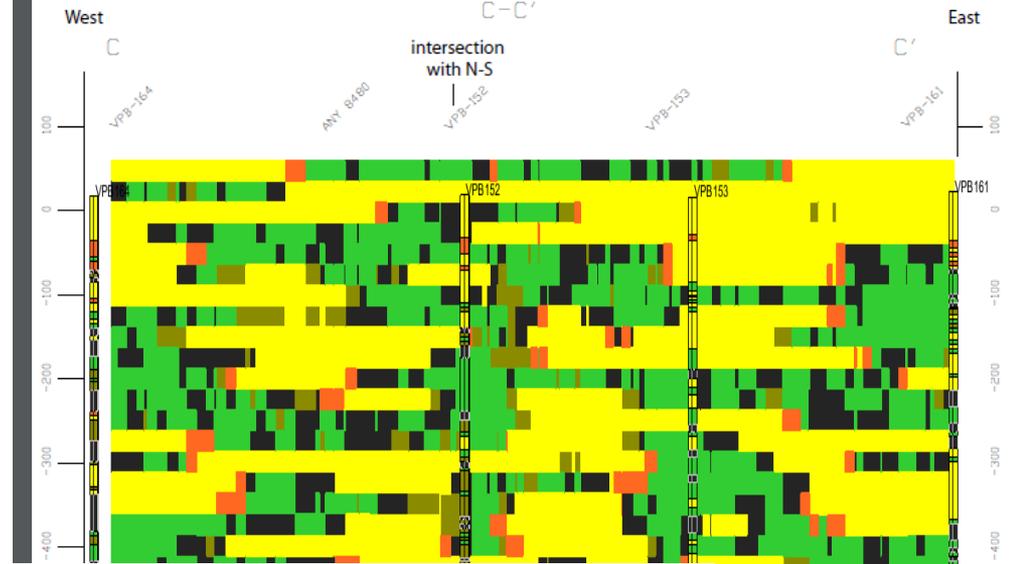
How Much Data is Enough?

- What we are doing is “statistical”. If you must generalize, knowing the breadth and depth of the conditions is important:
 - Need to be able to determine means, standard deviations, and confidence intervals.
 - Steady state calibration must be to mean conditions (not specific days)
 - Model calibration is based on how well the model reproduces the data – so how well do you know your data???



Subsurface conditions

- How variable is the subsurface?
- What level of detail is necessary to simulate the conditions?
- Fractured bedrock and Karst?



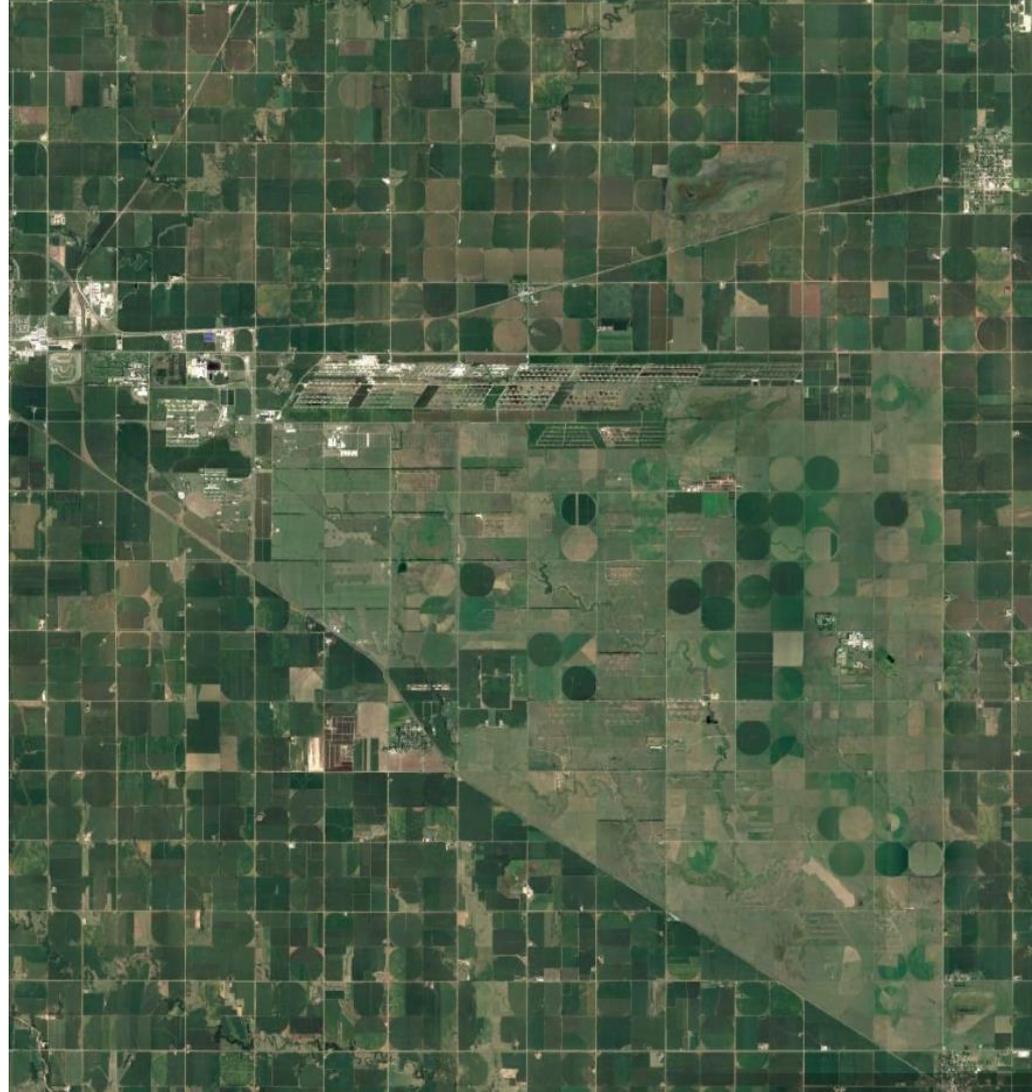
Surface Water: How variable are conditions?

- Most CCR facilities are near rivers...
 - How often do the rivers flood?
 - Does flooding affect groundwater flow?
- Stream flows – the keys to the kingdom!
 - Stream flows can be used to estimate groundwater recharge... if you don't have them you are using literature values.
 - Not just any stream flow measurement – several measurements at low-flow conditions .
 - They are also great model constraints as calibration targets.
 - *Almost no one does stream flow studies when working on a groundwater project...*



Groundwater Users

- Irrigation wells can be large variable stresses on the aquifer... how much they pump, from where and when is often difficult to determine...
- Wells come and wells go. During the lifetime of the CCR, was there a different set of stress for any length of time?



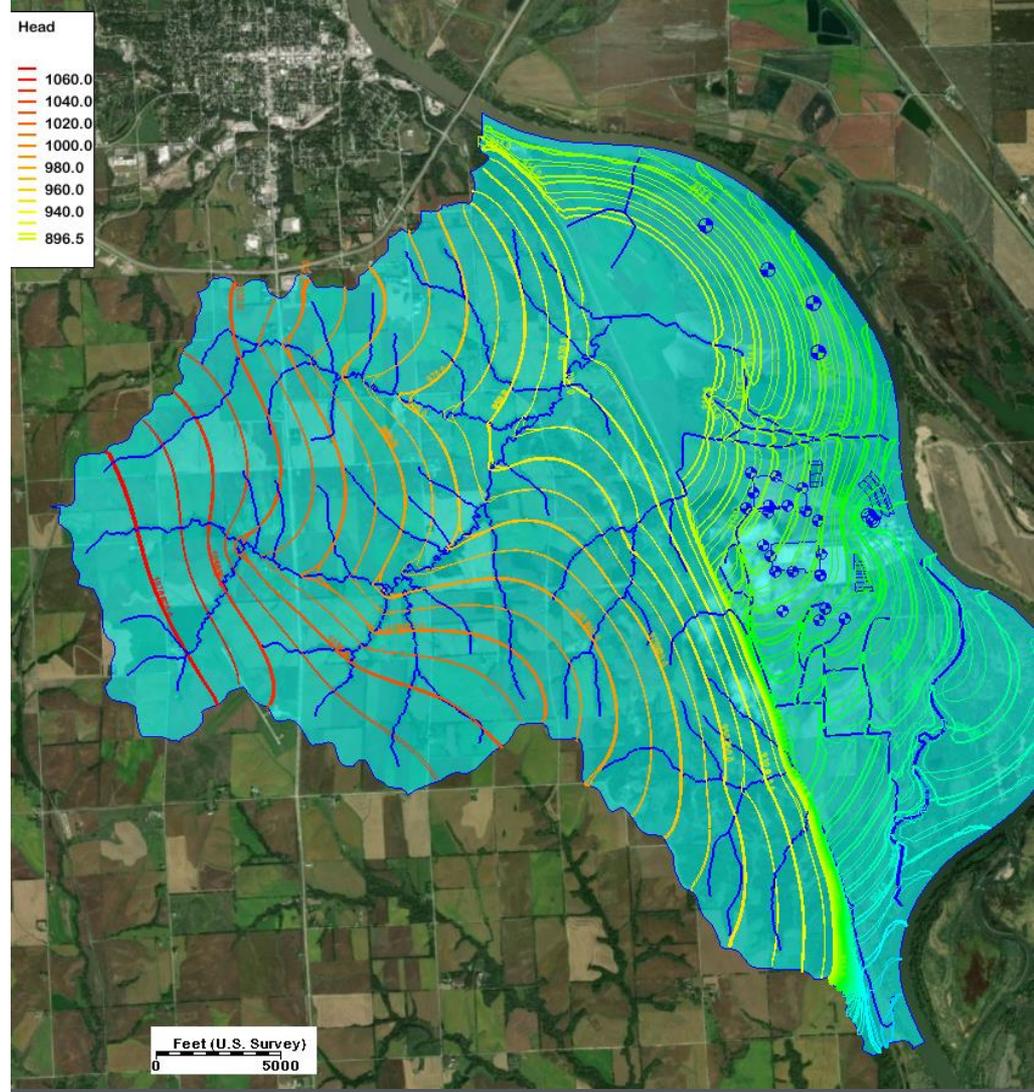
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Roadblocks and Detours

Oops, wrong model domain...

Choose your model domain wisely:

- Choose too small:
 - Important potential receptors may be outside the domain (you might hear from regulators/third parties...).
 - Boundary conditions can affect simulations.
 - Water budgets can be hard to justify
- Choose too large:
 - May increase data needs for the model (will increase areas that are generalized)
 - Can add computational baggage slowing model runs



Natural Boundaries are Best!

Where is the end?

Determining the point of compliance can be a source of discussion among various involved parties...

- Constituent fate and transport simulation has its own set of obscure data needs.
- Can a well across the river (outside your domain) really draw impacted water under the river???
- Sediment and surface water interface, ecologically speaking the rubber and the road (and a new set of models).



Conclusions/points to talk about

- Several factors around groundwater modeling cause uncertainty and present challenges.
- Both flow models and fate and transport models require constraining data to be defensible.
- Although data is king, the model is usually based on studies that were done prior to modeling for different purposes... no new data for you!
- Ultimately the modeling will be used in technical discussions with regulators, to evaluate corrective action, and support litigation – needs to be well-founded!

