

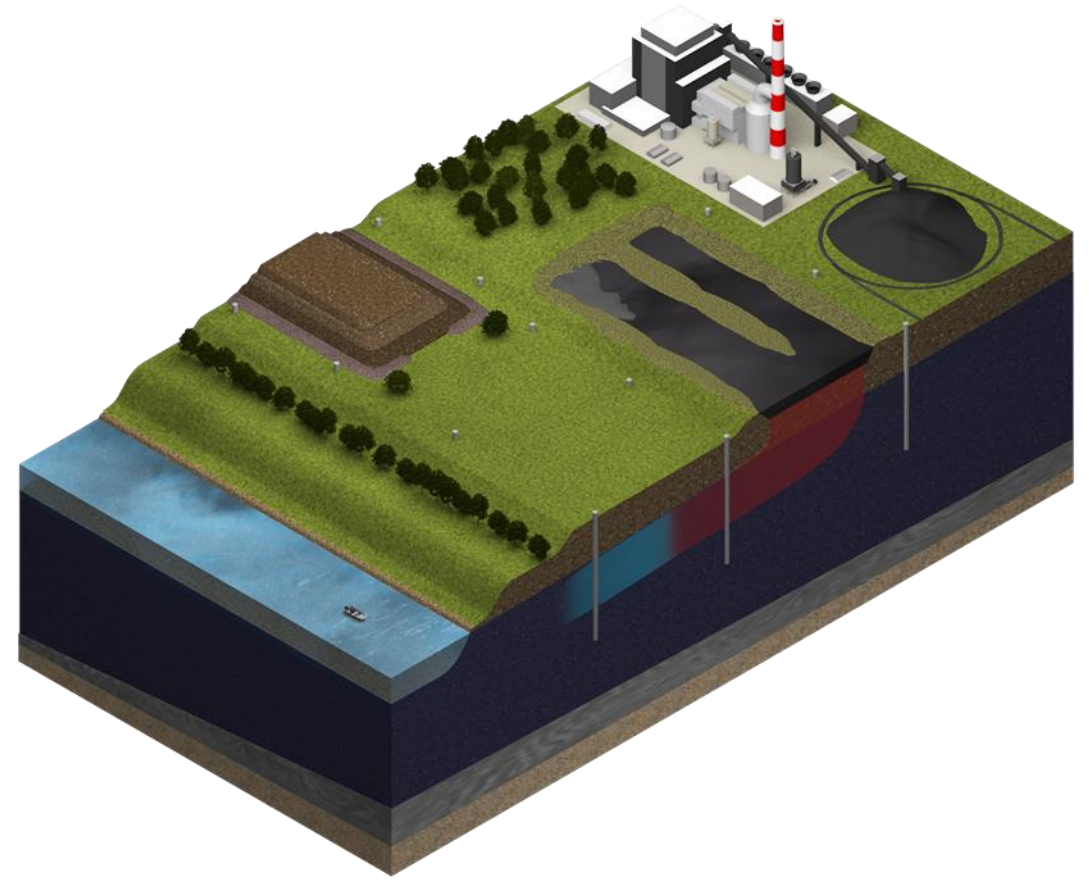
# **Development of CSMs and Evaluation of Groundwater Corrective Measures for Coal Ash Sites**

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Wayne Weber, PE, PG  
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# AGENDA

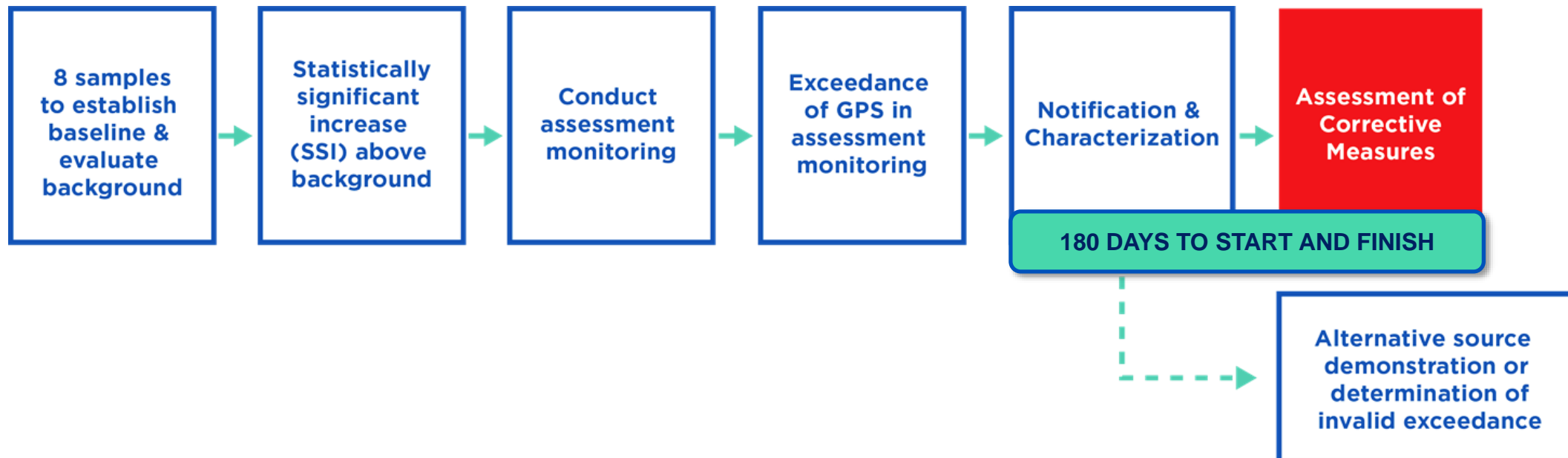
- ▶ Regulatory compliance drivers
- ▶ Conceptual Site Model (CSM) development
- ▶ Corrective measures development
- ▶ Corrective measures evaluation



# **REGULATORY COMPLIANCE DRIVERS**

# REGULATORY COMPLIANCE DRIVERS

- ▶ GPS exceedance during assessment monitoring (40 CFR § 257.95)
  - Characterize “release”
  - Within 90 days:
    - Alternate source demonstration
    - Demonstration of invalid SSI
    - Initiate assessment of corrective measures (40 CFR § 257.96)





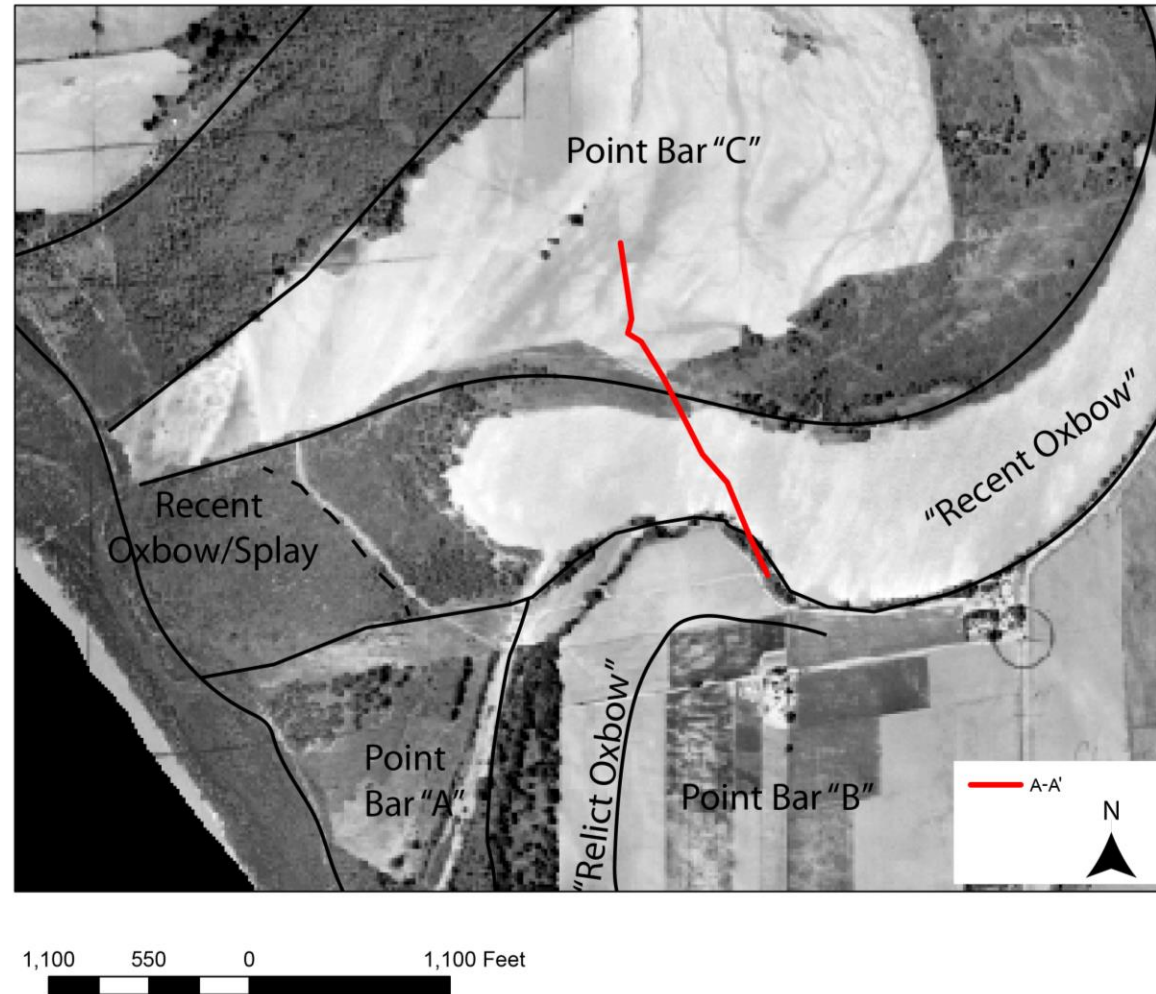
# **CSM DEVELOPMENT**

# CSM – ELEMENTS SPECIFIC TO CCR SITES

- ▶ Groundwater/surface water interaction
- ▶ Geochemical conditions
  - Speciation, mobility, attenuation potential
- ▶ Geology/stratigraphy
  - Impact of heterogeneity
- ▶ Hydrogeology
  - Variable flow regimes (spatial & temporal)
  - Contaminant transport (vertical and lateral)
  - Dewatering
- ▶ Risk Assessment
- ▶ Data gap identification



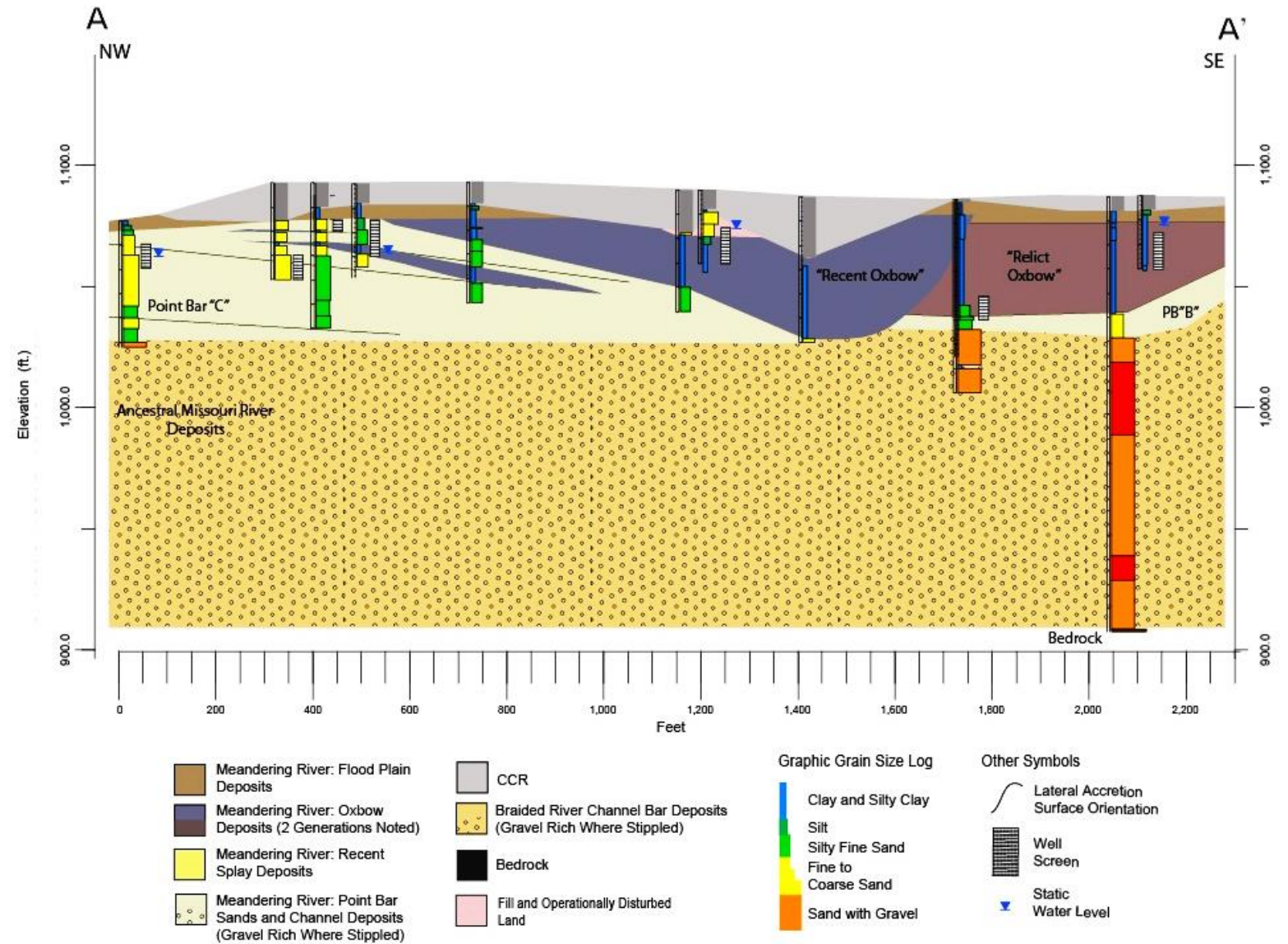
# SITE GEOMORPHOLOGY





# IMPACTS OF GEOMORPHOLOGY

## Environmental Sequence Stratigraphy (ESS) Evaluation





# GROUNDWATER FLOW REGIME

## Initial Evaluation



# GROUNDWATER FLOW REGIME

Refined Understanding





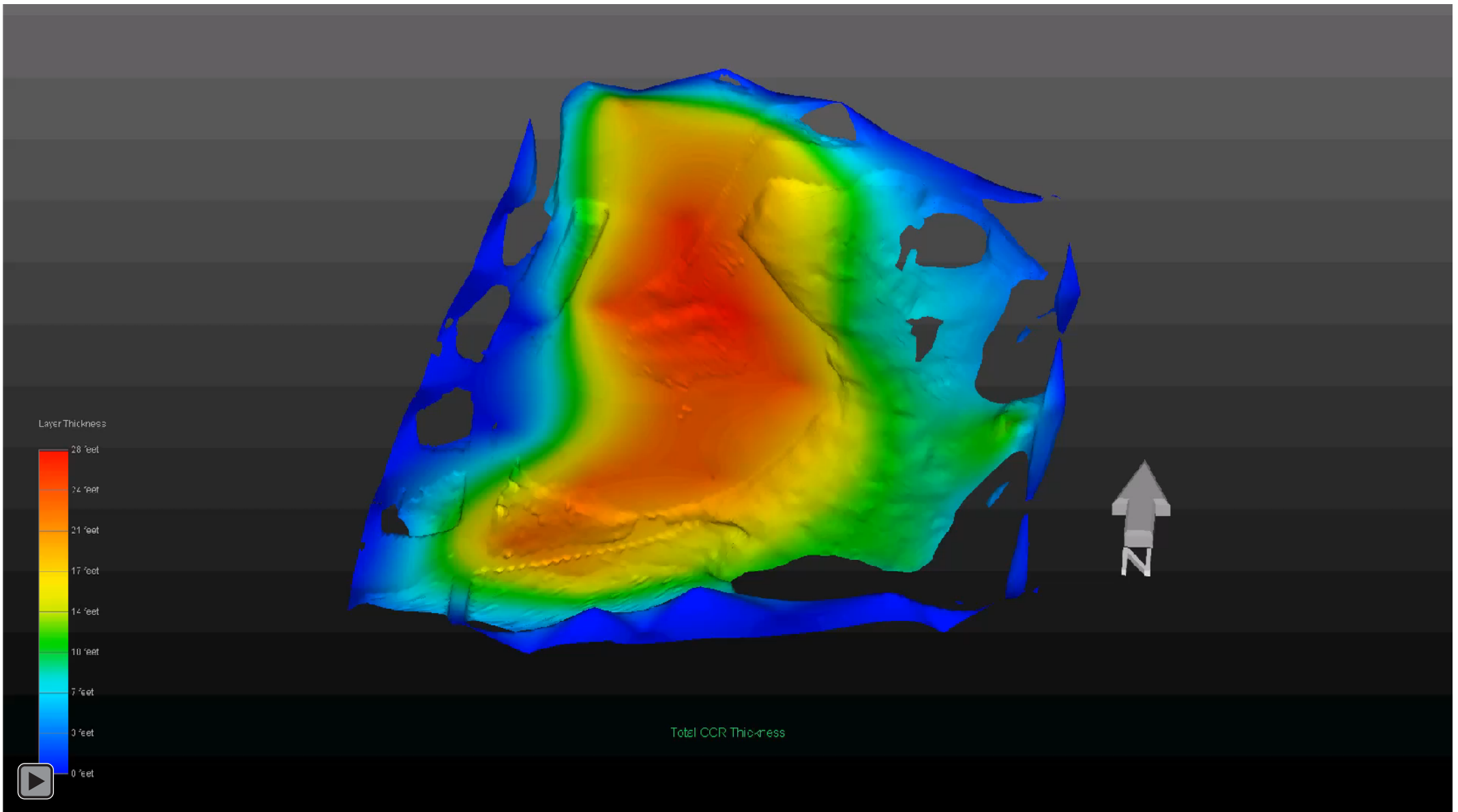
# GROUNDWATER FLOW REGIME

## ESS-based Understanding



# **THREE-DIMENSIONAL VISUALIZATION**

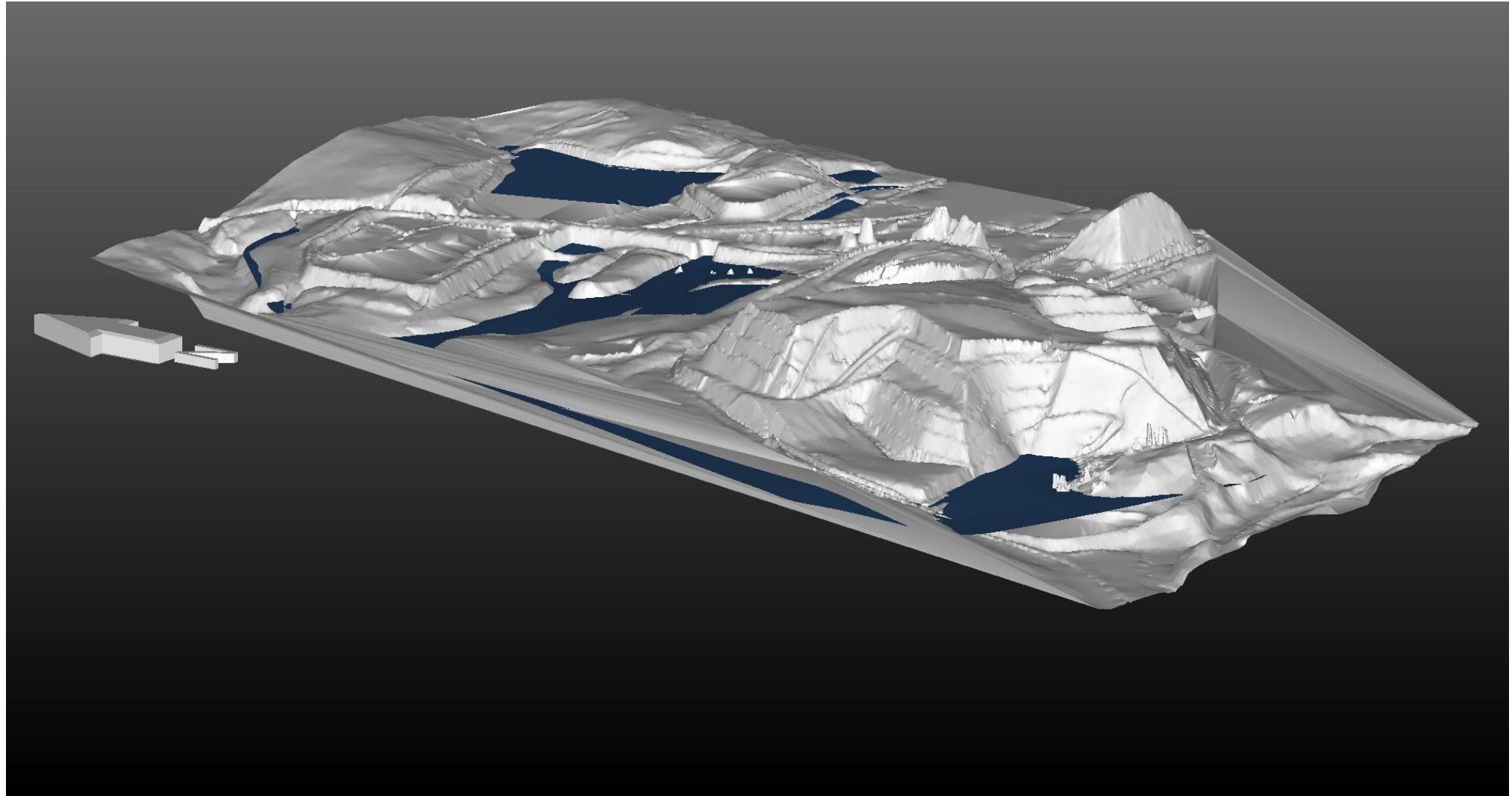






# **GROUNDWATER MODELING**

# SURFACE TOPOGRAPHY



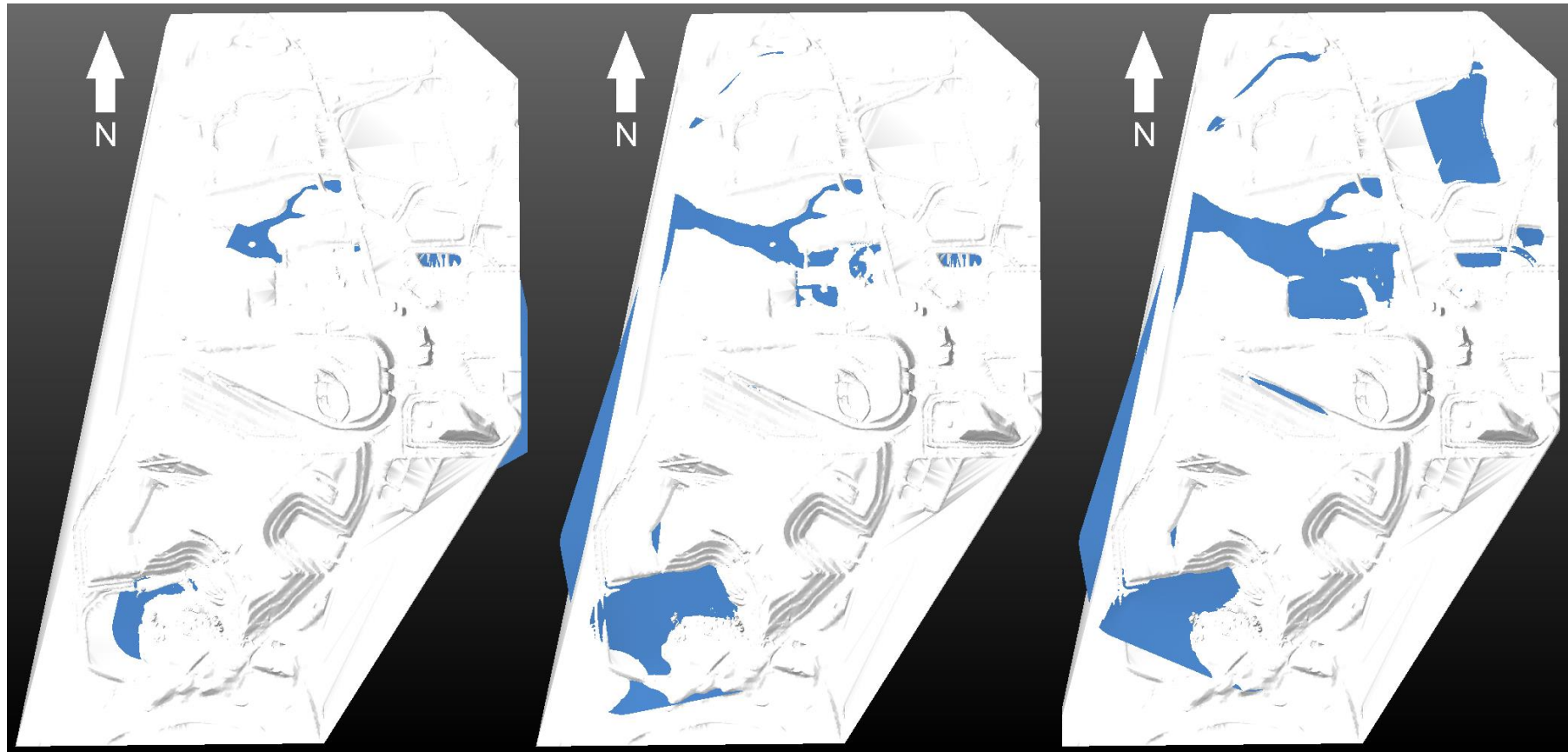


# LONGTERM GROUNDWATER ELEVATION TRENDS

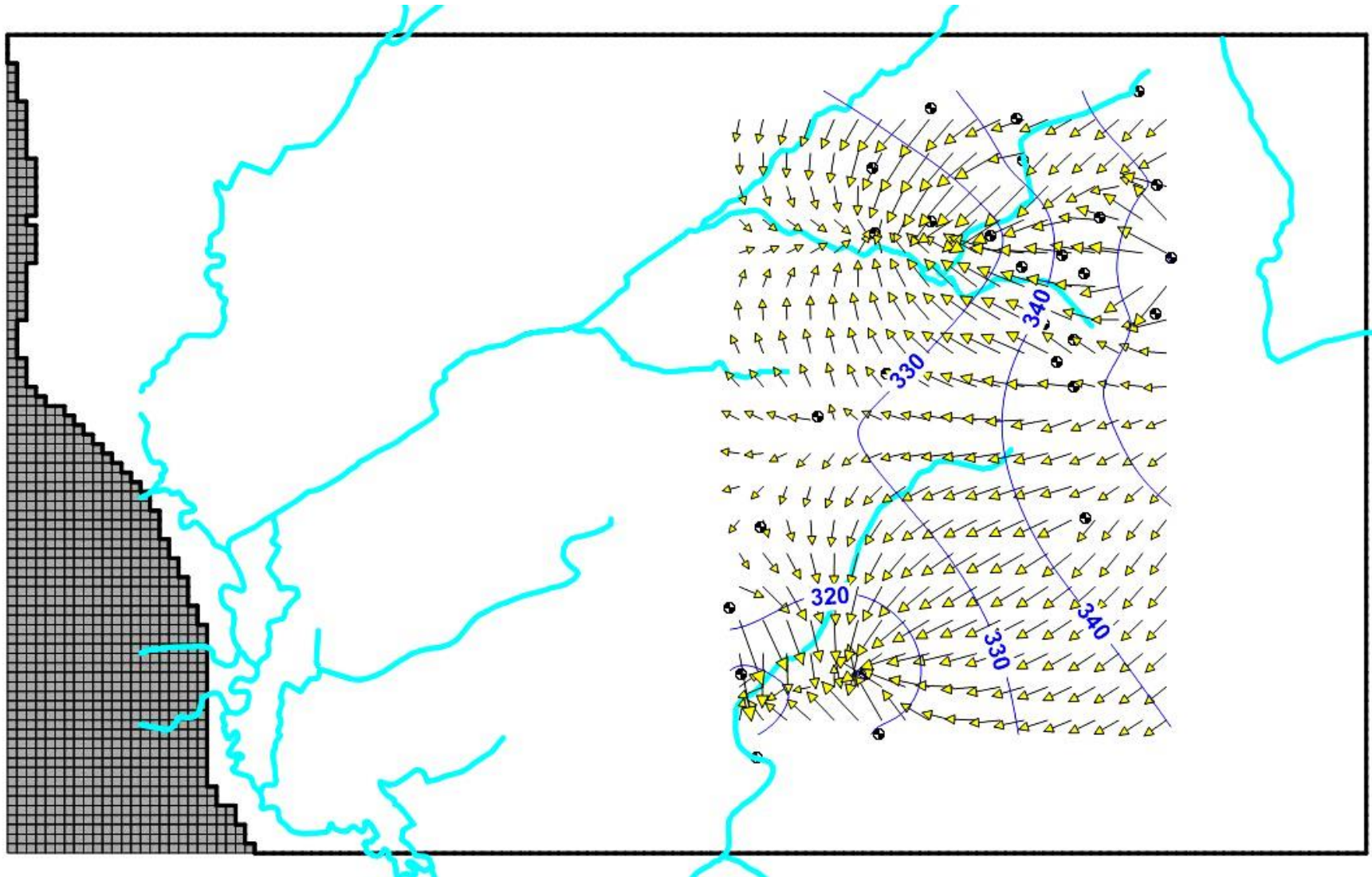
Year 0

Year 5

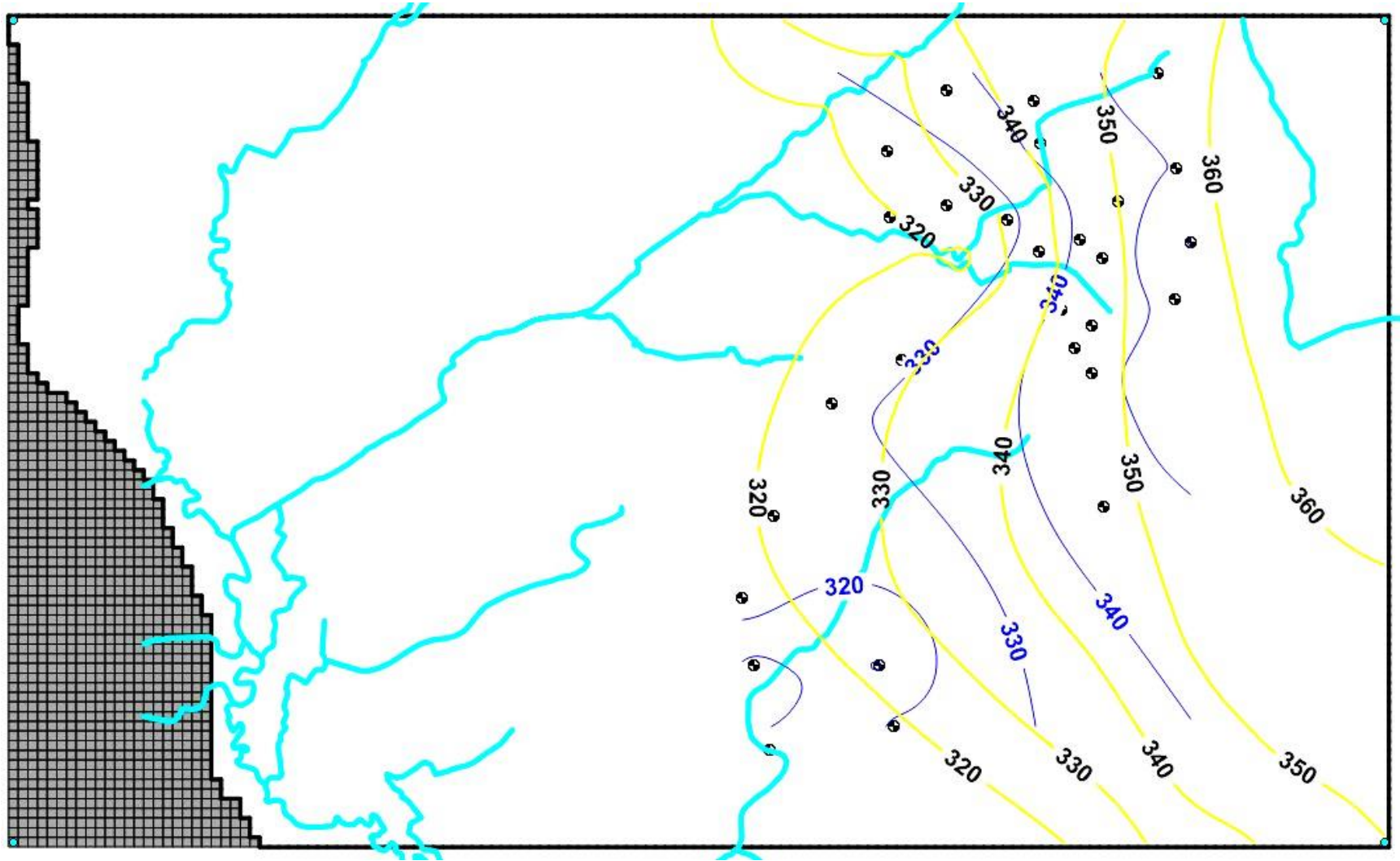
Year 10



# GROUNDWATER FLOW PATHS



# MODEL CALIBRATION



# **CORRECTIVE MEASURE DEVELOPMENT AND COST ESTIMATING**



# THE PROCESS

## Evaluation Process

- ▶ Cost
- ▶ Constructability
- ▶ Effectiveness
- ▶ Performance certainty
- ▶ Associated risk
- ▶ Other (as determined by owner/operator)

<sup>1</sup> (c) The assessment under paragraph (a) of this section must include an analysis of the effectiveness of potential corrective measures in meeting all of the requirements and objectives of the remedy as described under § 257.97 addressing at least the following:

(1) The performance, reliability, ease of implementation, and potential impacts of appropriate potential remedies, including safety impacts, cross-media impacts, and control of exposure to any residual contamination;

(2) The time required to begin and complete the remedy;

(3) The institutional requirements, such as state or local permit requirements or other environmental or public health requirements that may substantially affect implementation of the remedy(s).

(b) Remedies must:

(1) Be protective of human health and the environment;

(2) Attain the groundwater protection standard as specified pursuant to § 257.95(h);

(3) Control the source(s) of releases so as to reduce or eliminate, to the maximum extent feasible, further releases of constituents in appendix IV to this part into the environment;

(4) Remove from the environment as much of the contaminated material that was released from the CCR unit as is feasible, taking into account factors such as avoiding inappropriate disturbance of sensitive ecosystems;

(5) Comply with standards for management of wastes as specified in § 257.98(d).

CCR unit shall consider the following evaluation factors:

(1) The long- and short-term effectiveness and protectiveness of the potential remedy(s), along with the degree of certainty that the remedy will prove successful based on consideration of the following:

(i) Magnitude of reduction of existing risks;

(ii) Magnitude of residual risks in terms of likelihood of further releases due to CCR remaining following implementation of a remedy;

(iii) The type and degree of long-term management required, including monitoring, operation, and maintenance;

(iv) Short-term risks that might be posed to the community or the environment during implementation of such a remedy, including potential threats to human health and the environment associated with excavation, transportation, and re-disposal of contaminant;

(v) Time until full protection is achieved;

(vi) Potential for exposure of humans and environmental receptors to remaining wastes, considering the potential threat to human health and the environment associated with excavation, transportation, re-disposal, or containment;

(vii) Long-term reliability of the engineering and institutional controls; and

(viii) Potential need for replacement of the remedy.

(2) The effectiveness of the remedy in controlling the source to reduce further releases based on consideration of the following factors:

(i) The extent to which containment practices will reduce further releases; and

(ii) The extent to which treatment technologies may be used.

(3) The ease or difficulty of implementing a potential remedy(s) based on consideration of the following types of factors:

(i) Degree of difficulty associated with constructing the technology;

(ii) Expected operational reliability of the technologies;

(iii) Need to coordinate with and obtain necessary approvals and permits from other agencies;

(iv) Availability of necessary equipment and specialists; and

(v) Available capacity and location of needed treatment, storage, and disposal services.

(4) The degree to which community concerns are addressed by a potential remedy(s).

# VIABLE CORRECTIVE MEASURES

## Closure by Removal

- ▶ Removal of CCR (1.25 million cu. yd.)
- ▶ ROM Cost: \$115 million (\$92 / cu. yd.)
- ▶ Not a 'silver bullet' for groundwater



# VIABLE CORRECTIVE MEASURES

## In-situ Solidification/ Stabilization

- ▶ Stabilization of saturated CCR (0.25 million cu. yd.)
- ▶ ROM Cost: \$11 million (\$44 / cu. yd.)
- ▶ Potential risks: CCR disturbance, pH and geochemical impacts





# VIABLE CORRECTIVE MEASURES

## Slurry Wall

- ▶ ~2,600 feet to depth up to 50 feet
- ▶ ROM Cost:
  - \$6.4 million capital
  - \$40,000 (annual)
  - \$1.2 million (30 years)
- ▶ Potential risks: hydraulic failure





# VIABLE CORRECTIVE MEASURES

## Permeable Reactive Barrier

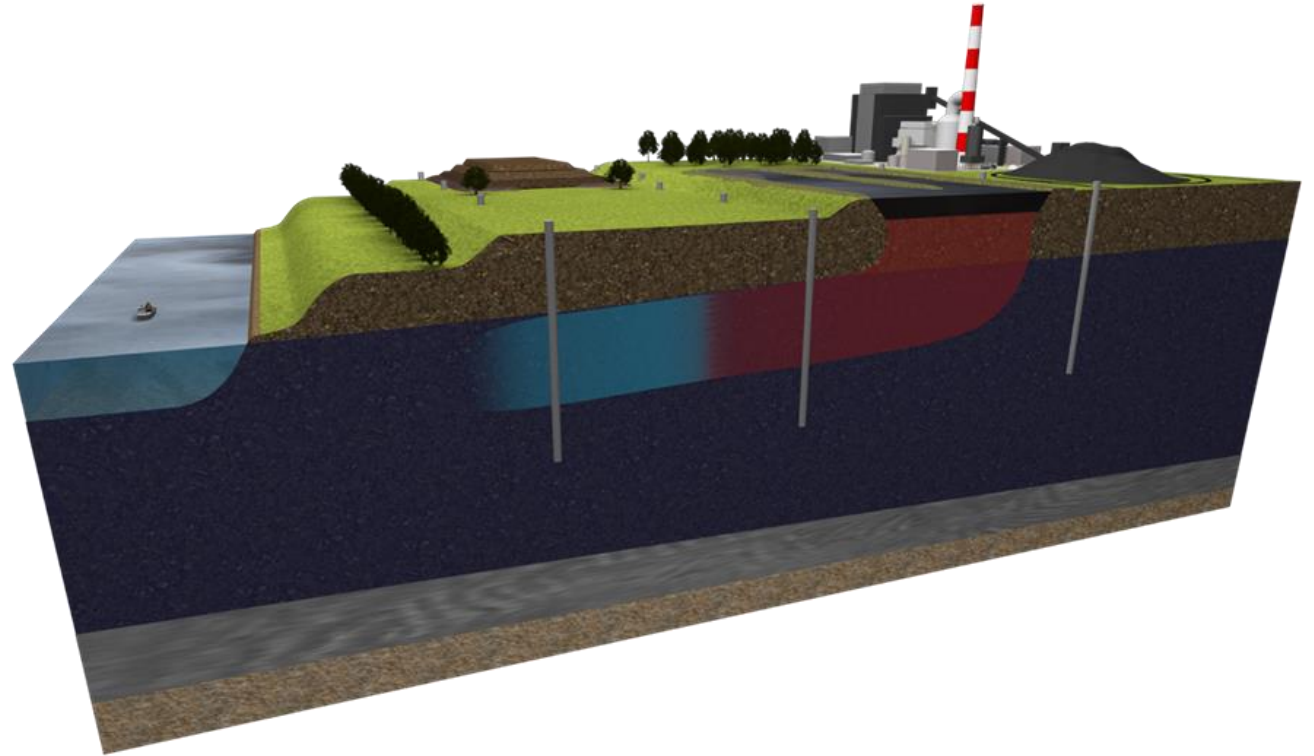
- ▶ ~2,600 feet to depth up to 50 feet
- ▶ ROM Cost:
  - \$4.6 million capital
  - \$120,000 (annual)
  - \$3.6 million (30 years)



# VIABLE CORRECTIVE MEASURES

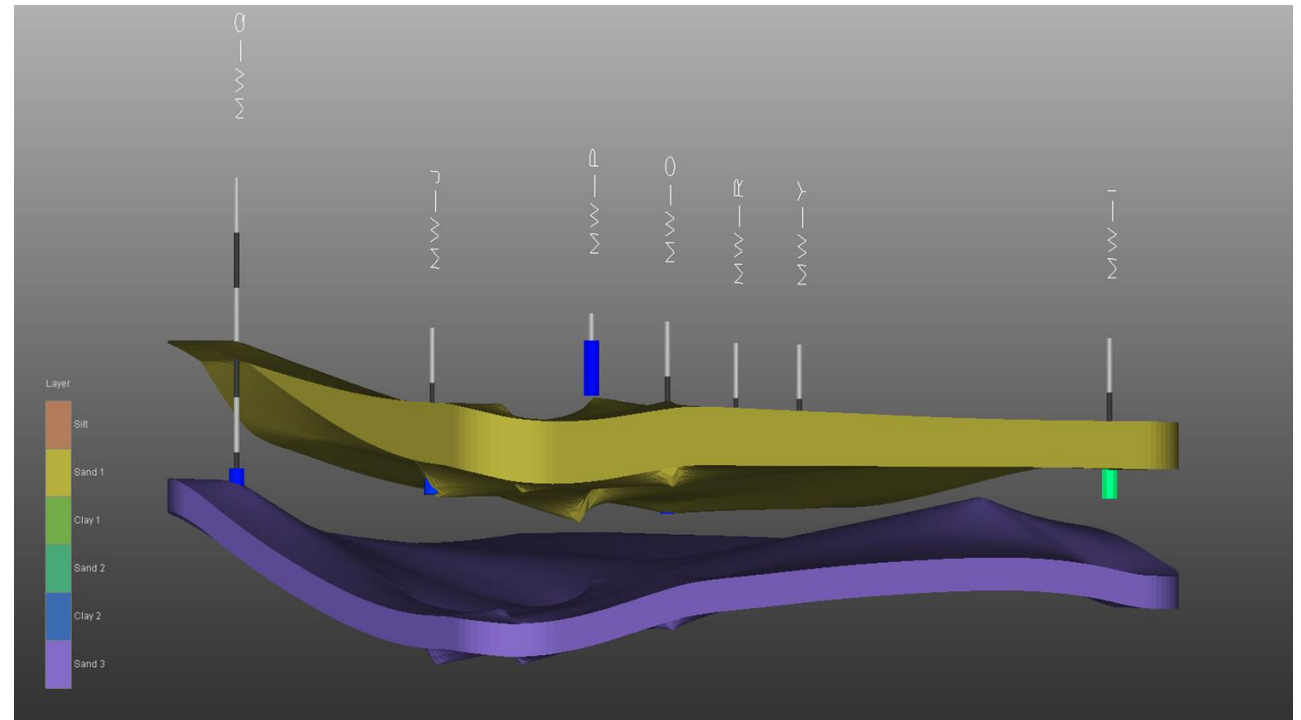
## Monitored Natural Attenuation

- ▶ Characterize nature and extent
- ▶ Natural attenuation demonstration
- ▶ ROM cost:
  - \$0.4 million capital
  - \$35,000 (annual)
  - \$1.1 million (30 years)



# KEY TAKEAWAYS

- ▶ Invest early in a strong CSM
- ▶ Don't underestimate the impacts of geochemistry and heterogeneity
- ▶ Stay informed of regulatory and legal developments



# GET IN TOUCH WITH US

**John Hesemann, PE**

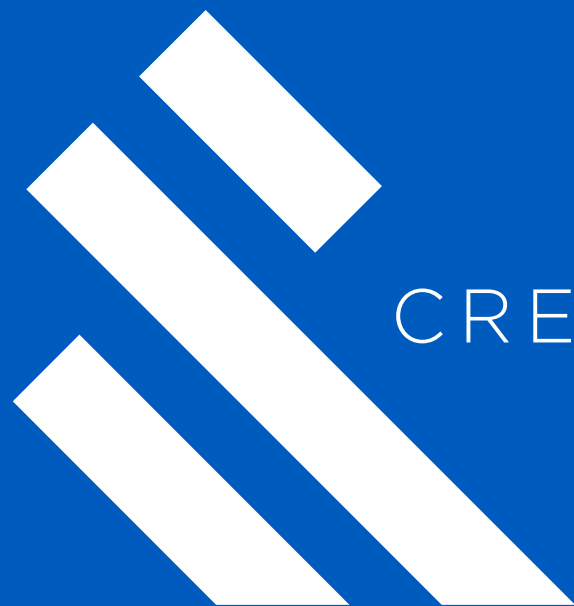
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CREATE AMAZING.