Beneficial Use of Harvested Ponded Fly Ash and Landfilled FGD Materials for High-Volume Surface Mine Reclamation

The Ohio State University

May 3, 2022

Project Objectives & Focus

A. Promote safe and cost-effective closure by removal of coal ash impoundments,

B. Harvest landfilled FGD, and

C. Promote high-volume beneficial use of these harvested coal combustion residues (CCRs) in reclamation of abandoned surface coal mine sites across the eastern and midwestern coal mining regions of the United States.

Focus on viability of beneficial use of harvested CCRs, especially ponded fly ash and landfilled FGD by-products (stabilized sulfite FGD material and FGD gypsum) in the vicinity (within 25 miles radius) of coal ash pond facilities and FGD landfills across the United States.

Methodology

Task 1.0 - Project Management and Planning

- *Subtask 1.1 – Project Management Plan*
- *Subtask 1.2 – Technology Maturation Plan*
- *Subtask 1.3 – Project Data Report*

Task 2.0 – Laboratory & Bench-Scale Testing

- *Subtask 2.1: Laboratory Testing*
- *Subtask 2.1.1 - Engineering Characterization*
- *Subtask 2.1.2 - Environmental Characterization*
- *Subtask 2.1.2.1 - Bulk Material Characterization*
- *Subtask 2.1.2.2 - Column Test*
- *Subtask 2.2 - Bench-Scale Testing*
- *Subtask 2.3 - Geochemical Modeling*
- *Subtask 2.4 – Assessment for Full-Scale Demonstration Project*

Task 3.0 - Conesville Full-Scale Demonstration Project

- *Subtask 3.1 – Pre-Constriction Assessment*
- *Subtask 3.2 – Pre-Constriction Permits*
- *Subtask 3.3: Removal and Placement of Ponded and Landfilled CCRs*
- *Subtask 3.4 – Reclamation Site Construction*
- *Subtask 3.5 - Environmental Monitoring*
- *Subtask 3.5.1 - Collecting Water Quality Data*
- *Subtask 3.5.2 - Statistical Analyses to Understand Occurring Geochemical Processes*
- *Subtask 3.5.3 – Isotope Analysis*
- *Subtask 3.6 - Appalachian Regional Reforestation*
- *Subtask 3.7 – Land End Use of Reclaimed Pond*
- *Subtask 3.8 - Technology Transfer*

Task 4.0 - Risk Analysis

- *Subtask 4.1 – Modeling of fate transport and geochemical reactions*
- *Subtask 4.2: Sensitivity analysis, model calibration, and validation*
- *Subtask 4.3. Human health and ecological risk evaluation*

Task 5.0 - Geographic Information System (GIS) Siting Study

- *Subtask 5.1 - Data Collection*
- *Subtask 5.2 - Data Analysis*
- *Subtask 5.3 - Reporting and Technology Transfer*
- *Subtask 5.4 - Assessment for Full-Scale Commercial Implementation*

Prep Work of AML Area

- Frontier began Site prep work in AML West and East Areas in July 2021
- Clearing of vegetation and general grading of areas of erosion along roads
- Dewatering Fly Ash in the ash pond complex for placement in the AML Areas
- Dewatering of AML East sedimentation pond

Placement of Material in Phase III AML East

- Frontier began placing FGD material to provide low permeability buffer for placement of dewatered Fly Ash and in AML East in August 2021
- FIC has placed the following materials (in the AML East Area) through the end of 2021 the following amounts have been placed

Placement of Materials AML East 2021	
Type of Material	Amount
FGD	128,110 Tons
Fly Ash	51,120 Tons
Bottom Ash	0 Tons

Placement of Material in Phase III AML West

- Frontier began placing dewatered Fly Ash and FGD material in AML West in August 2021
- In 2021 the following amounts have been placed in the AML West Area

Placement of Materials AML East 2021	
Type of Material	Amount
FGD	31,450 Tons
Fly Ash	2,500 Tons
Bottom Ash	0 Tons

AML West

AML East

FGD Landfill

Ash Ponds

Task 3.5 Monitoring Wells Drilling & Installation Update

Three new monitoring wells were installed in up-gradient locations on site.

Three of the previous 1700 series were grouted and abandoned.


HORIZONATAL DATUM: NAD83 OHIO NORTH ZONE
VERTICAL DATUM NAVD88
SURFACE WATER MONITORING SITE
ED EAST DETENTION POND
WD WEST DETENTION POND
MONITORING WELL
ODNR (DOMESTIC) WELL
BORING
1000ft HYDROLOGIC REVIEW BOUNDARY LINE
COUNTY ROAD 275
CONESVILLE CAPTIVE HAUL ROAD
1000FT HYDROLOGIC REVIEW BOUNDARY LINE
WD POND 2
OXFORD POND SW01
COUNTY ROAD 273
CONESVILLE PLANT ROADWAY
WD POND 1
CONESVILLE PLANT
COUNTY ROAD 271
PHASE 1 & 2
PHASE 3 WEST
SEDIMENTATION BASIN 3
SEDIMENTATION BASIN #3
EAST POND SW02 (DISCONTINUED)
SEDIMENT TRAP D
PHASE 3 EAST
SEDIMENT TRAP E
ED POND 1
ED POND 2
ED POND 3
STATE ROUTE 83
MW-2103
MW-2101
MW-2102
SW03
SW04
COLUMBUS SOUTHERN POWER COMPANY

Drilling Rig

New Wells:
- MW-2101
- MW-2102
- MW-2103

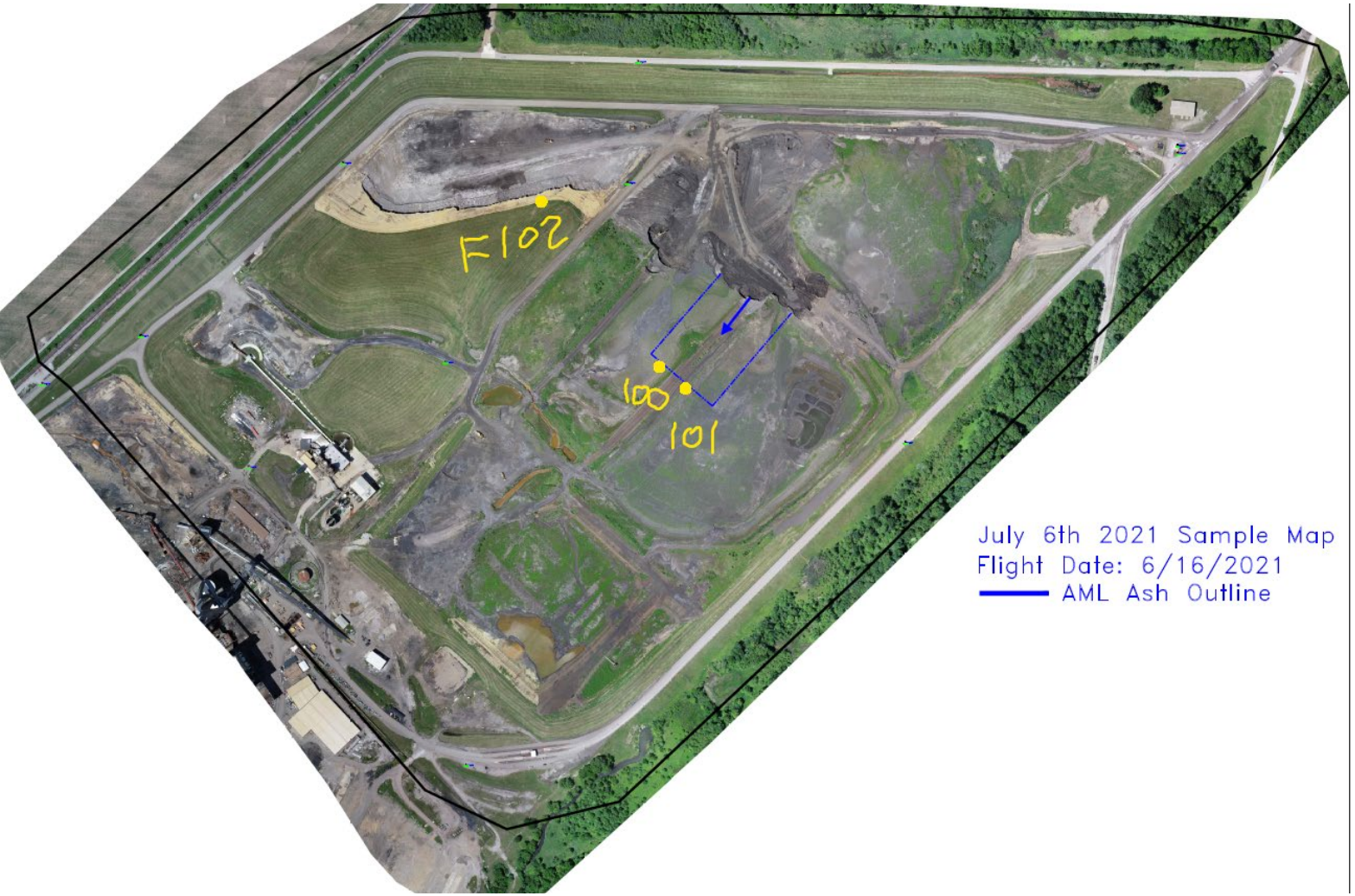
Drilling Dates:
- 11/16/2021 thru 11/29/2021
- By A Drilling Company, LLC

Survey Date: 12/6/2021
- By AG Engineering & Surveying

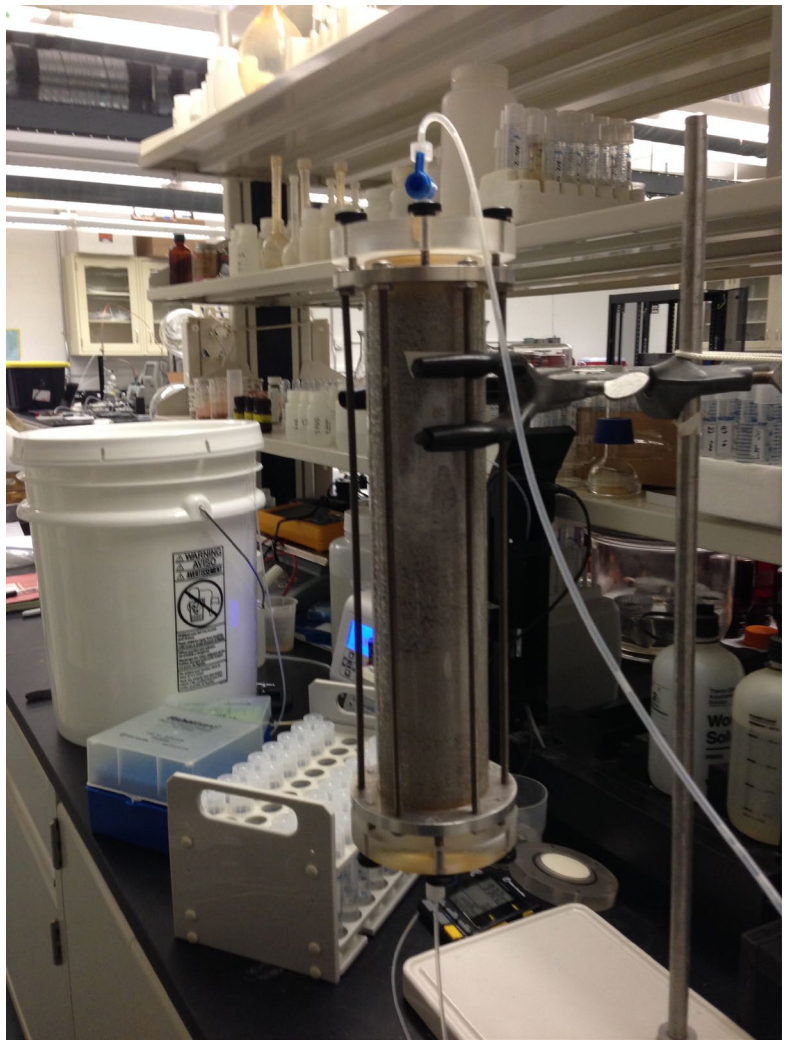
Closure of Wells

- MW-1703, MW-1704, & MW-1705 were grouted and closed on
- October 26, 2021.

Task 2.0 Harvested CCR Characterization



- Landfilled FGD material (F102) and ponded ash samples (100 and 101) were collected from the site (0-20’ in 5’ increment)
- Intact samples undergoing geotechnical properties testing for:
  - Particle size distribution
  - Strength
  - Permeability
- Air dried and homogenized samples are currently being analyzed for
  - Chemical composition
  - Mineral composition analysis
  - Isotope analysis

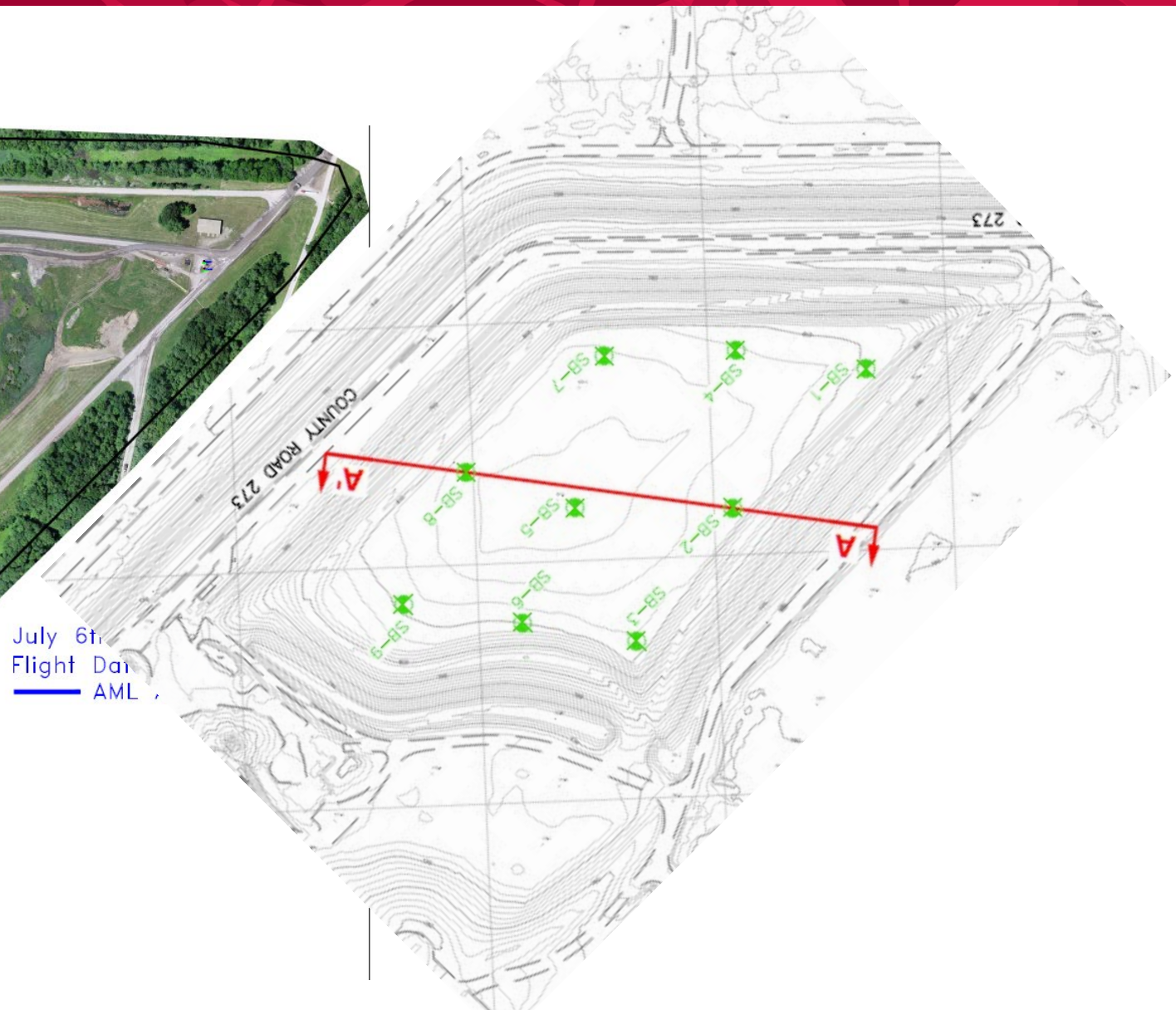


Column Test

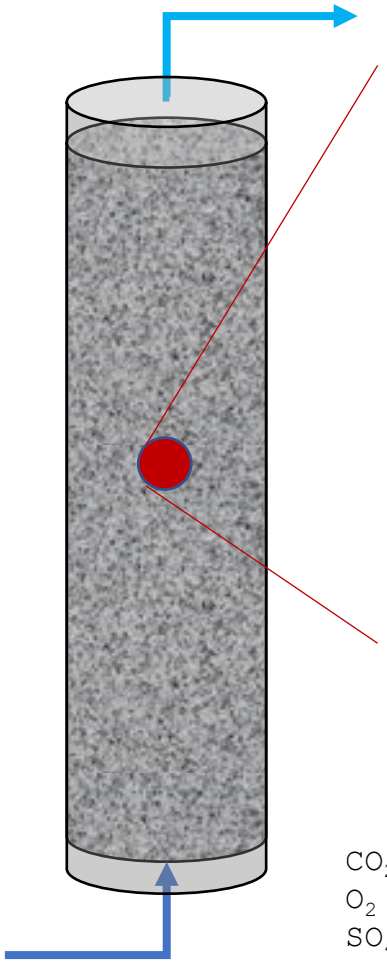
- Landfilled FGD material is used to backfill Phase 3.
  - Column 1: 10-20’
  - Column 2: 40-50’
  - Column 3: 65-75’
- Percolation rate: 0.8-1.2 L/S per day
- Synthesized rainwater
- 1st column test starts in April

Task 3.0


F102
100
101


COUNTY ROAD 273
A'
A
SB-1
SB-2
SB-3
SB-4
SB-5
SB-6
SB-7
SB-8
SB-9
July 6t
Flight Da
AML

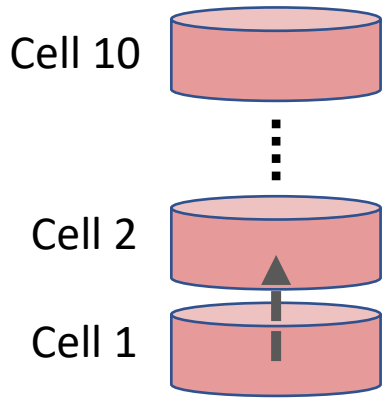
1-D Hydrogeochemical Transport Model



CO_2
O_2
SO_4^{-2}
NO_3^-

Mineral Phases

Calcite ($CaCO_3$)
Magnesite ($MgCO_3$)
Dolomite ($CaMg(CO_3)_2$)
Brucite ($Mg(OH)_2$)
Halite (NaCl)
Portlandite ($Ca(OH)_2$)
Epsomite ($MgSO_4:7H_2O$)
Ettringite
Hematite (Fe_2O_3)
Hannebachite ($Ca(SO_3):0.5(H_2O)$)
Magnetite
Quartz (SiO_2)
Sillimanite
Gypsum ($CaSO_4:2H_2O$)
$Fe(OH)_3$



Dissolution/Precipitation Kinetics

```
-start
 10 REM use the rate from Plummer and others (1978) for
dissolution or precipitation
 20 si_cc = SI("Calcite")
 30 if (M<=0 and SI_cc<0) then goto 350
 40 REM PARM(1)=specific surface area of calcite,
cm^2/mole calcite
 50 REM PARM(2)=exponent for m/m0
 60 REM PARM(3)=correction factor
 70 k1=10^(0.198-444.0/298.0)
 80 k2=10^(2.84-2177.0/298.0)
 90 k3=10^(-5.86-317.0/298.0)
100 IF M0>0 THEN area=PARM(1)*(M/M0)^PARM(2) ELSE
area=PARM(1)
110 rate = area *
(k1*ACT("H+")+k2*ACT("CO2")+k3*ACT("H2O"))
130 rate=rate*(1-10^(2/3*si_cc))
140 moles = rate*0.001*TIME
350 save moles
-end
```

$$R = k_1 \frac{A}{V}\left(\frac{m}{m_0}\right)^{0.67}\left(1-\left(\frac{IAP}{K}\right)\right)$$

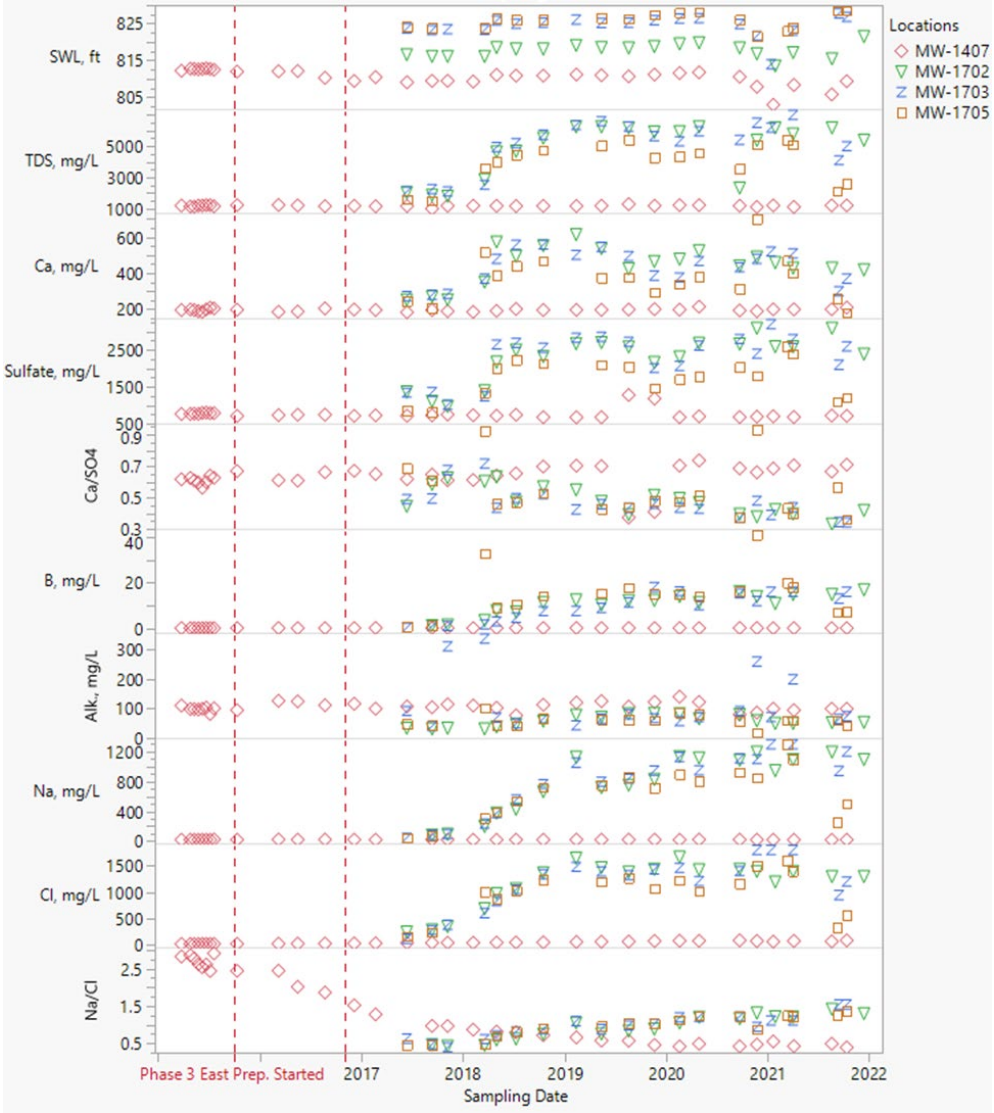
Transportation

$$C_L = \frac{C_i}{2}\left(erfc\left(\frac{1-x}{2\sqrt{x\alpha/L}}\right) + \exp\left(\frac{L}{\alpha}\right)\left(erfc\left(\frac{1+x}{2\sqrt{x\alpha/L}}\right)\right)\right)$$

Isotope Analysis

- Water samples were collected from the following locations in November 2021 for isotope analysis
  - MW-1701
  - MW-1703
  - MW-1705
  - MW-1401
  - MW-1403
  - MW-1407
  - MW-1409
  - MW-1507S
  - SW-04
  - ED-2
  - SW-03
- 11/10 B and 87/86 Sr
  - Stony Brook
- $\delta^{18}O$ and $\delta^{2}H$
  - Univ. of Buffalo
- $^{34}S/^{32}S$ and $^{18}O/^{16}O$ ratios
  - USGS

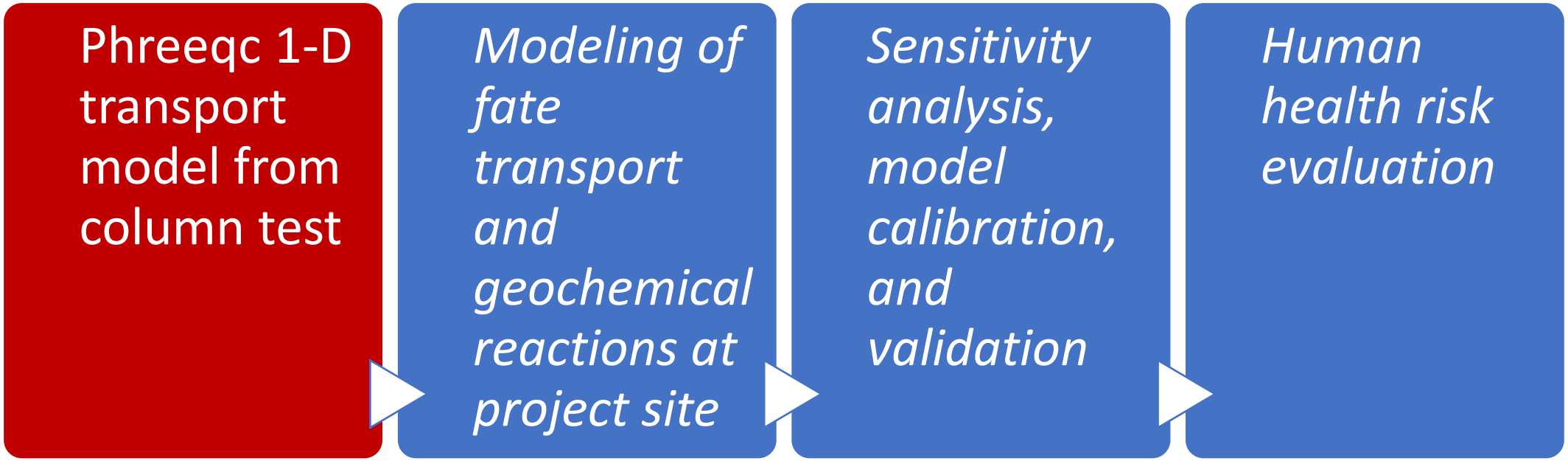
Water Quality Data Analysis



- Quarterly water samples are currently collected from 16 groundwater monitoring wells in Phase 3 area and 10 surface water sampling locations
- Water quality analysis was completed for data collected in 2021
  - temporal trends
  - principal component analysis
  - equivalent ratios of Ca/sulfate, Na/Cl, and Ca/Alkanility to detect change of hydrogeochemical characteristics

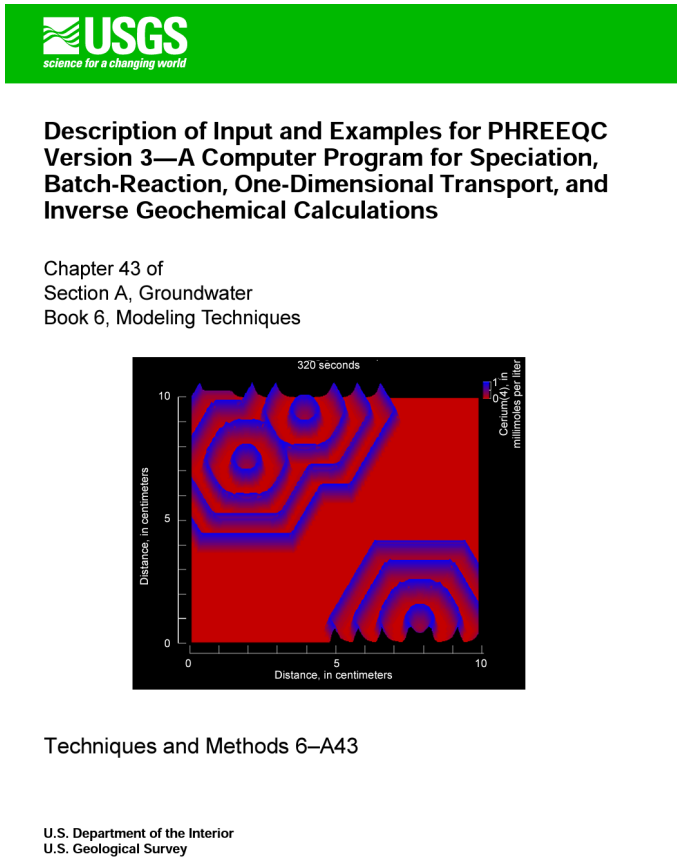
Task 4.0 Risk Analysis

Goal: to assess human health risks posed by exposure to pollutants



Modeling of fate transport and geochemical reactions

- This will be facilitated through computational models such as
  - PHAST and
  - water quality analysis simulation program (WASP)

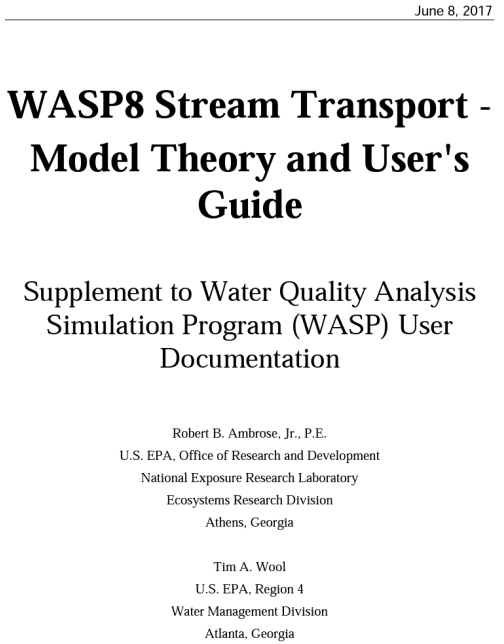

USGS
science for a changing world

Description of Input and Examples for PHREEQC Version 3—A Computer Program for Speciation, Batch-Reaction, One-Dimensional Transport, and Inverse Geochemical Calculations

Chapter 43 of
Section A, Groundwater
Book 6, Modeling Techniques

Techniques and Methods 6–A43

U.S. Department of the Interior
U.S. Geological Survey


June 8, 2017

WASP8 Stream Transport - Model Theory and User's Guide

Supplement to Water Quality Analysis Simulation Program (WASP) User Documentation

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Sensitivity analysis, model calibration, and validation

- The computational models will be calibrated and validated against site measurements
- Using machine learning techniques, we will train a surrogate model to emulate the computational models
- Global sensitivity studies will be performed using the surrogate model

Human health risk evaluation

- It will be characterized in terms of cancer and noncancer risks
- It can be measured in terms of the excess lifetime cancer risk for individuals exposed to contaminants
- We will use simulation methods to propagate uncertainties

Task 5.0 GIS Study Update

Goal: Identify Dangerous Highwalls, Highwalls, & pits within a 25-mile radius & 50-mile radius of CCR Impoundments and FGD landfills that could be viable for Coal Combustion byproducts with the Appalachian & Illinois Basin Area.

Basin Areas Contain

Appalachian Basin Area Contain:

Ohio
Pennsylvania
West Virginia

Illinois Basin Area Contain:

Illinois
Indiana

Progress

Completed work by OSU - Robert Baker with the help of Tom Henry

- Shapefiles for recorded dangerous highwalls, highwalls, and pits came from OSMRE database
- US CCR Impoundment Sites
- Ohio Sites have been evaluated

Current direction of work to be completed by Amanda Graphics, LLC with the help of Tyler Voss

- US CCR Impoundment & FGD Landfill Sites - Refining the search criteria initially found to be the actual facility and ideally the impoundment itself for PA, WV, IL, IN
- Evaluation of the 25-mile & 50-mile radius to get top candidate sites.

Final Product

Map for each state showing CCR Impoundment & FGD Landfill Locations

Map for each state showing dangerous highwall, highwall, & pit locations

Radius map –25 & 50 mile from each CCR Impoundment Location per state.

Final Figure per state showing potential reclamation sites using CCRs.

Goals / Expected Results

- Successful completion of this project will result in increased beneficial use of impounded and landfilled CCRs.
- Our research will address both of the R&D approaches listed under AOI 1 (Advanced Concepts & Technologies to Increase Beneficial Use of CCR):
  - First, use of landfilled CCRs (such as stabilized sulfite FGD material and FGD gypsum) will result in increased beneficial utilization of CCRs in high volume mine reclamation applications. These CCRs have already been disposed as undesirable wastes.
  - Secondly harvesting of CCRs (especially fly ash and incidental amounts of bottom ash) from closed out and active impoundments will allow for removal of these CCRs for high-volume beneficial use.