DOE-FIU Cooperative Agreement Annual Research Review – FIU Year 1

September 14, 2021		
9:00 - 9:05 am EDT	Kick-Off	Kurt Gerdes (Director, Technology Development) – DOE EM-3.2
9:05 - 9:10 am EDT	Welcoming Remarks (DOE-EM)	Nicole Nelson-Jean (Assoc. Principal Deputy Asst. Secretary for Field Ops) – DOE EM-3
9:10 - 9:15 am EDT	Welcoming Remarks (DOE-LM)	Carmelo Melendez (Director, Office of Legacy Management) – DOE LM-1
9:15 - 10:30 am EDT	Projects 4 & 5: STEM Workforce Development and Training	FIU, DOE HQ (EM & LM), SRNL, PNNL, WIPP, SRS, ORP, LBNL, WRPS, INL, Grand Junction
10:30 am - 12:00 pm EDT	Project 1: Chemical Process Alternatives for Radioactive Waste	FIU, DOE HQ, PNNL, WRPS, SRNL, SRS
1:30 - 3:00 pm EDT	Project 3: Waste and D&D Engineering & Technology Development	FIU, DOE HQ, SRNL, PNNL, LBNL, INL, ANL
3:00 - 4:30 pm EDT	Project 2: Environmental Remediation Science & Technology	FIU, DOE HQ, SRNL, PNNL, LANL, ORNL
September 15, 2021		
9:30 - 11:00 am EDT	Wrap Up (FIU Projects 1, 2, 3, 4 & 5)	FIU, DOE HQ (EM & LM)

PROJECT 2

Environmental Remediation Science & Technology

FIU Personnel and Collaborators

Principal Investigator: Leonel Lagos

Project Manager: Yelena Katsenovich

Faculty/Staff: Ravi Gudavalli, John Dickson, Vadym Drozd, Angelique Lawrence, Hamid Bazgirkhoob, *Muhammad Alam

Postdoctoral Fellows: *Yan Zhou, *Shambu Kandel

DOE Fellows/Students: *Silvina Di Pietro, Juan Morales, *Katherine De La Rosa, *Alexis Vento, Gisselle Gutierrez, *Nathalie Tuya, Mariah Doughman, Phuong Pham, Jonathan Williams, Stevens Charles, Angel Almaguer.

DOE-EM: Genia McKinley, Kurt Gerdes, Paul Beam, Skip Chamberlain, Nick Machara, John Mocknick

DOE-SRS: Jeff Crenshaw, Nixon Peralta

SRNL: Brian Looney, Hansell Gonzalez-Raymat, Carol Eddy-Dilek, Daniel Kaplan, Mark Amidon, Bruce Wiersma, Connie Herman

SREL: John Seaman

PNNL: Vicky Freedman, Nik Qafoku, Jim Szecsody, Hilary Emerson, Matthew Asmussen

LANL: Paul Dixon, Don Reed, Juliet Swanson, David Moulton

DOE-CBFO: Anderson Ward, Russ Patterson

ORNL: Eric Pierce, Alexander Johs

*Former staff/student contributors

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Project Tasks and Scope

TASK 1: REMEDIATION RESEARCH AND TECHNICAL SUPPORT FOR THE HANFORD SITE	
Subtask 1.1	Remediation Research of Ammonia Gas for Uranium Treatment
Subtask 1.2	Re-oxidation of Redox Sensitive Contaminants Immobilized by Strong Reductants **(NEW)**
Subtask 1.3	Eval. of Competing Attenuation Processes for Mobile Contaminants in Hanford Sediments **(NEW)**
Subtask 1.4	Experimental Support of Lysimeter Testing
TASK 2: REMEDIATION RESEARCH AND TECHNICAL SUPPORT FOR THE SAVANNAH RIVER SITE	
Subtask 2.1	Environmental Factors Controlling the Attenuation and Release of Contaminants in the Wetland Sediments at Savannah River Site Sediments **(NEW)**
Subtask 2.2	Humic Acid Batch Sorption Experiments with SRS Soil
TASK 3: CONTAMINANT FATE AND TRANSPORT MODELING FOR THE SAVANNAH RIVER SITE	
Subtask 3.1	Calibration of the Tims Branch Watershed Model and Scenario Analysis
Subtask 3.2	Model Development for the Fourmile Branch and/or Lower Three Runs Watersheds **(NEW)**
TASK 5: RESEARCH AND TECHNICAL SUPPORT FOR WIPP	
Subtask 5.2	Fate of Actinides in the Presence of Ligands in High Ionic Strength Systems
TASK 6: HYDROLOGY MODELING FOR WIPP	
Subtask 6.1	Digital Elevation Model and Hydrologic Network
Subtask 6.2	Model Development
TASK 7: ENGINEERED MULTI-LAYER AMENDMENT TECHNOLOGY FOR HG REMEDIATION ON OAK RIDGE RESERVATION (NEW)	

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Task 1

Remediation Research and Technical Support for the Hanford Site

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Subtask 1.1: Remediation Research of Ammonia Gas for Uranium Treatment

Site Needs:

- DOE-EM has a critical need to understand the geochemical reactions that may occur with pH manipulations via alkaline treatment for uranium (U) sequestration in the vadose zone following release of >200,000 kg of U during WWII and the Cold War. Alkaline pH manipulation is a potential remediation technology that can lead to incorporation of U(VI) into the sediments. These studies complement the applied work at the field scale with contaminated sediments as it provides a more fundamental understanding of the dominant mechanisms controlling U fate and provide information that can potentially aid in the interpretation of long-term monitoring of the disposal sites.

Objectives:

- To conduct speciation modeling via Geochemist's Workbench® software using input data relevant to 200 Area aqueous system conditions. This helps to predict the U-solid phases formed after pH manipulation via NH_3 gas (95%N_2/5% NH_3 gas) injections. The output data help to predict the U-solid phases formed and thus, understand the long-term effectiveness of this potential remediation technique as well as provide useful parameters for risk assessment models.

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Subtask 1.1: Remediation Research of Ammonia Gas for Uranium Treatment

FIU Year 1 Research Highlights & Accomplishments:

- Speciation modeling used to predict the formation of U solid phases likely to be present in our experiments
  - The Geochemist Workbench® (GWB) version 12.0 with the Visual *MINTEQ* database
  - Manually updated the database with the most recently published thermodynamic equilibrium constants
  - K-boltwoodite, Na-boltwoodite, and uranophane are the most likely to precipitate. They are the most common uranyl silicate solid phases found in the vadose zone environment at Hanford Site (Szecsody et al., 2012; Um et al., 2009; Zachara et al., 2007).

- Calcite is abundant in the Hanford soil and it exists as a mineralogical component in all of subsurface sediments.
- Groundwater and pore waters are in equilibrium with calcite (Liu *et al*., 2004). As a result, U is likely to be coprecipitated with calcite.

Uranyl mineral phases used in the Geochemist Workbench® speciation modeling

Mineral Phase	Structural Formula
Uranyl Carbonates	
Liebigite	$Ca_2UO_2(CO_3)_3 \cdot 10H_2O$
Uranyl hydroxides	
Clarkeite	$Na(UO_2)O(OH)$
Uranyl Silicates	
K-Boltwoodite	$KH_4SiO_4\ UO_2\ \cdot 1.5H_2O$
Na-Boltwoodite	$NaHSiO_4\ UO_2\ \cdot 1.5H_2O$
Uranophane	$Ca(UO_2)_2(HSiO_4)_2\ 5H_2O$

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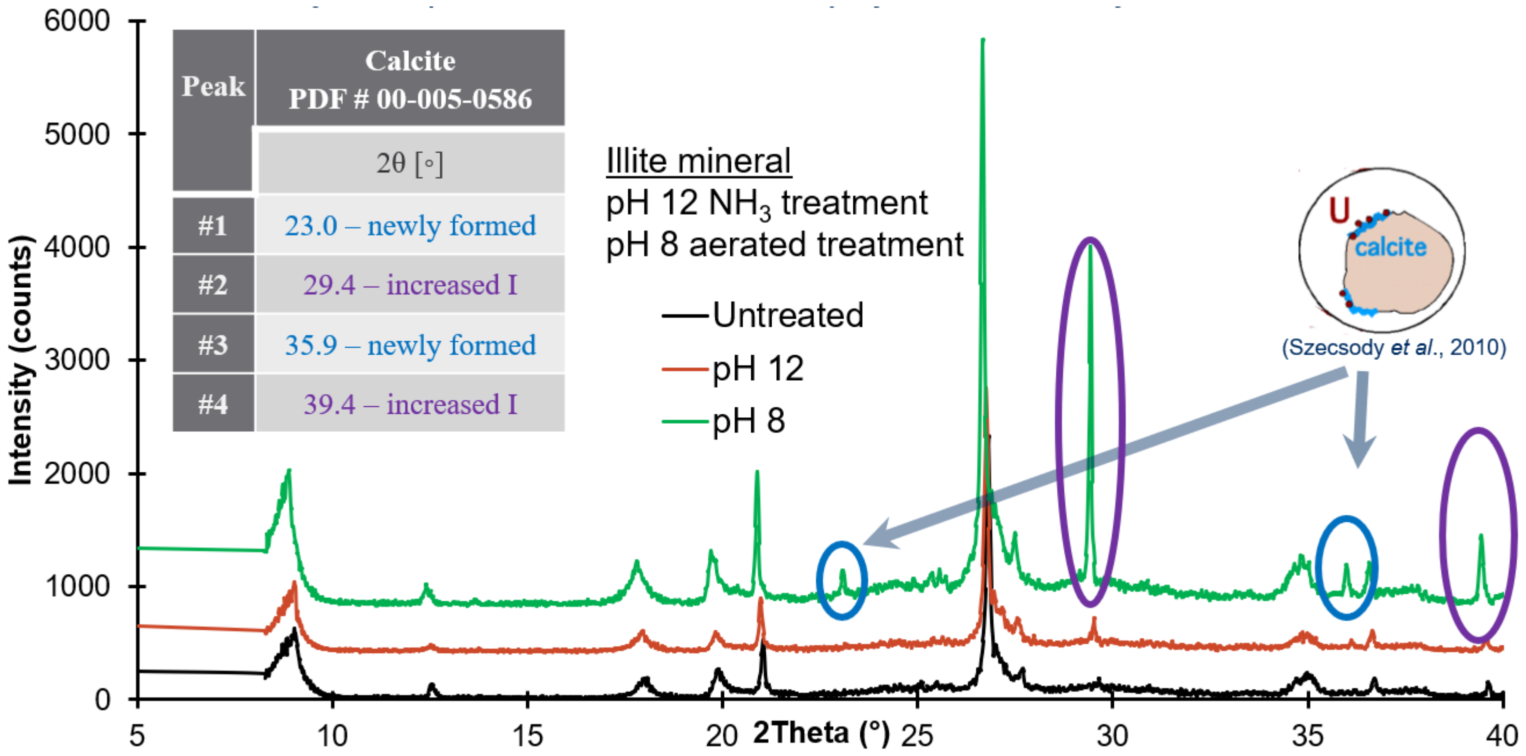
Subtask 1.1: Remediation Research of Ammonia Gas for Uranium Treatment

FIU Research Major Findings:

- ***Multi U-removal processes:*** Four different mechanisms for U-sequestration:
    1. Fe-oxide formation (EMPA)
    2. Co-precipitation of reduced U(IV) (XANES)
    3. Coating of U phases with secondary phases (Al/Si from *incongruent dissolution phenomena*)
    4. Secondary calcite precipitation (XRD) shown in blue circles figure on the right →



Subtask 1.1: Remediation Research of Ammonia Gas for Uranium Treatment

FIU Year 1 Research Highlights & Accomplishments:

- Di Pietro, *et al*., Solid phase characterization and transformation of illite mineral with gas-phase ammonia treatment (under review in the *Journal of Hazardous Materials*).
- Di Pietro, *et al*., Phyllosilicate mineral dissolution upon alkaline treatment under aerobic and anaerobic conditions, 2020. *Applied Clay Science*, v.189, p.105520
- Emerson, H.P *et al.*, 2018 Uranium immobilization in the presence of minerals following remediation via base treatment with ammonia gas, *Journal of Environmental Management*, 223, 1, 108-114. DOI: 10:1016/jenvman.2018.06.12
- Katsenovich, *et al*., 2018. Assessment of Calcium Addition on the Removal of U(VI) in the Alkaline Conditions Created by NH_3 Gas. Applied Geochemistry, 92, p.94-103.
- Emerson, *et al*., 2017. Effects of ammonium on uranium partitioning and kaolinite mineral dissolution. *Journal of Environmental Radioactivity* 167,150-159.
- Katsenovich, *et al*., 2016. The effect of Si and Al concentrations on the removal of U(VI) in the alkaline conditions created by NH_3 gas. *Applied Geochemistry*, 73, p. 109-117
- Seven presentations on the WM conferences and proceeding manuscripts including one awarded as “Paper of Note” (2016)
- Students posters at WM and other students poster competitions.

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FIU Year 2 Projected Scope

- FIU completed Subtask 1.1 “Remediation Research of Ammonia Gas for Uranium Treatment”.
- The research results based on this task were included in two Master’s theses by:
  - **Robert Lapierre** (May 2018, chemistry)
  - **Alberto Abarca** (December 2018, environmental engineering)
- And two PhDs defended by:
  - **Claudia Cardona** (May 2017, environmental engineering)
  - And most recently **Silvina Di Pietro**, who successfully defended her thesis and graduated with a PhD degree in chemistry in April 2021. Silvina is currently working at NNSA as a postdoctorate fellow.

Silvina Di Pietro
DOE Fellow Class of 2015

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National Nuclear Security Administration

Subtask 1.2: Re-oxidation of Redox Sensitive Contaminants Immobilized by Strong Reductants

Site Needs:

- Subtask supports evaluation of potential *in situ* treatment technologies for the vadose zone, groundwater and perched water zone located within the 200 Area at Hanford. This research evaluates re-oxidation kinetics of ^{99}Tc in the presence of other co-contaminants (e.g., ^{238}U and nitrate) after initial immobilization via reduction. The results from these batch experiments will be used to determine the rate and extent of Tc remobilization in the presence of co-contaminants and provide insights for remedial actions.

Objectives:

- To study re-oxidation kinetics of perched (PW) and groundwater (GW) contaminants, such as $^{99}Tc^{(VII)}$, in the presence of ^{238}U, and NO_3^-, that have been initially reduced by strong reductants such as ZVI, SMI and CPS in batch-scale experiments under anaerobic initial conditions followed by aerobic conditions. Sediment samples that evaluated in these experiments include ^{99}Tc comingled with uranium and nitrate.

Subtask 1.2: Re-oxidation of Redox Sensitive Contaminants Immobilized by Strong Reductants

FIU Year 1 Research Highlights & Accomplishments:

- Batch experiments to study re-oxidation kinetics of reduced ^{99}Tc comingled with ^{238}U and nitrate after treatment with strong reductants- 0.1% Zero valent iron (ZVI) and 0.1% Sulfur modified iron (SMI) mass of GW or PW.
- Used sieved Ringold Formation sediment <2 mm in triplicate samples
- Two phases of experiments:
  - 1. Reduction of ^{99}Tc, U and NO_3^- in the presence of strong reductants under anaerobic conditions for up to 30 days
  - 2. Re-oxidation of ^{99}Tc and other contaminants under aerobic conditions for up to 45 days. Total testing duration is 75 days
- Measured pH, oxidation reduction potential (ORP), dissolved oxygen (DO), Tc, U, Fe concentrations at each sampling point.
- Test matrix:
  - Prepared synthetic solutions of GW and PW
  - Purged with N_2, pH adjusted, and spiked with ^{99}Tc, ^{238}U, and NO_3^-
  - PW: pH 8.2 & 10µg/L Tc, 150 mg/L U.
  - GW: pH 7.8 and 420µg/L Tc, 124 mg/L NO_3^-
- Phase 1 DO and ORP measurements showed ~0.03-0.05 mg/L and -200 mV -300 mV, respectively, indicative of reducing conditions.
- Phase 2 DO and ORP showed an increase of DO concentrations up to 5-6 mg/L and ORP up ranging from +200 to +500 mV consistent with oxidative conditions.

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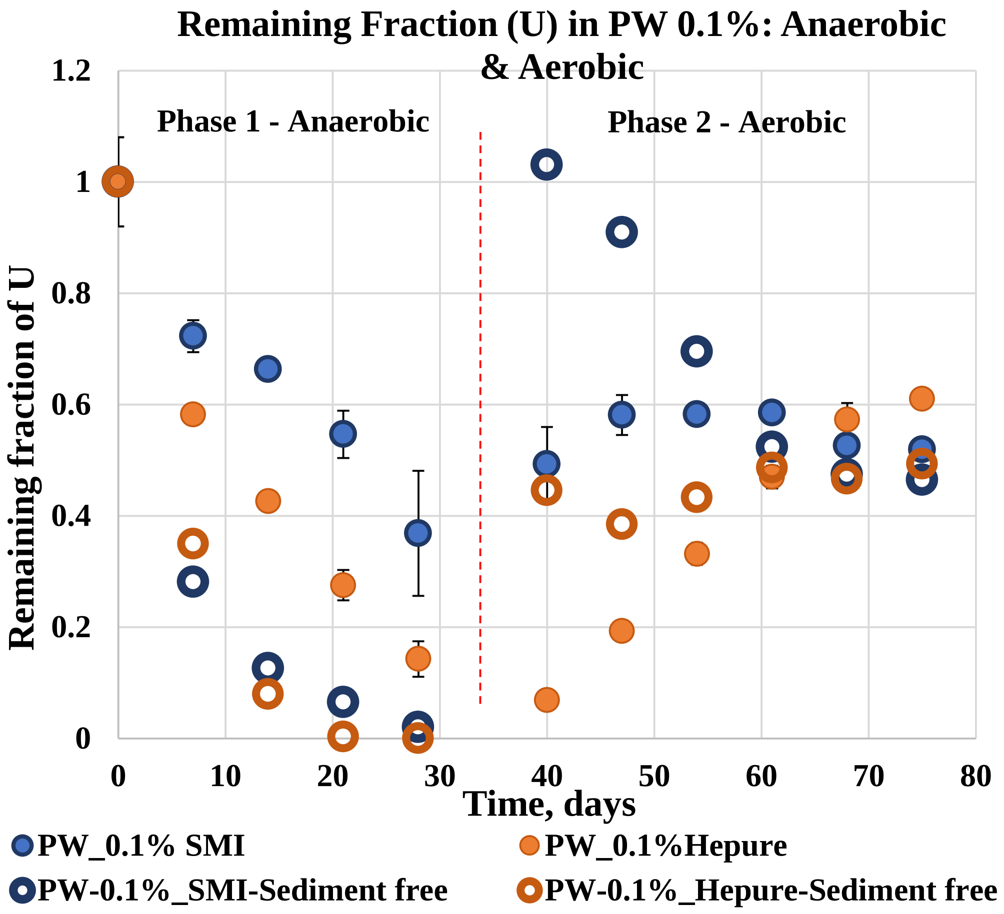
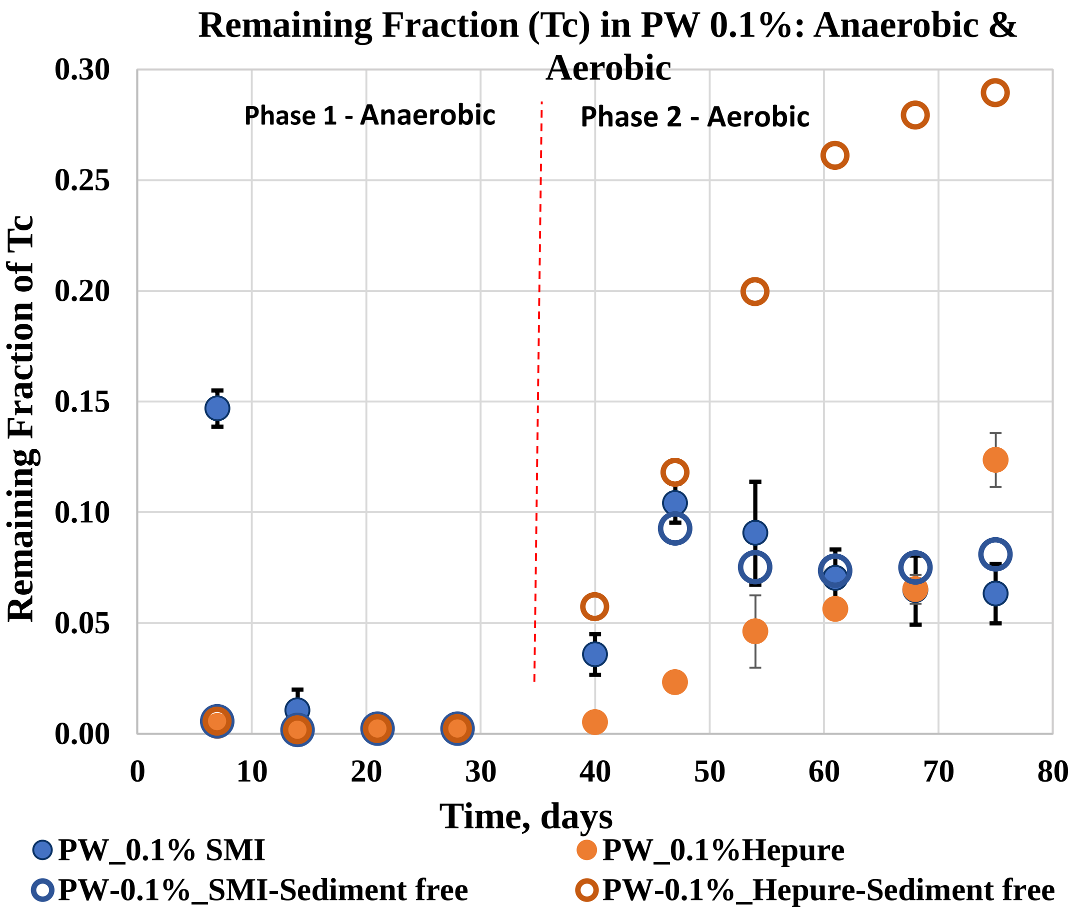
Subtask 1.2: Re-oxidation of Redox Sensitive Contaminants Immobilized by Strong Reductants

FIU Year 1 Research Highlights & Accomplishments:





In anaerobic conditions Hepure ZVI was more effective reductant than SMI. In aerobic conditions, SMI was more effective in resisting re-oxidation. This tendency was similar in sediment-free samples.

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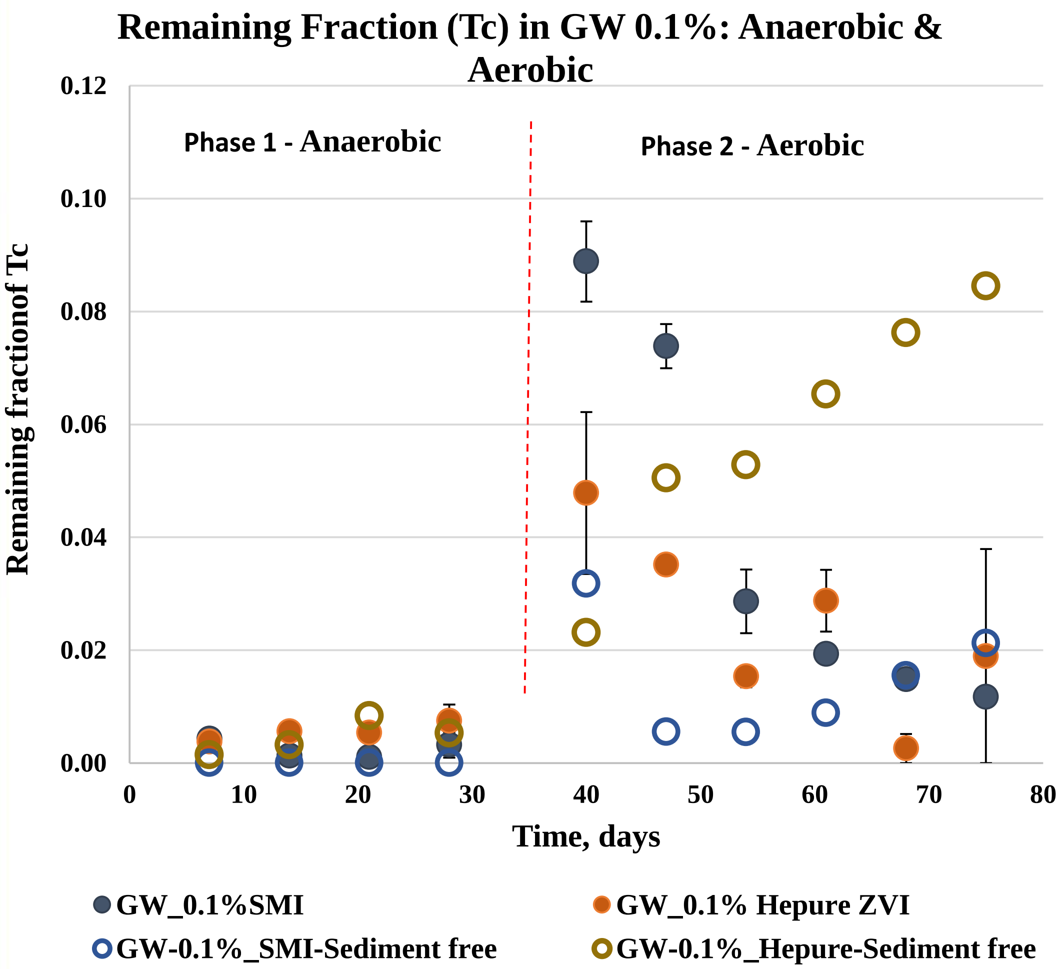

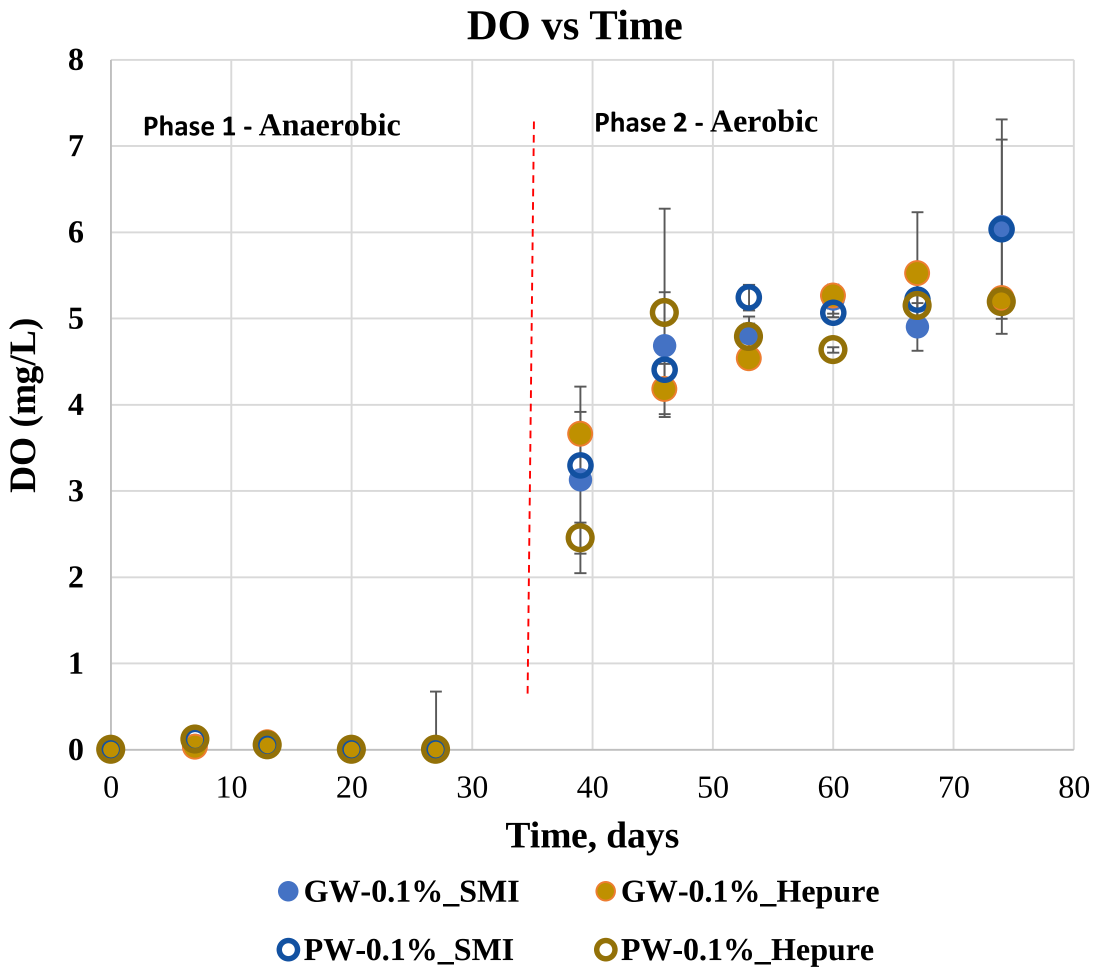

In aerobic conditions, SMI was more effective in resisting re-oxidation.

In aerobic conditions, samples were aerated twice a week for 30 s.

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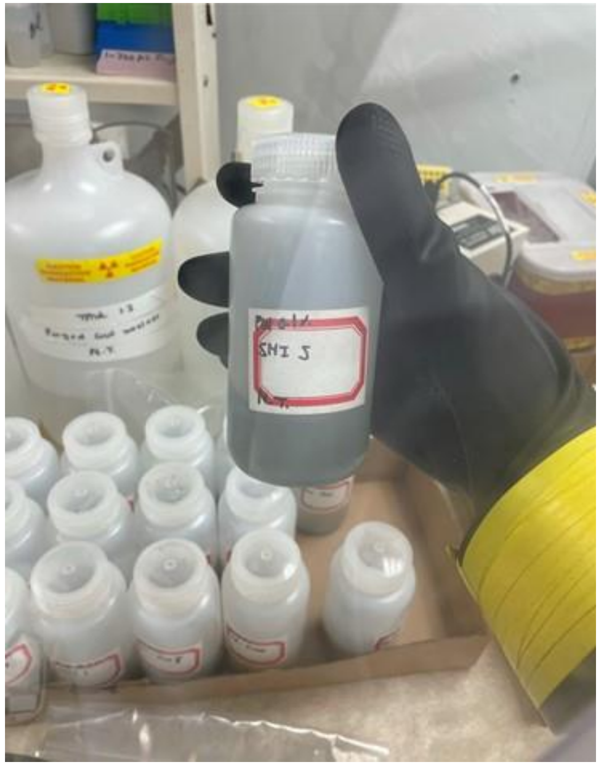
Subtask 1.2: Re-oxidation of Redox Sensitive Contaminants Immobilized by Strong Reductants

FIU Year 2 Projected Scope

- Finalize analyses for nitrate via IC
- Conduct solid characterizations studies via XRD and SEM/EDS
- Conduct experiments using 1% ZVI and 1% SMI iron and 0.5% and 5% CPS reductants.



Experimental samples kept in the anaerobic glove box during Phase 1

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Subtask 1.3: Evaluation of Competing Attenuation Processes for Mobile Contaminants in Hanford Sediments

Site Needs:

Contaminants (U (VI), ^{129}I, ^{99}Tc, Cr(VI) and NO_3^-) that were released to the environment can potentially impact groundwater. Once active remediation is completed, a transition to monitored natural attenuation (MNA), is needed. Effective MNA requires a thorough understanding of the contaminant immobilization processes that keep the contaminants stable and resistant to remobilization due to changes in environmental conditions or GW chemistry.

Objectives:

Evaluate attenuation processes that affect fate and transport mechanisms of contaminants of concern present in VZ sediment collected from the Hanford Site.

- Conduct competitive adsorption experiments on selected sediment fractions with key contaminants of concern at the max concentrations found at Hanford 200 Area GW and porewater when all contaminants are commingled together to compare adsorption results when each contaminant is present separately.

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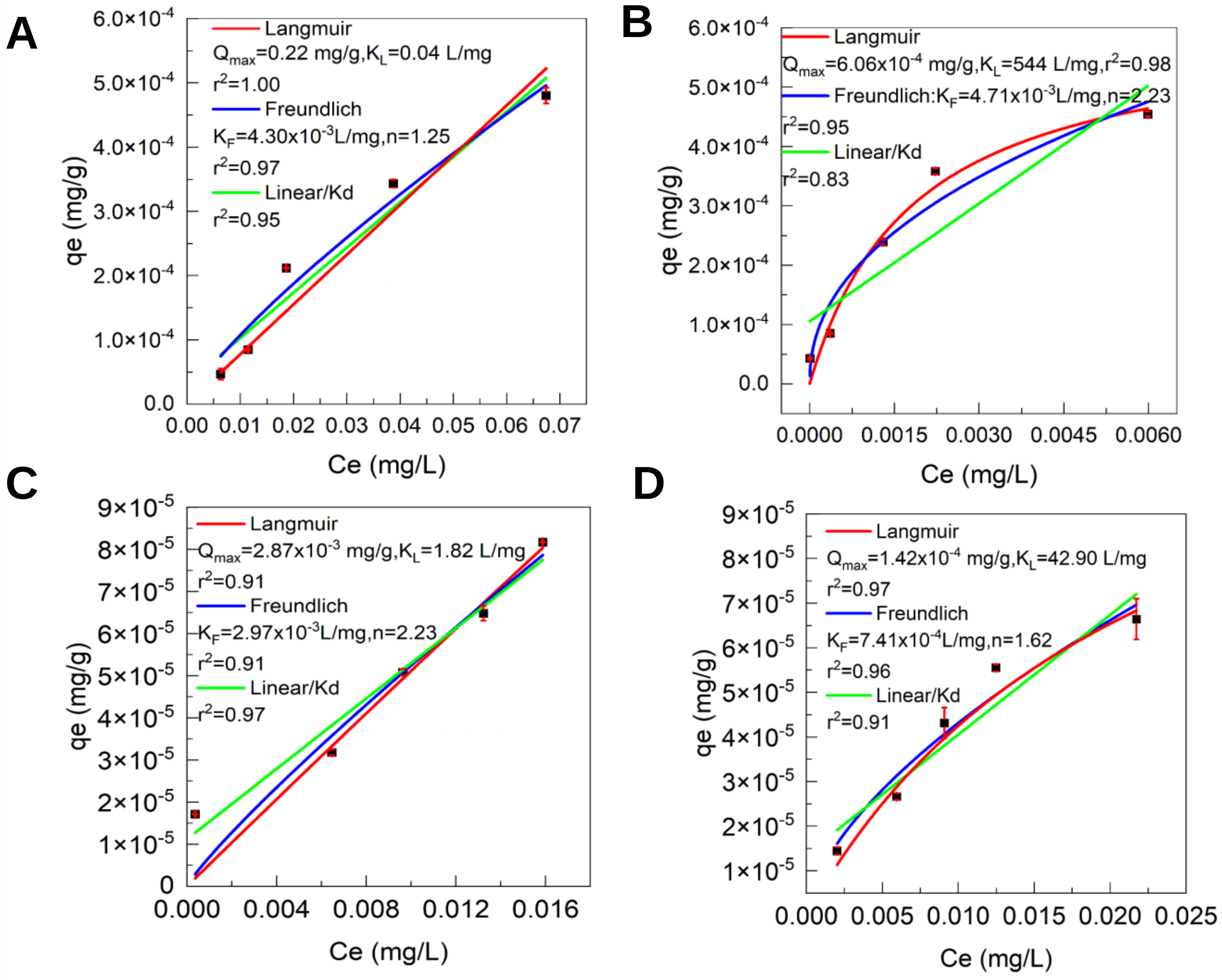
Subtask 1.3: Evaluation of Competing Attenuation Processes for Mobile Contaminants in Hanford Sediments

FIU Year 1 Research Highlights & Accomplishments:

Adsorption of **A** Cr (50-530 ppb) **B** Cr in the presence of I-127 (20-100 ppb) **C** I-127 **D** I-127 in the presence of Cr in AGW ($NaHCO_3$, $KHCO_3$, $MgSO_4 \cdot 7H_2O$, $MgCl_2 \cdot 6H_2O$, $CaCl_2 \cdot 2H_2O$, pH: 7.90 ± 0.03) onto Hanford Formation Sediment



- Adsorption for both Cr and ^{127}I is less by an order of three magnitude as compared to each contaminant present separately.
- The Cr alone and competitive kinetic modeling follow pseudo-first order kinetics.
- The ^{127}I alone and competitive kinetic modeling follow pseudo-second order kinetics.

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Subtask 1.3: Evaluation of Competing Attenuation Processes for Mobile Contaminants in Hanford Sediments

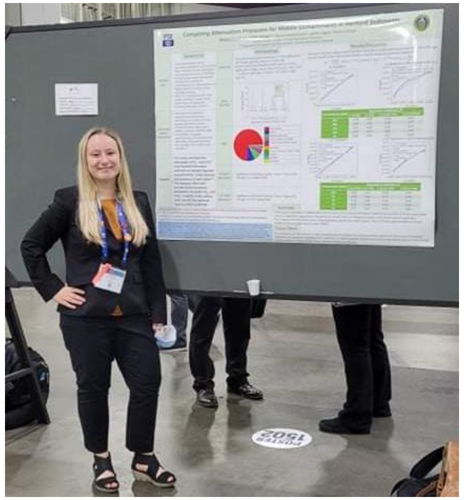
FIU Year 1 Research Highlights & Accomplishments:

Pseudo-first order (PFO) and pseudo-second order (PSO) kinetics of Cr and I-127 spiked AGW adsorption onto Hanford Formation sediment

Concentration (ppb)	Regression Coefficient, R^2			
	Cr PFO	Cr PSO	Cr+I-127 PFO	Cr+I-127 PSO
530	0.99	0.98	0.99	0.97
400	0.98	0.96	0.99	0.97
250	0.61	0.85	0.99	0.97
100	0.99	0.97	0.98	0.95
50	0.98	0.95	0.97	0.92

Concentration (ppb)	Regression Coefficient, R^2			
	I-127 PFO	I-127 PSO	I-127 + Cr PFO	I-127 + Cr PSO
100	0.80	0.91	0.80	0.91
80	0.69	0.85	0.77	0.89
60	0.76	0.89	0.74	0.85
40	0.57	0.78	0.71	0.84
20	0.77	0.87	0.79	0.89

- Completion of Tc-99 and U batch adsorption studies onto Hanford Sediments.
- Remote summer internship under the mentorship of Dr. Nikolla Qafoku.
- Poster presentation at Waste Management 2021 and ACS Fall 2021 meeting: Evaluation of Competing Attenuation Processes for Mobile Contaminants in Hanford Sediments



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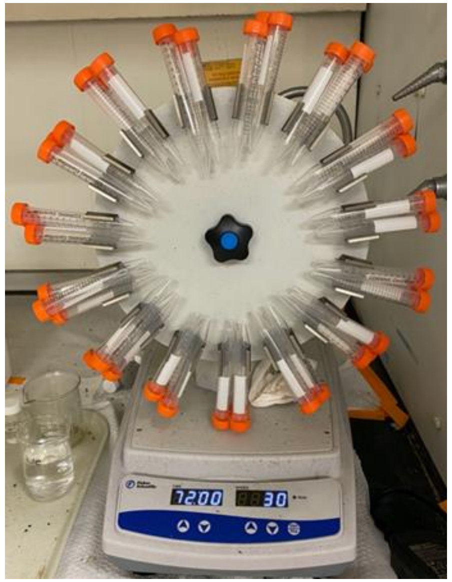
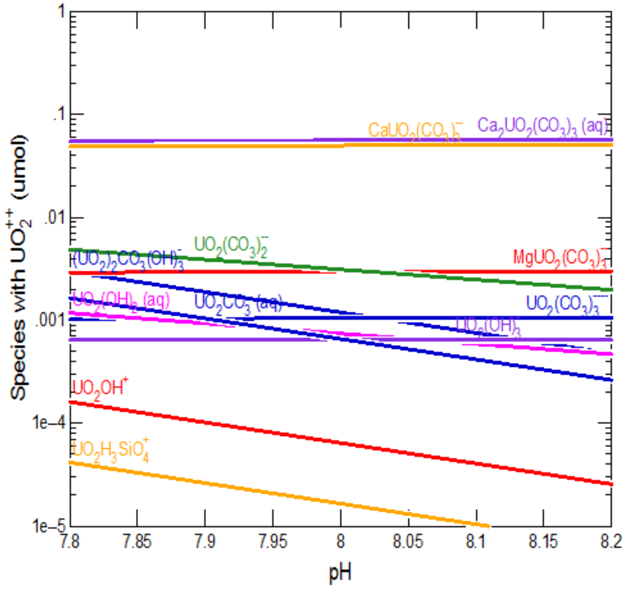
Subtask 1.3: Evaluation of Competing Attenuation Processes for Mobile Contaminants in Hanford Sediments

FIU Year 2 Projected Scope

- Investigation of uranium batch adsorption studies in the presence of collocated contaminants (chromate, iodine-127, nitrate, and technetium-99)
- Speciation modeling of all contaminants using Geochemist Workbench program
- Solid phase characterization of post treated sediment (SEM-EDS and XRD analysis)
- Development of column studies to better understand uranium adsorption under site conditions.



Experimental samples on end-over-end tube revolver



Speciation diagram for uranium via GWB

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Subtask 1.4: Experimental Support of Lysimeter Testing

Site Needs:

This task provides support to the large-scale field experiments at the Hanford Field Lysimeter Test Facility (FLTF) located in the 200-W Area of the Hanford site. The FLTF study is being initiated as a long-term experiment to provide data on glass and cementitious waste form durability, contaminant release from waste forms, and resulting transport in the near-field environment anticipated to be present at the Hanford Site Integrated Disposal Facility (IDF). The findings of the FLTF will be used to validate model predictions of long-term waste form behavior upon safe disposal of immobilized low-activity waste (ILAW) in the IDF and used in the IDF Performance Assessment (PA) calculations.

One of the planned configurations of the lysimeter units described in the Implementation Plan (Bacon et. al., 2018) is to place grout waste forms above glass waste forms. This waste form arrangement has limited laboratory data regarding the dissolution of glass in the presence of grout-contacted water.

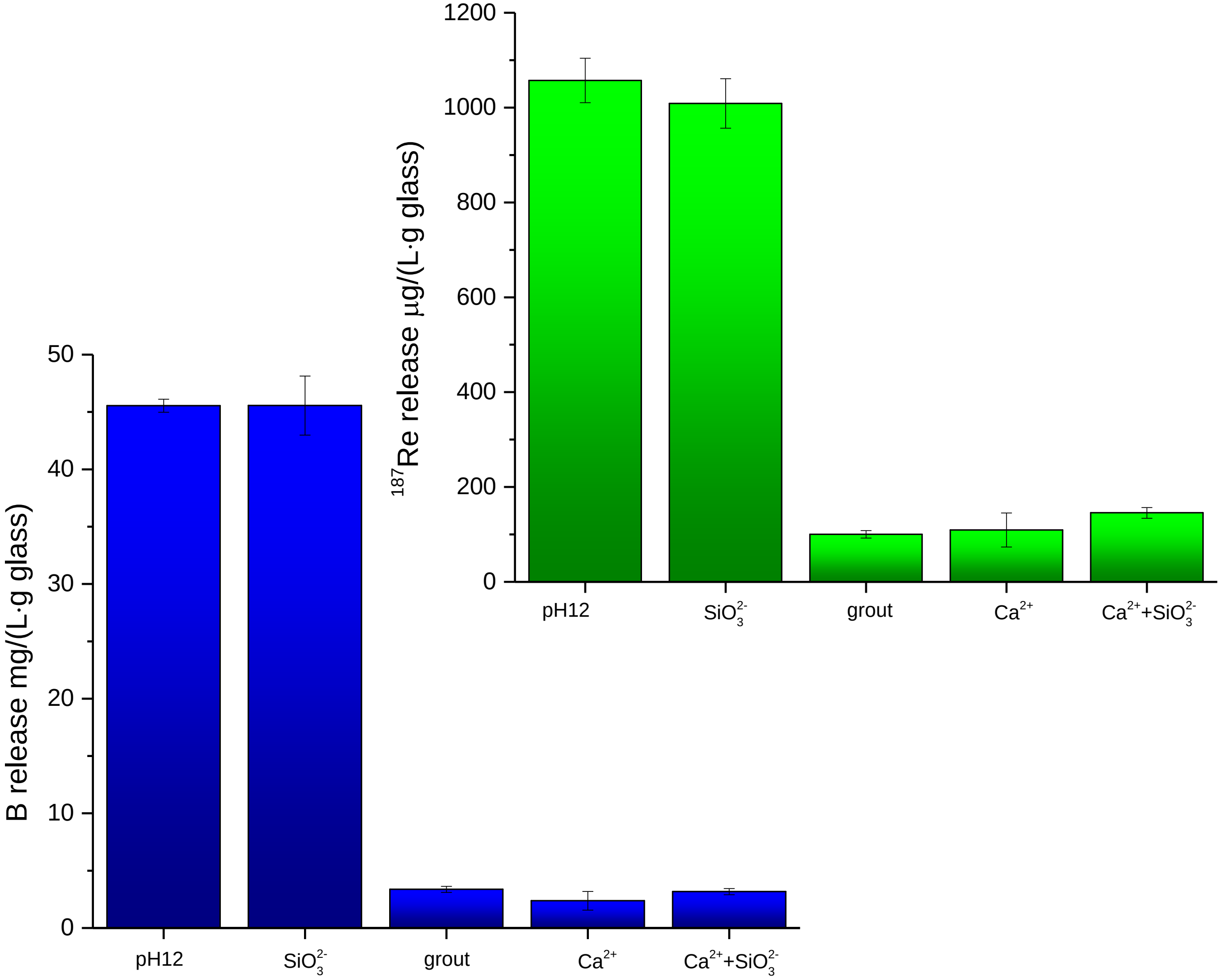
Objectives:

To investigate the impact of major elements present in the grout-contacted solution on the dissolution behavior of borosilicate glass at varying temperatures (25°C, 40°C, 70°C) using single-pass flow-through (SPFT) and static Product Consistency Test (PCT) (90°C).

Subtask 1.4: Experimental Support of Lysimeter Testing

FIU Year 1 Research Highlights & Accomplishments:

- Investigated effects of major elements in the grout-contacted GW, Si, Ca and Al on dissolution behavior of ORLEC28 glass.
  - Test matrix in SPFT: duplicated reactors with Si-amended soln., a reactor with pH 12 buffered soln., flow rate 40mL/day at 25°C, 40°C, and 70°C.
  - Test matrix in PCT: triplicated reactors, pH 12 buffer, grout soln., Si (5 ppm), Ca (130 ppm) and Al-amended buffers at 90°C
- XRD analyses of treated glass and SEM/EDS measurements in cross-sections of glass coupons to study glass erosion
- Oral presentation at Waste Management Symposia (March 2021) "Effect of grout impacted groundwater on the ORLEC28 glass dissolution behavior at various temperature."



PCT results on the ^{187}Re and B release by ORLEC28 glass in different solutions at 90°C

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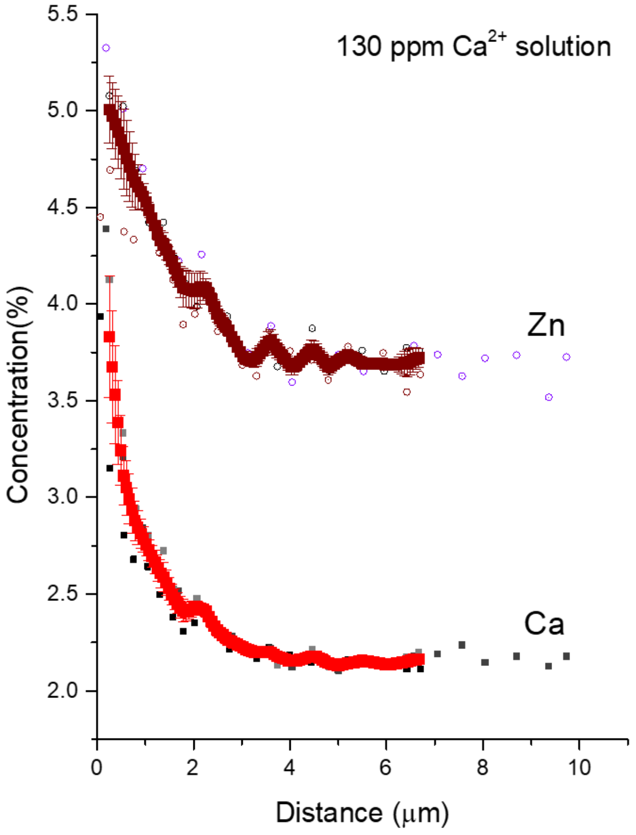
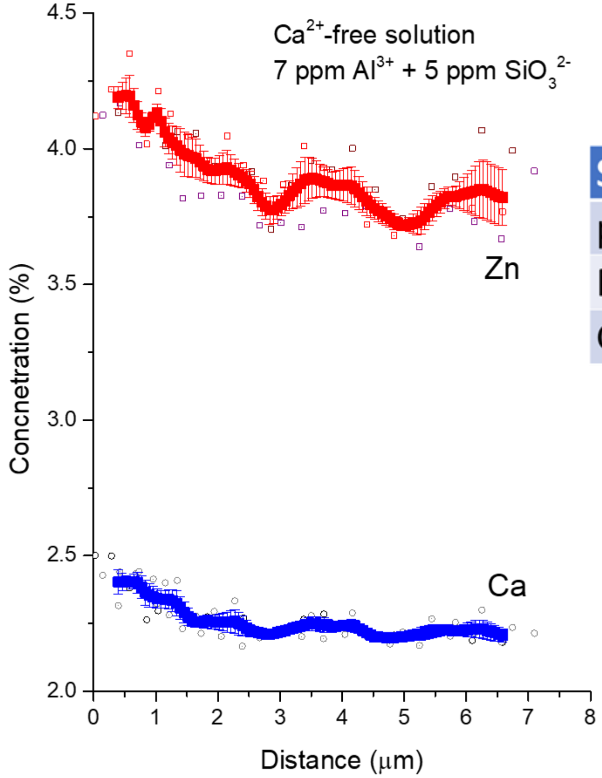
FIU Year 1 Research Highlights & Accomplishments:

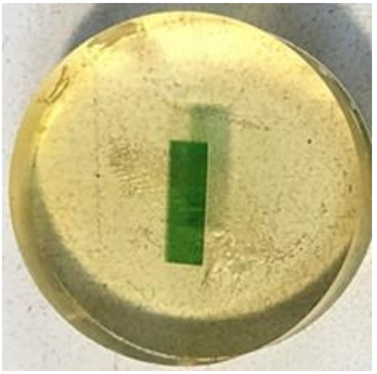
SEM/EDS in cross-section on the glass coupons from the static test





Depth of alternation layers for different elements in glass coupons after static test measured by EDS

Solution	Na, µm	K, µm	Si, µm	Al, µm
pH 12	3.84	2.87	2.77	2.32
Na_2SiO_3	4.71	3.54	2.70	1.87
Grout-contacted	3.00	3.00	1.35	2.08



ORLEC28 glass coupons to study glass erosion

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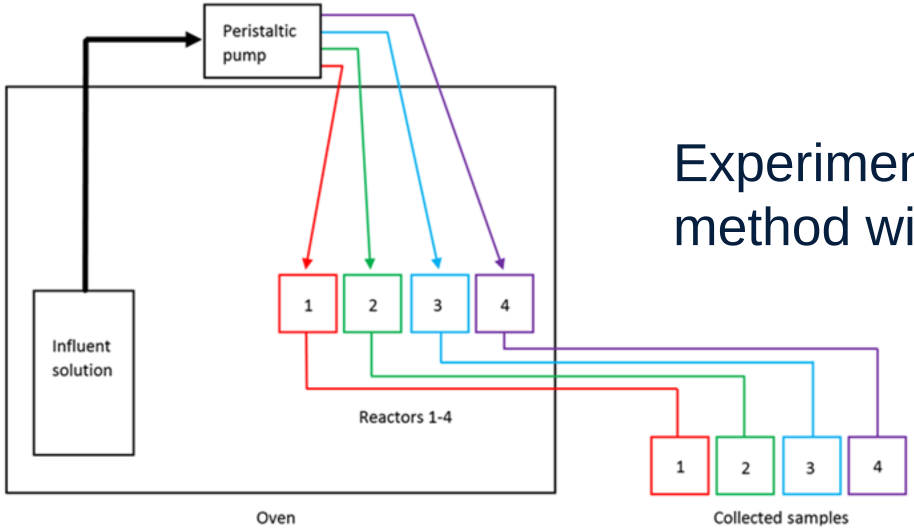
Subtask 1.4: Experimental Support of Lysimeter Testing

FIU Year 2 Projected Scope

- Continue SPFT dissolution experiments at different temperatures (25°C, 40°C and 70°C) with Ca- amended buffer solutions to measure glass dissolution rates
- Conduct long-term static PCTs at 90°C to measure depth of glass alternation layers.
- Study the effect of calcium carbonate on the release of elements from glass
- Investigate the effect of grout/sediment-contacted groundwater to simulate specific conditions being studied in the current field lysimeter experiment and measure the response of the glasses to these conditions



Experimental setup for SPFT method with four reactors.

Task 2

Remediation Research and Technical Support for the Savannah River Site

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Subtask 2.1: Environmental Factors Controlling the Attenuation and Release of Contaminants in the Wetland Sediments at Savannah River Site (NEW)

Site Needs:

- **Iodine-129** poses a substantial clean-up problem at Savannah River Site due to its perceived high mobility in the environment, toxicity, long half-life (~16 million years), and is one of the lowest maximum contamination levels (1 pCi L^{-1}) of all radionuclides.
- Wetlands at the F-Area have been an important sink for I-129 and other contaminants. The complex and diverse physical and biogeochemical processes within the wetlands are mainly responsible for retaining these contaminants.
- However, these areas are sensitive to changing boundaries and geochemical conditions, resulting in the release of iodine-129 into surrounding areas.

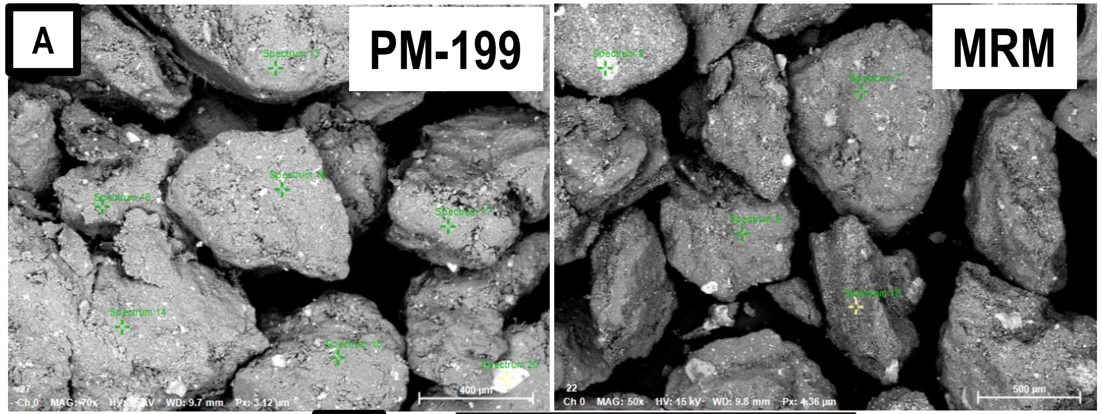
Objectives:

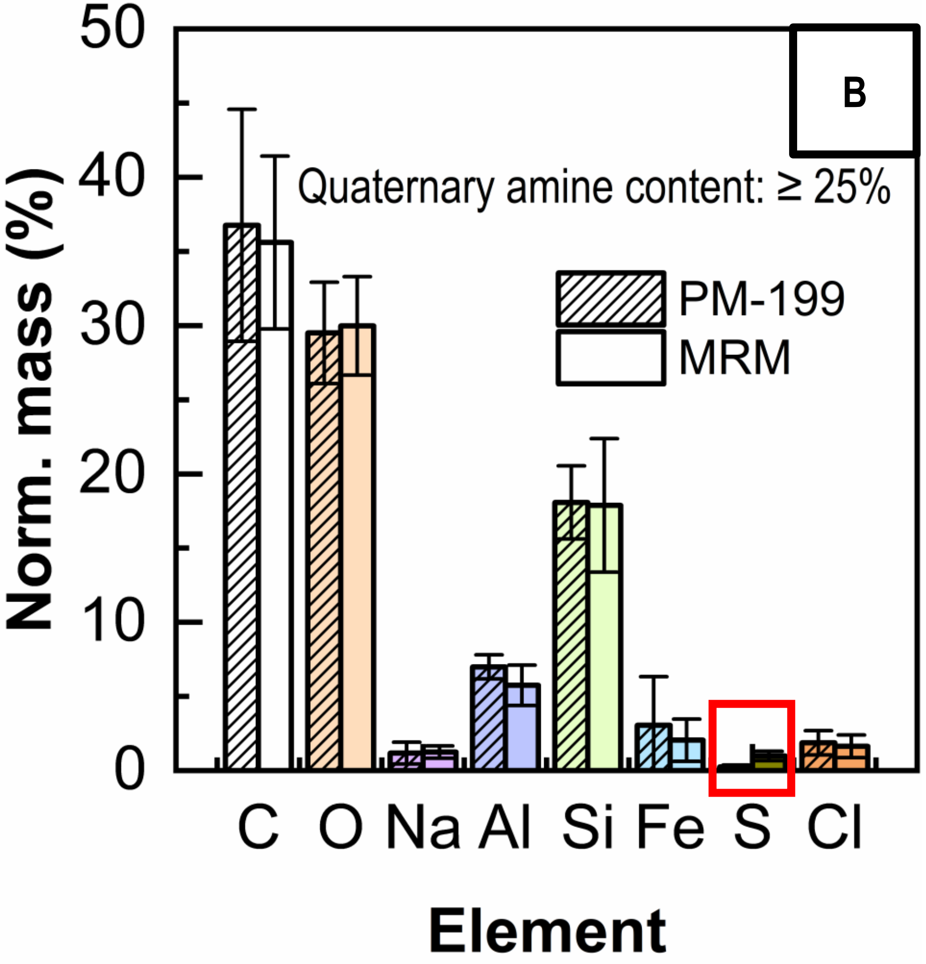
- Elucidate the key factors controlling the transport and fate of iodine species and investigate if the organoclays can help to reduce the elevated concentration of iodine species in the SRS F-Area wetland.
- Study the sorption of iodine on the wetland soils to improve the understanding of factors that contribute to the attenuation of iodine-129 at the F-Area wetlands.

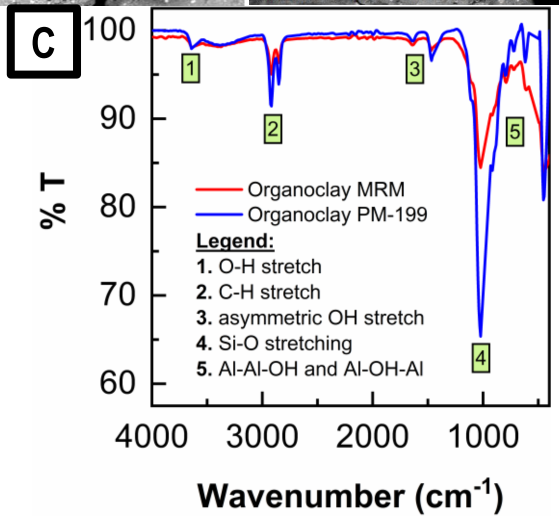
Subtask 2.1: Environmental Factors Controlling the Attenuation and Release of Contaminants in the Wetland Sediments at Savannah River Site (NEW)

FIU Year 1 Research Highlights & Accomplishments:

- Two low-cost and environmentally friendly organoclays (PM-199 and MRM) were studied as potential sorbents for *in-situ* remediation treatment of iodine species, i.e., iodide (I^-), iodate (IO_3^-), in the wetland.







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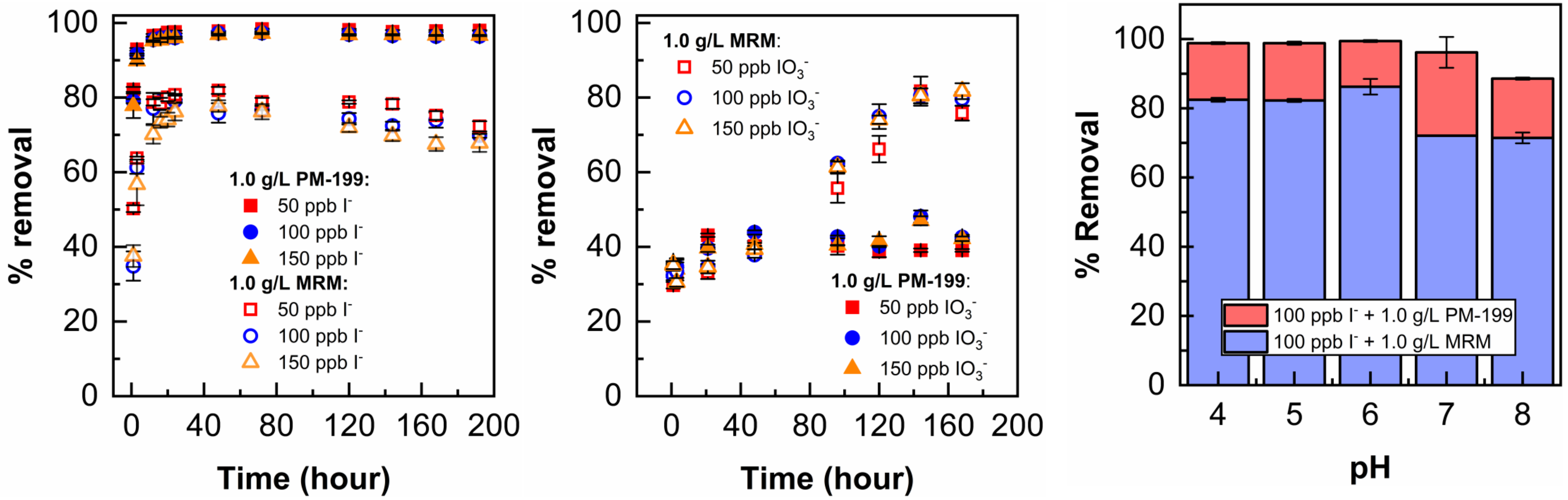
Subtask 2.1: Environmental Factors Controlling the Attenuation and Release of Contaminants in the Wetland Sediments at Savannah River Site (NEW)

FIU Year 1 Research Highlights & Accomplishments:

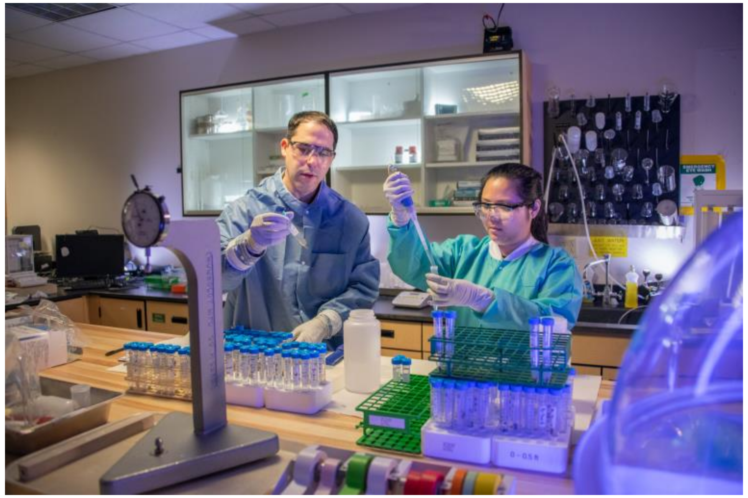


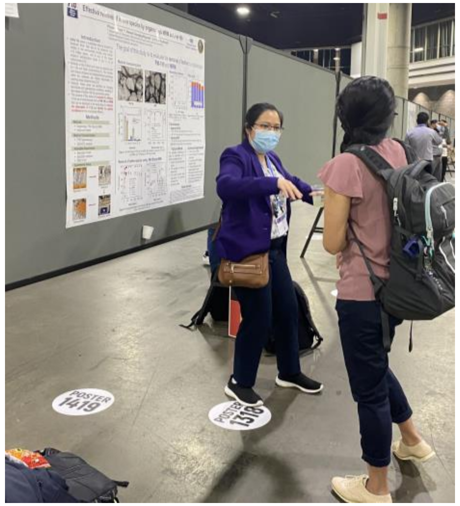
- **Organoclay PM-199:**
  - ~ 40 % of the IO_3^- was adsorbed within 24 hours.
  - ~ 99 % of I^- was removed from the aqueous solution with in 12 hours.
- **Organoclay MRM:**
  - ~ 70 – 80 % of I^- and IO_3^- were removed from the aqueous solution by MRM with in 12 hours and 7 days, respectively.
- pH has a little effect on the removal of iodide by PM-199 and MRM

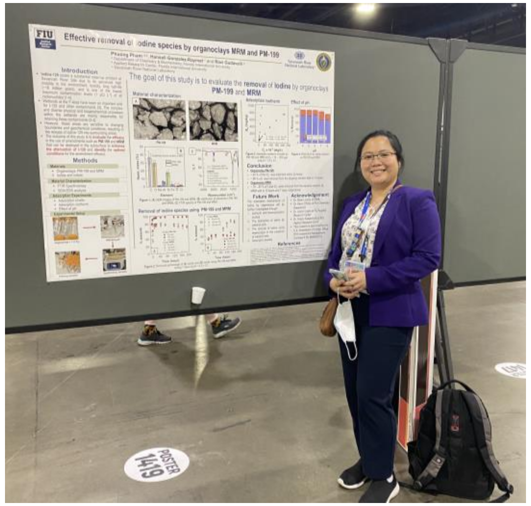
Subtask 2.1: Environmental Factors Controlling the Attenuation and Release of Contaminants in the Wetland Sediments at Savannah River Site (NEW)

FIU Year 1 Research Highlights & Accomplishments:

- Completion of organoclays PM-199 and MRM characterization
- Poster presentation at ACS Fall 2021 meeting on: Effective removal of iodine species by organoclays PM-199 and MRM
- ACS abstract was selected by the Environmental division program chair to be presented at the SCI-MIX event to represent one of the most exceptional abstracts submitted to the division
- Summer internship at SRNL working on the sorption of iodine species by wetland soils at different depth intervals under the mentorship of Dr. Hansell Gonzalez-Raymat.







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Subtask 2.1: Environmental Factors Controlling the Attenuation and Release of Contaminants in the Wetland Sediments at Savannah River Site (NEW)

FIU Year 2 Projected Scope

FIU will investigate:

- Sorption of iodine species using organoclays in the presence and absence of wetland soils
- Sorption of iodine species on soils collected at different depth intervals
- Solid phase characterization of bulk wetland soils and fractionated soils
- Solid phase characterization of post treated soils and sorbents

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Subtask 2.2: Humic Acid Batch Sorption Experiments with SRS Soil

Site Needs:

- Low cost unrefined humic substances are potential amendments for treatment of uranium in groundwater associated with F-Area Seepage Basins plume
- These experiments will determine necessary parameters helping to simulate the creation of a sorbed humate treatment zone in the acidic groundwater contaminated with uranium

Objectives:

- Investigate, via batch experiments, the sorption behavior of modified humic substances (KW-15 and KW-30) for groundwater remediation and the effect of sorbed humic substances on uranium removal

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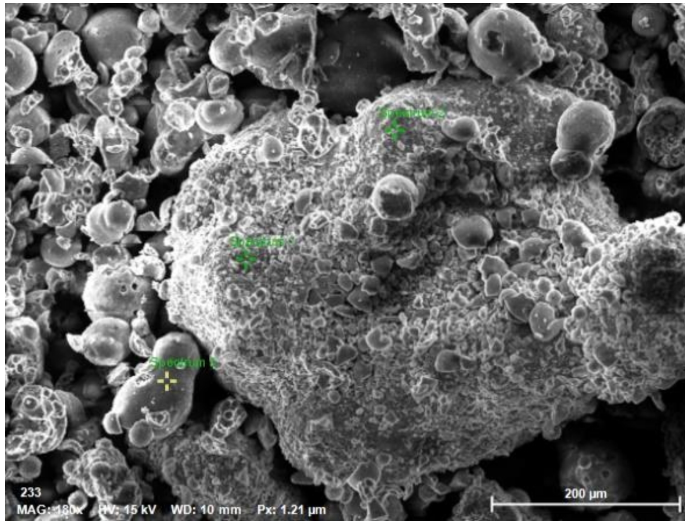
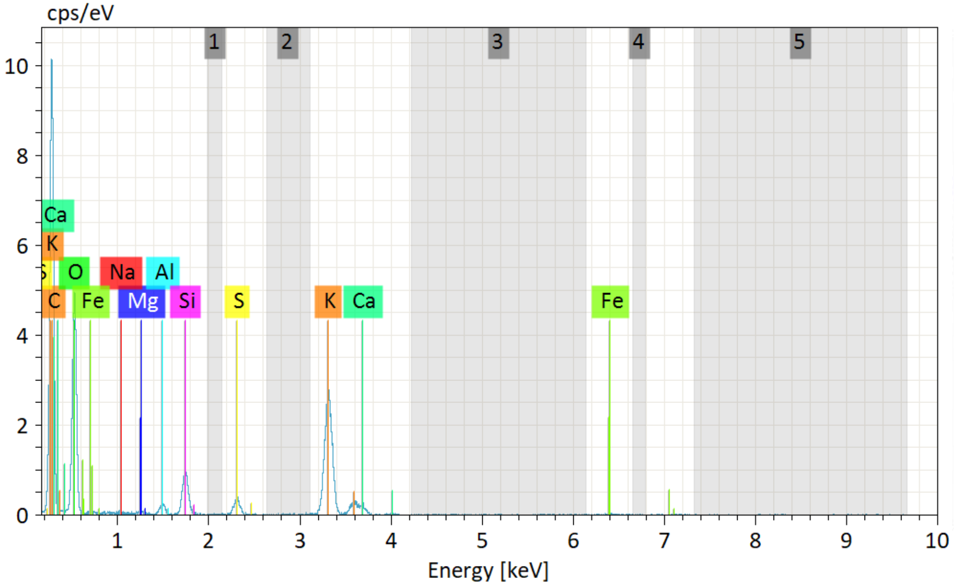
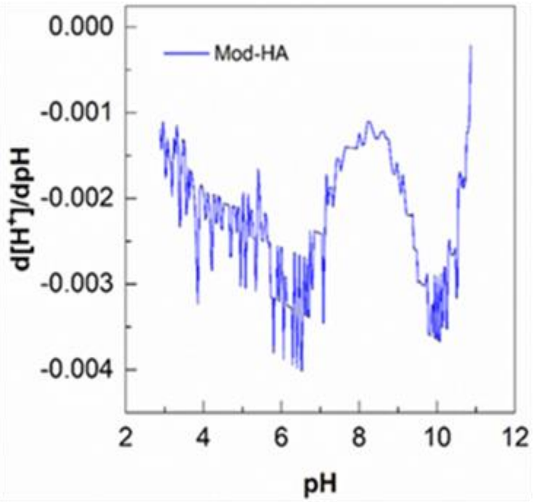
Subtask 2.2: Humic Acid Batch Sorption Experiments with SRS Soil

FIU Year 1 Research Highlights & Accomplishments:

- Characterized modified humic acid (KW-15) using
  - Dynamic light scattering (DLS),
  - Brunauer-Emmett-Teller (BET),
  - Scanning electron microscopy coupled with energy dispersive X-ray spectroscopy (SEM-EDS), and
  - Potentiometric titration



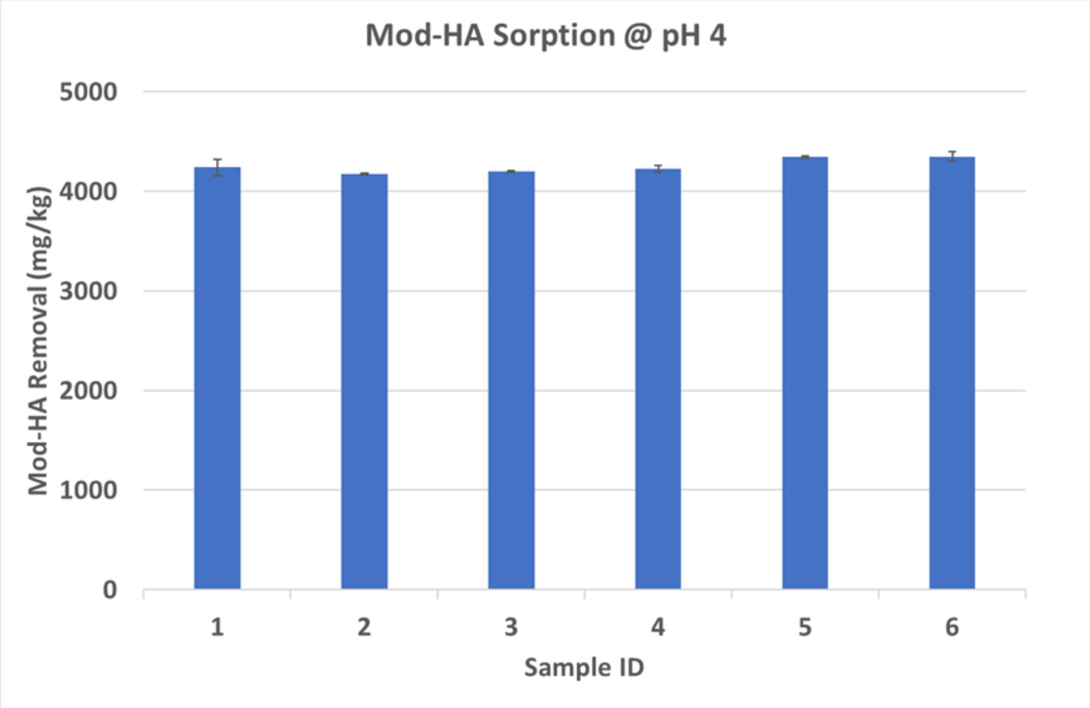


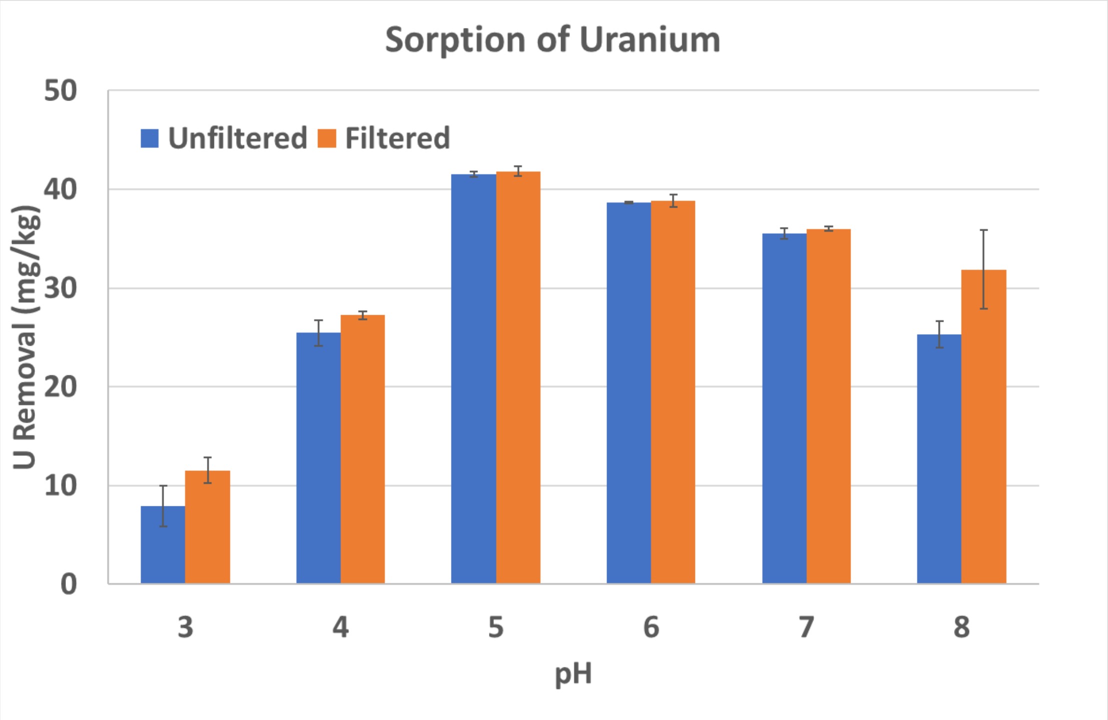


Subtask 2.2: Humic Acid Batch Sorption Experiments with SRS Soil

FIU Year 1 Research Highlights & Accomplishments:

- Studied sorption of uranium on to KW-15 coated sediments
  - 50 mg/L of humate was brought in contact with 200 mg of SRS Sediment @ pH 4
  - 500 µg/L uranium was introduced and samples were analyzed via ICP-MS





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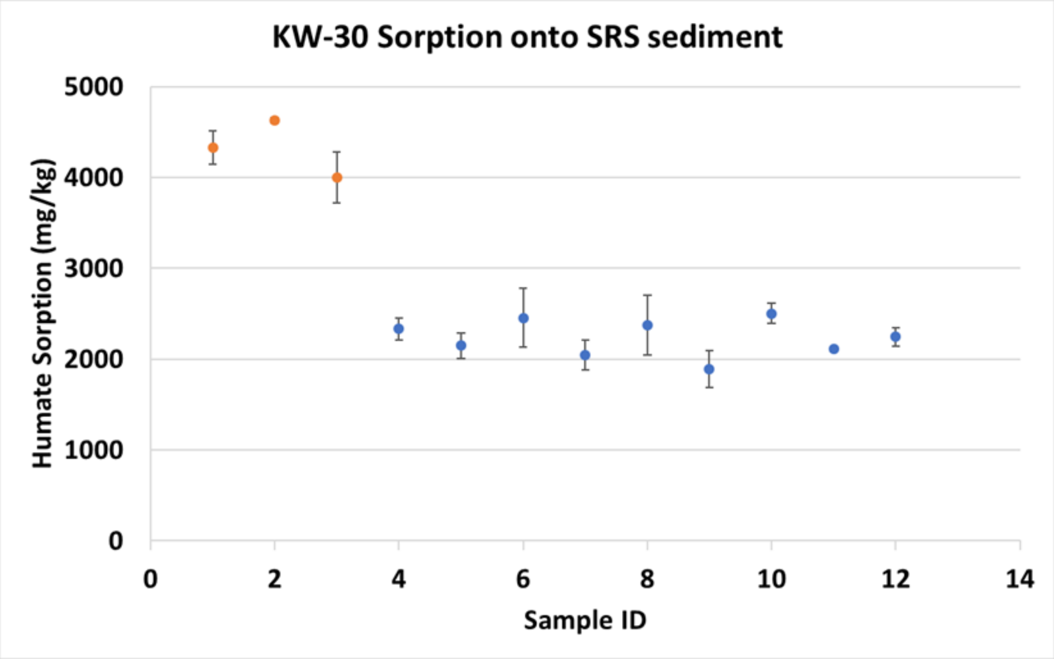
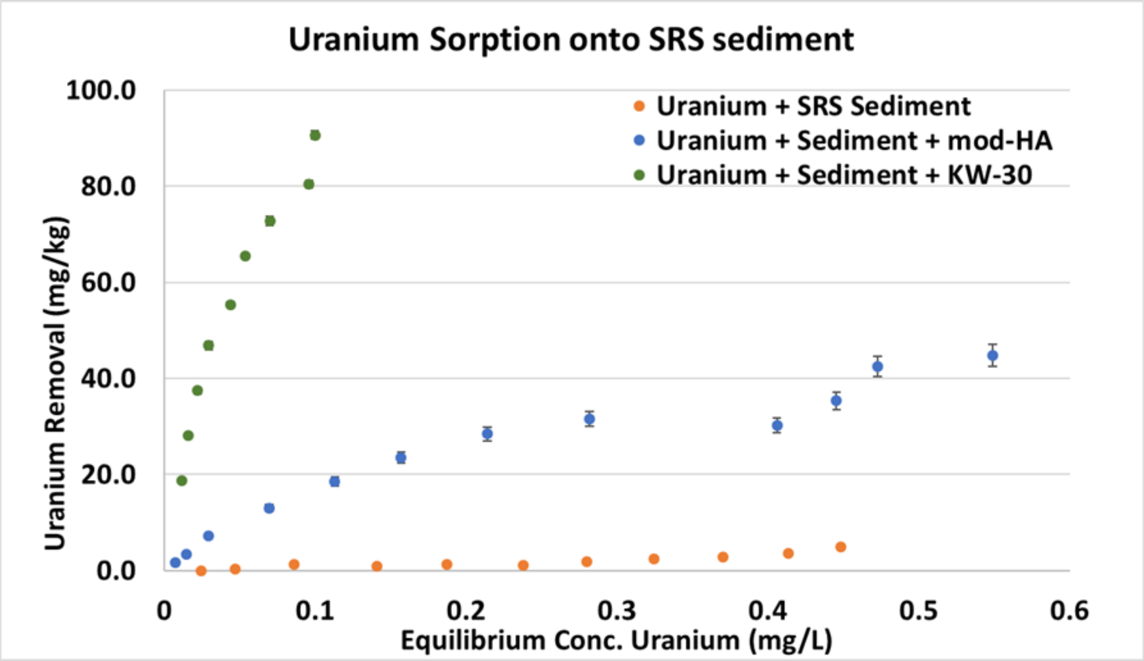
Subtask 2.2: Humic Acid Batch Sorption Experiments with SRS Soil

FIU Year 1 Research Highlights & Accomplishments:

- Studied sorption isotherms of uranium on to KW-30 coated sediments
  - 50 mg/L of humate was brought in contact with 200 mg of SRS Sediment @ pH 4
  - 200 - 1000 µg/L uranium was introduced and samples were analyzed via ICP-MS
- Presented 3 posters at WM21





Subtask 2.2: Humic Acid Sorption Experiments with SRS Soil

FIU Year 2 Projected Scope

- Study the effect of minerals of KW-30 sorption
- Extend isotherms to include higher U concentrations
- Conduct column experiments to evaluate KW-30 performance in flow through settings

Task 3

Contaminant Fate and Transport Modeling for the Savannah River Site

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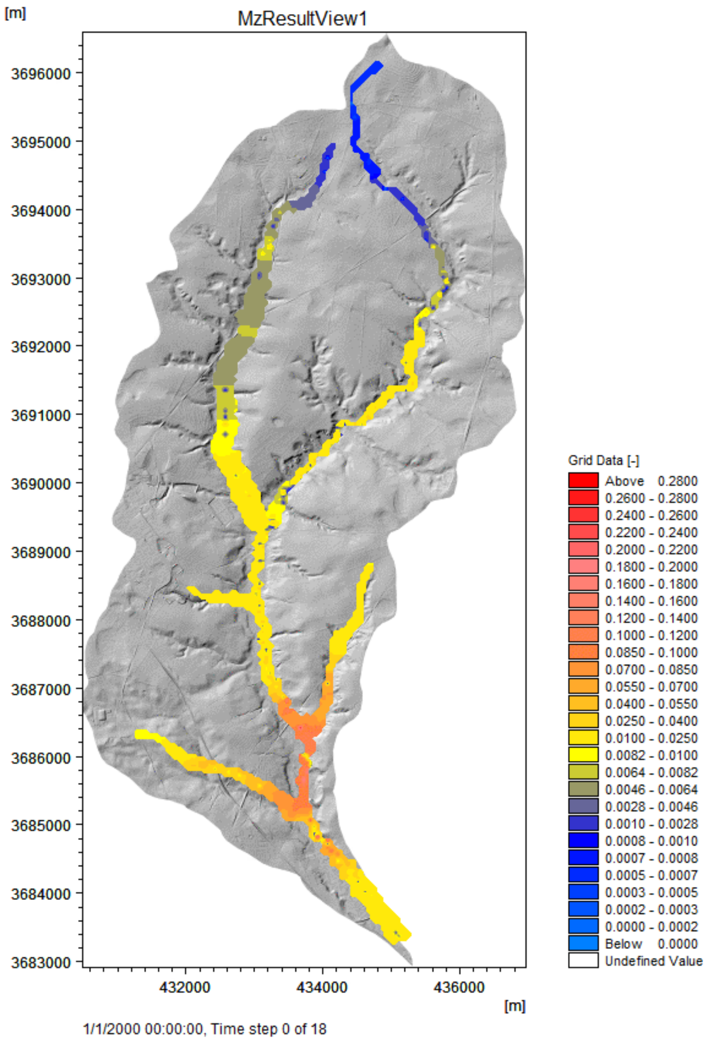
Contaminant Fate and Transport Modeling for the Savannah River Site

Site Needs:

- SRS and other DOE sites challenged with heavy metal and radionuclide contamination in surface/subsurface environments.
- With the push towards site closure, there is a need to:
    - Evaluate effectiveness of applied remediation technologies
    - Establish long-term monitoring strategy
- Address knowledge gaps related to fate and transport of major contaminants of concern in SRS stream systems by developing numerical models to better understand impact of episodic storm events on contaminant transport.

Objectives:

- Develop numerical models to evaluate impact of extreme hydrological events on fate and transport of major contaminants of concern in SRS stream systems.
- Collect field data to support model calibration and validation.
- Train FIU graduate and undergraduate students (DOE Fellows).



Animation: Temporal distribution of Velocity*Flow Depth (U*D) for a 100-year 24-hour design storm event.

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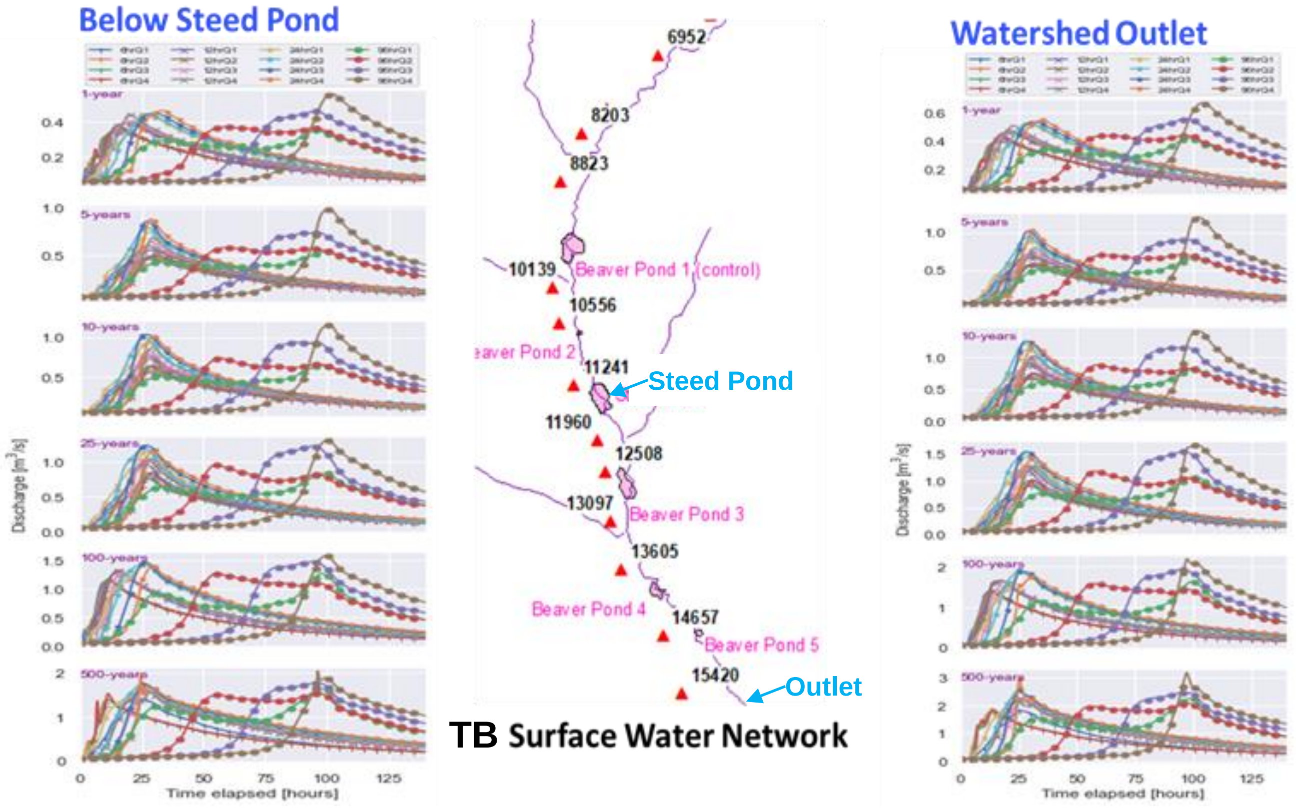
Subtask 3.1: Calibration of the Tims Branch Watershed Model and Scenario Analysis

FIU Year 1 Research Highlights & Accomplishments:

- Calibrated coupled Surface Water (SW)/ Groundwater (GW) interaction model
- Simulates Overland (OL), Unsaturated (UZ) & Saturated (SZ) flow, and exchange of water between GW and river system
- MIKE11 Advection-Dispersion (AD) module was set up, calibrated, and validated to simulate sediment transport process in Tims Branch (TB) based on available field data.
- Ran extreme event scenarios ranging from 500-yr to 5-yr return periods with storm durations ranging from 6-hr to 72-hr to simulate and differentiate sediment fluxes at key locations of the watershed **(below Steed Pond & TB watershed outlet**) under various design storm conditions.
- Shows potential hotspots for resuspension/remobilization of sediment-bound contaminants under different climate conditions.



Simulated suspended sediment conc. (SSC) below Steed Pond (left) and at outlet of Tims Branch watershed (right)

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Subtask 3.1: Calibration of the Tims Branch Watershed Model and Scenario Analysis

FIU Year 1 Research Highlights & Accomplishments:

MIKE model components:

- **Hydrodynamic Module**

  Statistical measures show a good correlation between simulated and observed values for discharge.

  Nash-Sutcliffe Efficiency (NSE) = 0.637

- **AD Module (Sediment Transport)**
  Available field data is limited for further calibration and validation of model. Consistent sets of simultaneously measured suspended sediment concentrations (SSC) and flows at outlet are needed.

Left: DOE Fellow Juan Morales and Dr. Daniel Kaplan (SRNL) adding a turbidity sensor to the remote monitoring station in Tims Branch, SRS. Right: ISCO sampler located near the remote monitoring station.

- Turbidity sensor therefore integrated into remote monitoring station (July 2021) for simultaneous recording of water level and turbidity in 15 min time steps at TB outlet.
- Water quality and flow data from nearby ISCO sampler will also be provided by SRNL.

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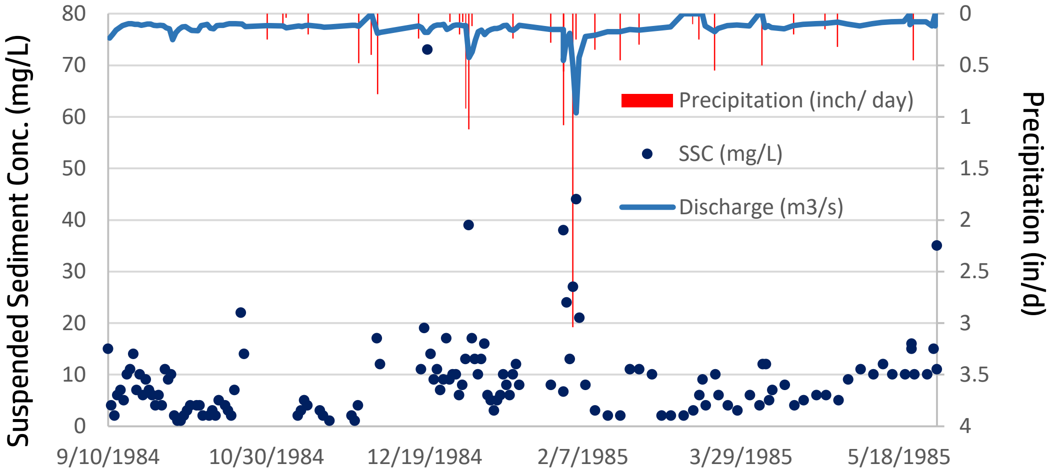
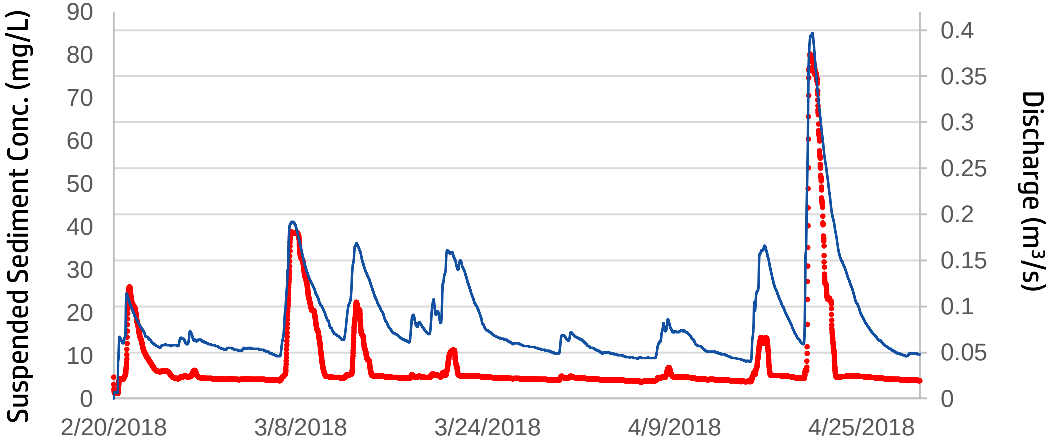
Subtask 3.1: Calibration of the Tims Branch Watershed Model and Scenario Analysis

FIU Year 1 Research Highlights & Accomplishments:

- To develop a contaminant transport model, based on site needs and contaminant data availability.
    - Uranium (U)
    - Tin (Sn)
    - Nickel (Ni)
- Metals are mostly sediment-bound. (Kaplan et al., 2017)
- Their presence and transfer is related to transport of suspended sediments in TB stream (Batson et al., 1996)
- A (U) transport model has been set-up and is currently being calibrated.



Field measurements of suspended sediment concentration (SSC) and streamflow collected 200 yards upstream of the confluence between Tims Branch and Upper Three Runs (Hayes, 1986)



Simulated suspended sediment concentration (SSC) and discharge. Computed results are in agreement between suspended sediment concentrations (SSC) and the observed values.

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Subtask 3.1: Calibration of the Tims Branch Watershed Model and Scenario Analysis

FIU Year 1 Research Highlights & Accomplishments:

- Ongoing:
  - Sensitivity analysis to determine controlling variables and optimum values for parameters affecting uranium geochemical processes in the TB system.
    - K_{oc} – Organic carbon partition coeff.
    - K_w – Desorption rate in water
    - f_{oc} – Fraction of organic carbon
    - porosity
  - Calibration of MIKE 11 ECO Lab contaminant transport model to simulate U transport in TB watershed.

TBW - CALIBRATION OF URANIUM ENVIRONMENT USING MIKE ECO LAB				
Order	**Series number**	**Reference**	**Calibration Parameters**	**Approximate model runs**
1	Series 2	Peer-reviewed literature	K_{oc}, K_w, f_{oc}, porosity	55
2	Series 3	Calibrated hydrodynamic model	K_{oc}, f_{oc},	115
3	Series 4	Calibrated hydrodynamic model	K_w	NA

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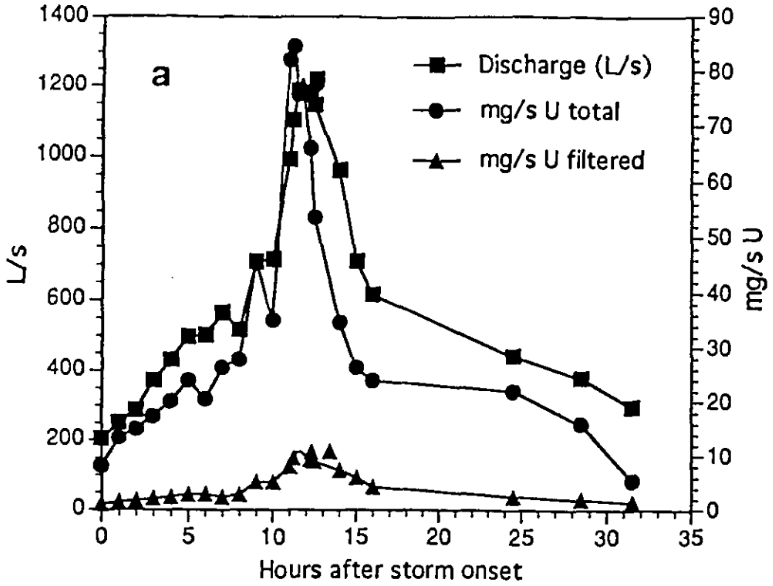
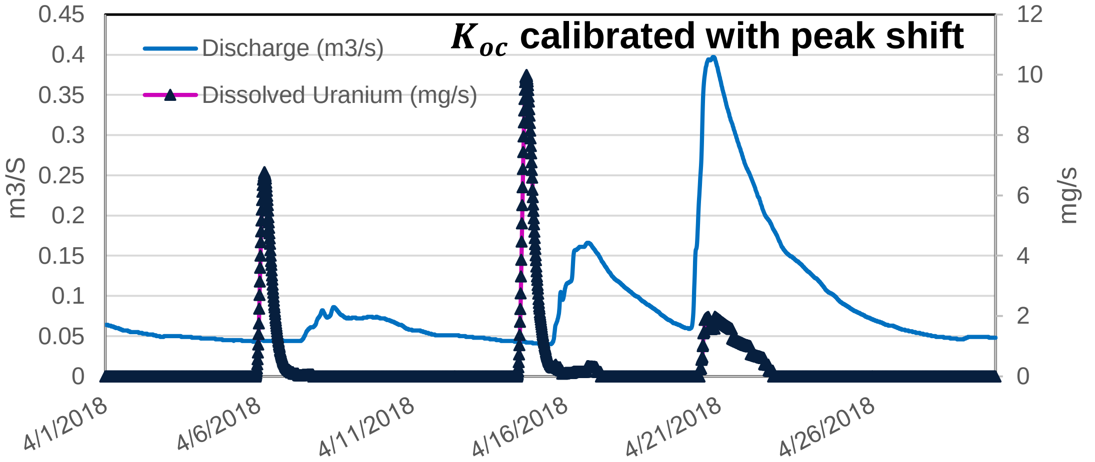
Subtask 3.1: Calibration of the Tims Branch Watershed Model and Scenario Analysis

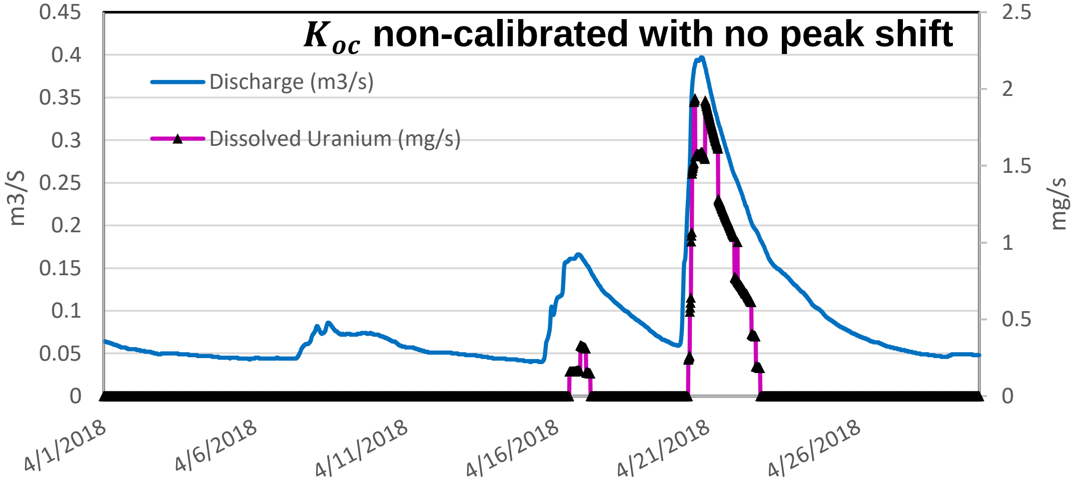
FIU Year 1 Research Highlights & Accomplishments:

- Simulated series tests highlight K_{oc} to be a driver in U flux at the TB outlet.
- Optimum values in K_{oc} were determined and U flux falls in agreement with the observed data reported by (Batson et al., 1996)



Observed data:
Reference:(Batson et al., 1996)



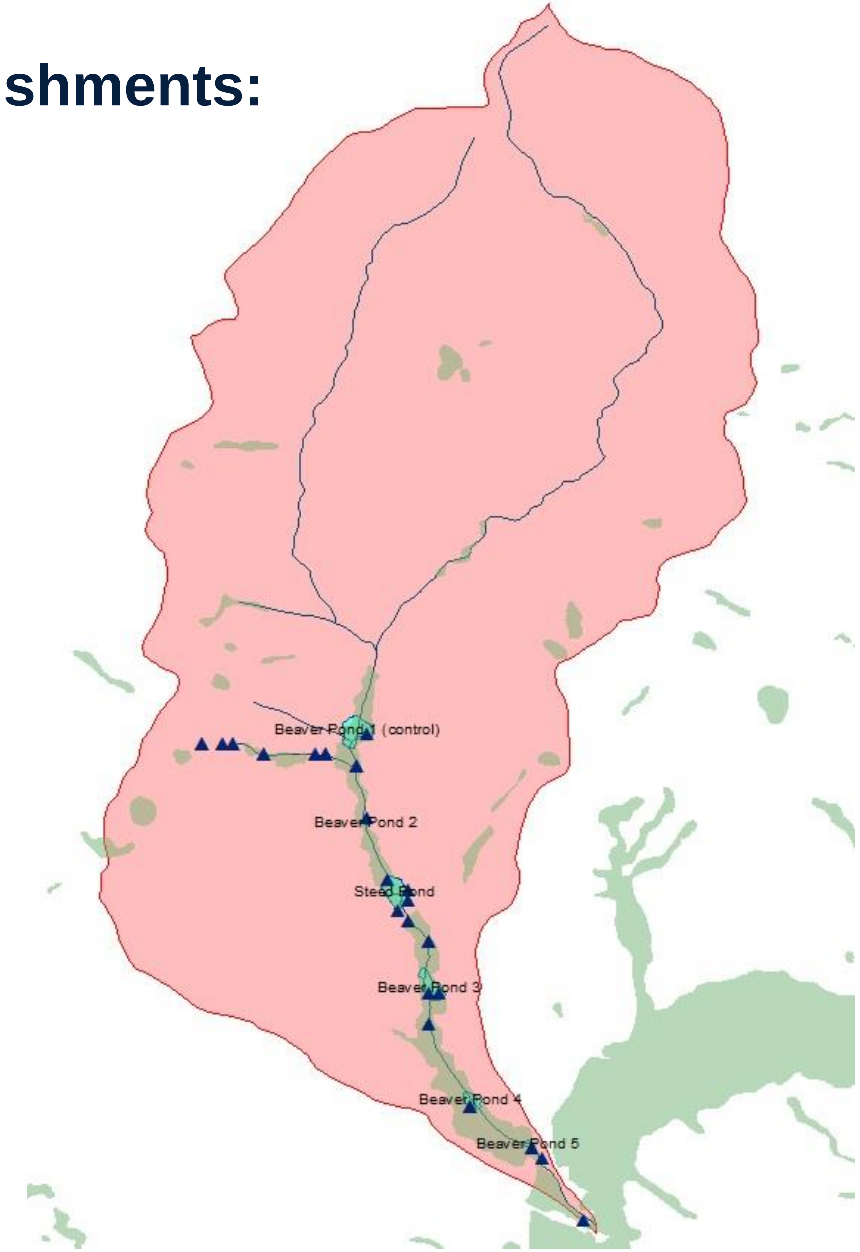


Simulation results highlighting the uranium flux (mg/s) and discharge (m^3/s) after a designed storm event generated in MIKE ECO Lab.
Top: Results have shifted in time and simulated a flux in U of 9.996 mg/s.
Bottom: Produced results such as 1.94 mg/s of U flux, however it falls in agreement with the peak discharge during the time of the storm event.

Subtask 3.1: Calibration of the Tims Branch Watershed Model and Scenario Analysis

FIU Year 1 Research Highlights & Accomplishments:

- Other contaminant data have been acquired from published reports and SRNL collaborators for the simulation period. (Betancourt & Looney, 2011)
- The sites have been geo-referenced. The associated monitoring data will need to be revised based on more recent conditions in TB and will be used as boundary and initial conditions, and for calibration/validation.
- An approximate method is under investigation to measure the contaminant loads that have entered TB during the simulation period.



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Subtask 3.1: Calibration of the Tims Branch Watershed Model and Scenario Analysis

FIU Year-2 Projected Scope:

- Complete calibration and validation of the U transport model for current hydrodynamic simulation time period.
- Conduct simulations of design storm events (500-yr, 100-yr, etc.) for U transport in TB *(delayed milestone 2020-P2-M11 due to loss of technical personnel)*.
- Set up contaminant transport model for other contaminants of interest (Sn & Ni).
- Continue maintenance of HOBO units and acquiring remote monitoring data at the TB watershed outlet to apply the model for other time periods.

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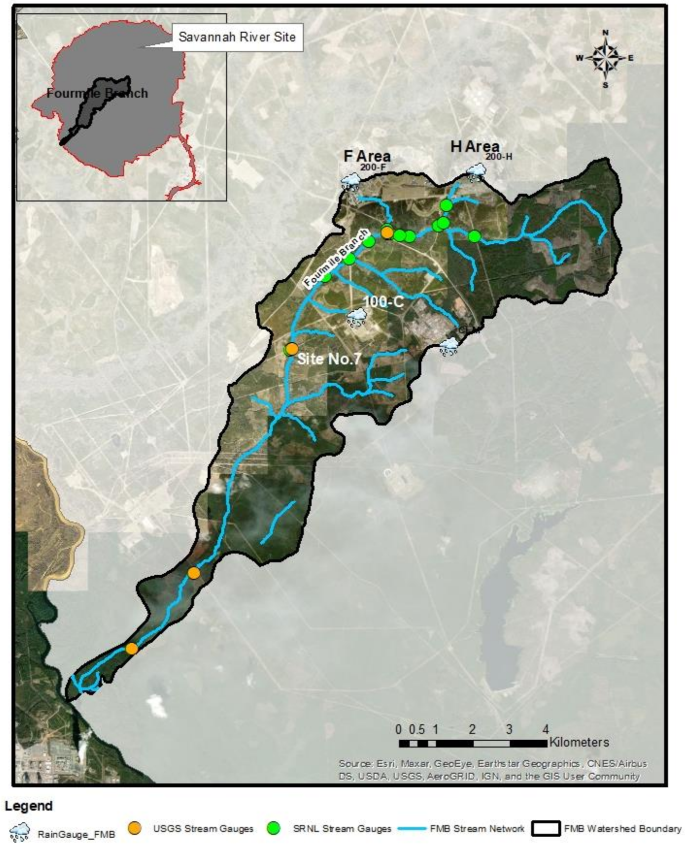
Subtask 3.2: Model Development for the Fourmile Branch and/or Lower Three Runs Watersheds (NEW)

Site Needs:

- Fourmile Branch (FMB) and Lower Three Runs (LTR) stream systems of Savannah River Site (SRS) contaminated by historical release of radionuclides (e.g., ^{137}Cs, ^{129}I) from on-site nuclear production facilities to surface water (SW) as well as underground seepage basins.
- Site environmental reports indicate contaminants bound to sediment and soil along wetland riparian forests downstream from reactor discharge points.
- Concern of potential remobilization and redistribution of sediment-bound contaminants during frequent/heavy rainfall or storm events.
- Hydrological models of these watersheds will serve as useful tools to understand the hydrological processes, and coupled with sediment and contaminant transport models, help to predict hydrological behavior and the fate and transport of contaminants under various environmental conditions.
- Results from this study will assist SRS in refinement of the site conceptual model by contributing to a better watershed-scale understanding of contaminant fate and transport in SRS streams.

Fourmile Branch Watershed, SRS



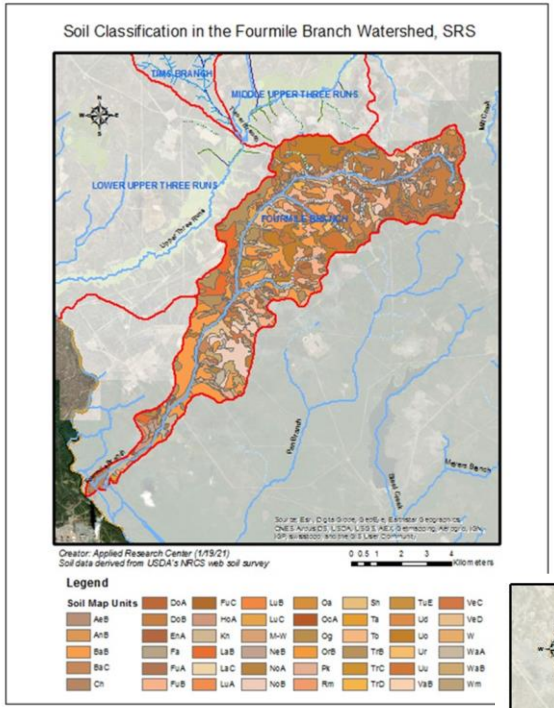
Objectives:

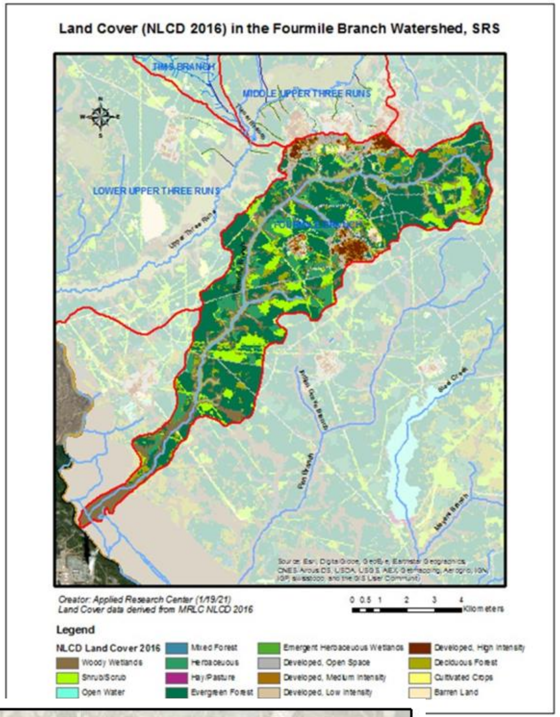
- To develop surface water and sediment/contaminant transport models of the FMB/LTR stream systems to evaluate potential fate and transport of major contaminants of concern during extreme meteorological events.
- Model development will be executed in the three phases:
  - Phase 1 – Data collection and pre-processing and conceptual model development of FMB watershed.
  - Phase 2 – FMB hydrology model development and calibration.
  - Phase 3 – Coupling of FMB hydrology model with sediment & contaminant transport components.

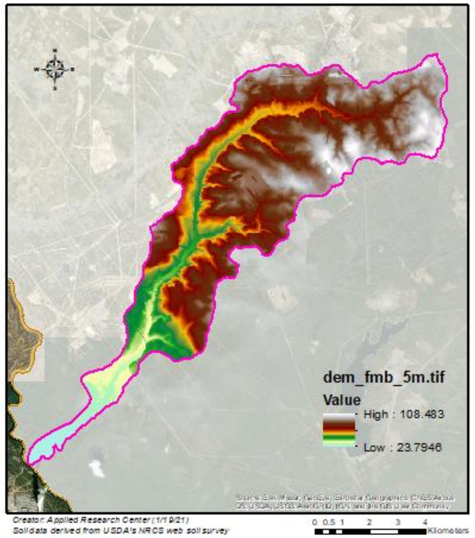
Subtask 3.2: Model Development for the Fourmile Branch and/or Lower Three Runs Watersheds (NEW)

FIU Year 1 Research Highlights & Accomplishments:

- Initiated Phase 1: Data collection and pre-processing to support future development of FMB hydrology model.
  - Lit. review of site background, history of contamination, applied remediation technologies
  - Data retrieval from fed. & state databases (USGS/USDA/SCDNR), SRNS/SRNL (scientists, ATG)
    - Climate: rainfall and evapotranspiration
    - Geospatial: DEM, stream network, soil, land cover, vegetation, monitoring sites/gauges, hydraulic structures (culverts, dams), etc.
    - Hydrological: river discharge and stage
    - Water quality (relevant to transport and interactions of contaminants and sediment): contaminant conc., suspended sediment conc., partitioning coefficient, desorption rate, critical velocity and settling velocity
- Created geodatabase to store and manage GIS data and applied ArcGIS geoprocessing and visualization tools to prepare the data for model input and to map the study area.







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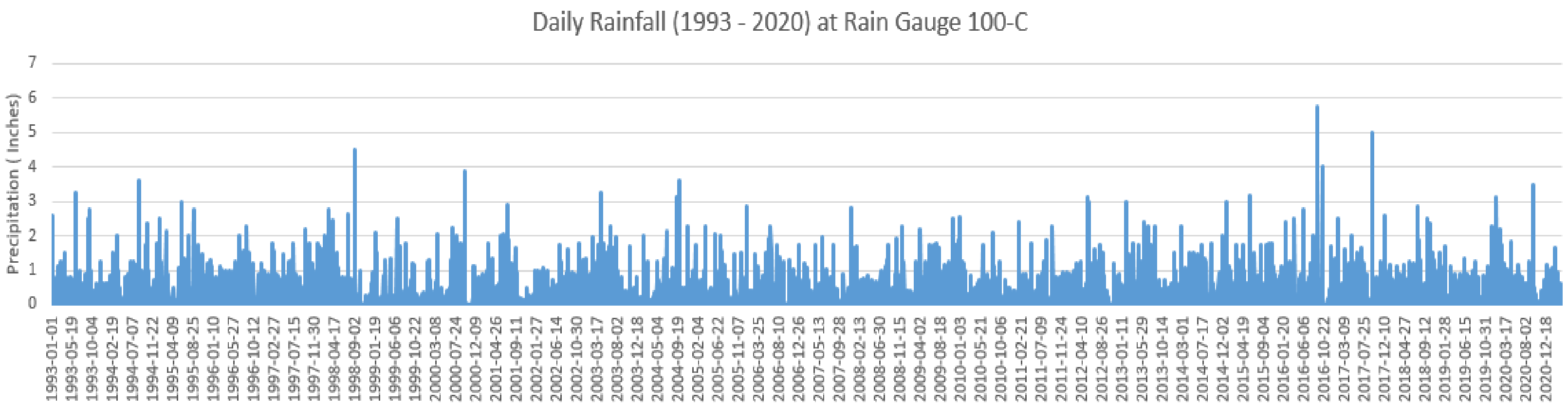
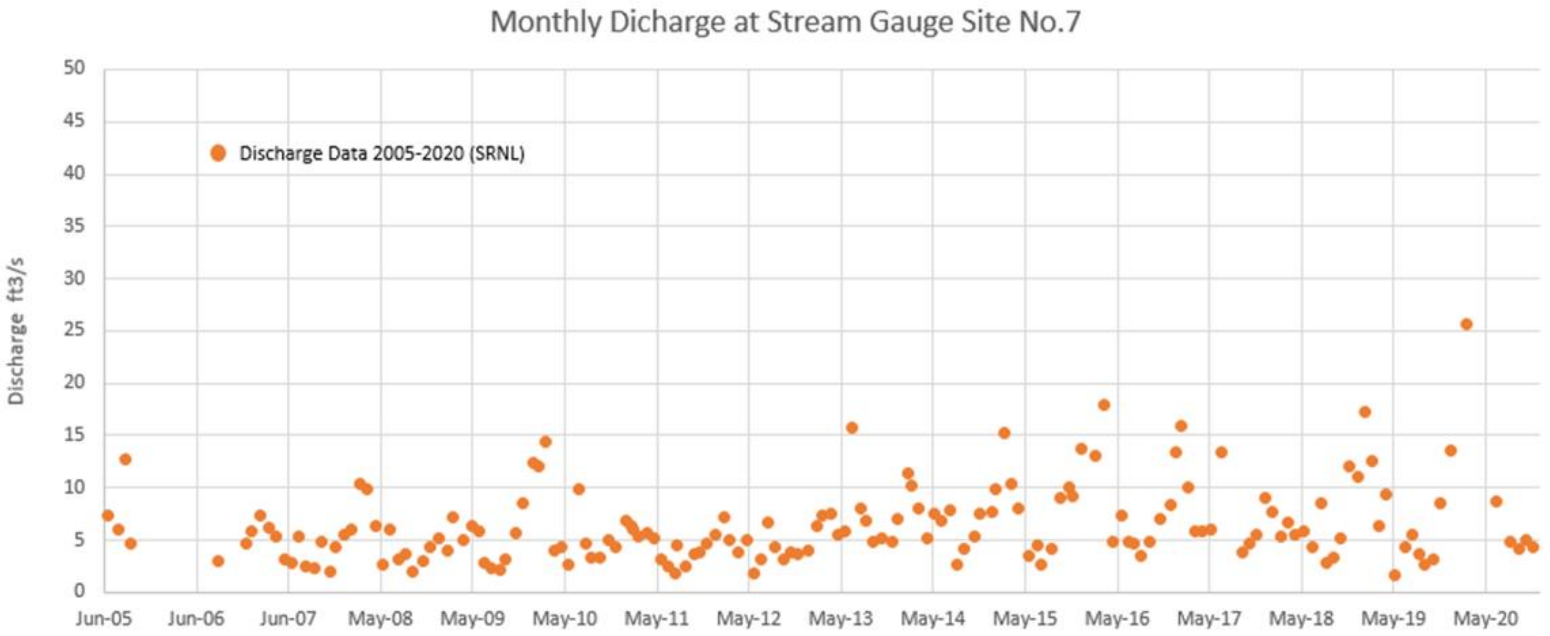
Subtask 3.2: Model Development for the Fourmile Branch and/or Lower Three Runs Watersheds (NEW)

FIU Year 1 Research Highlights & Accomplishments:

- Conducted analysis of timeseries data records (rainfall & discharge) to identify any significant storm events (500 yr/ 100 yr/ 50 yr, etc.)
- Simultaneous records of rainfall and discharge timeseries in time steps that would capture major storm events was limited. Remote monitoring at key locations in watershed needed to support model calibration & validation.
- FIU undergrad. student (DOE Fellow) was trained on geospatial mapping and analysis tools used and assisted in the data retrieval, processing and analysis.





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FIU Year 2 Projected Scope

- Complete milestones and deliverables related to the Project 2 Task 3 modeling efforts delayed due to loss of technical personnel. FMB watershed conceptual model development and numerical model development will be main priority.

Milestone/ Deliverable #	Milestone/Deliverable	Subtask	Orig. Due Date	Proj. Due Date
2020-P2-D3	Draft report on conceptual model development for Fourmile Branch watershed	3.2	6/30/2021	Reforecast to FIU Year 2
2020-P2-M10	Complete numerical model development for Fourmile Branch watershed	3.2	9/15/2021	Reforecast to FIU Year 2

Task 5

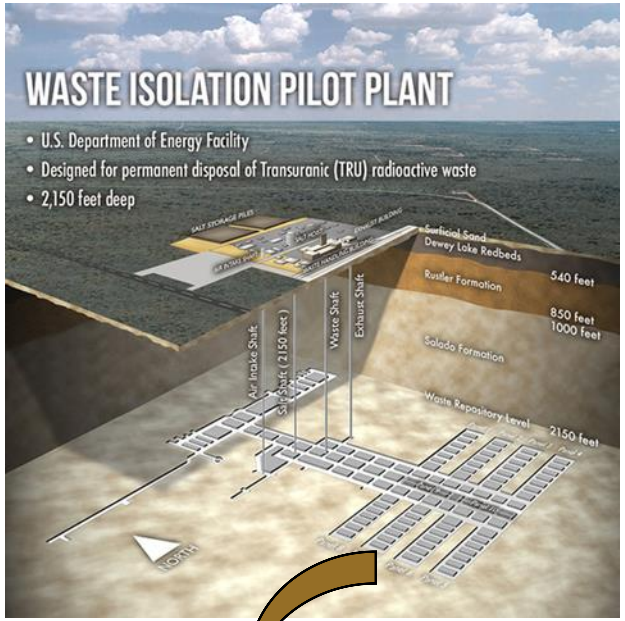
Research and Technical Support for WIPP

Applied Research Center

Subtask 5.2: Fate of Actinides in the Presence of Ligands in High Ionic Strength Systems

Site Needs:

- Because a safety assessment is required for the Waste Isolation Pilot Plant (WIPP) recertification every 5 years, there is a critical need by DOE to understand the safety ramification of the long-term stability of the stored TRU waste. Furthermore, a better understanding of the fate and transport of actinide in a high ionic-strength brine environment is important to addressing the low-probability scenario of potential brine inundation and contaminants' release due to human intrusions. Thus, the regulatory need to address these low-probability and/or worst-case scenarios is the main objective of this research on actinide interaction with brines in the WIPP environment. This research efforts complement ongoing actinide research by the LANL ACRSP team and will provide an improved understanding of the role of ligands such as gluconate, a cement additive, and iron oxide (corrosion product of steel containers) expected in the hyperalkaline WIPP conditions that have not been previously accounted for in current safety assessment models.



Objectives:

- This ongoing research is geared toward improving the scientific basis underpinning the robustness of the safety assessment for actinide (An) storage in the WIPP salt repository.
- Because the presence of corrosion product such iron oxide minerals (e.g. magnetite) and cement additive, (gluconate [GLU]) may enhance sorption or solubility of actinide at increased ionic strength, batch sorption studies are being conducted to understand the ternary interactions between actinides and WIPP-relevant ligands and minerals and their potential fate in the subsurface. The study data will help to predict the fate of actinide as well as provide useful parameters for safety/risk assessment models.

A cross section of the Waste Isolation Pilot Plant repository

Applied Research Center

Subtask 5.2: Fate of Actinides in the Presence of Ligands in High Ionic Strength Systems

FIU Year 1 Research Highlights & Accomplishments:

- Batch experiments were conducted to glean the impact of ionic strength and gluconic acid on sorption of actinide onto iron oxide mineral (magnetite) under anaerobic conditions.
- Brines: 0.1, 1.0 and 5.0 mol/L NaCl, $MgCl_2$ and $CaCl_2$
- U[VI], neodymium (Nd[III]) and thorium (Th[IV]) as stable chemical analogs for americium and plutonium under anaerobic conditions
- An actinide concentration ($[M]_{initial} = 10^{-8}$ M, where M= Nd, Th, U) representative of the undersaturation limit was used in these studies:
    - 1 g/L magnetite and 1 mg/L GLU (10^{-6} mol/L)
    - All batch experiments were performed in triplicates with standard deviations <10%
    - Centrifuged (filtered) vs. settling (unfiltered).
- Samples were collected at various time intervals up to two weeks and analyzed on ICP-MS.

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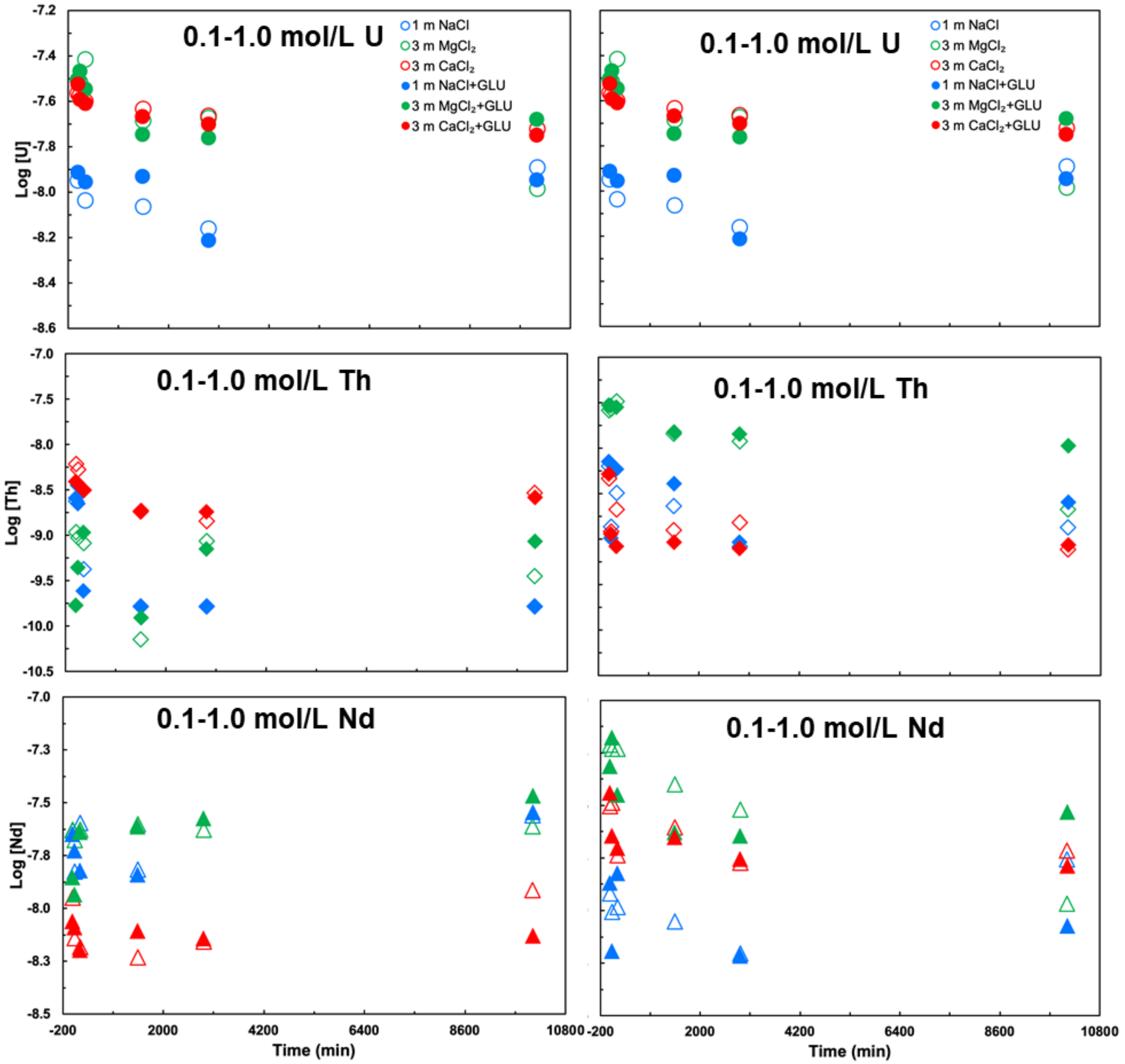
Subtask 5.2: Fate of Actinides in the Presence of Ligands in High Ionic Strength Systems

FIU Year 1 Research Highlights & Accomplishments:

- Addition of GLU had negligible impact on solubility of U, Th, Nd, suggesting absence of tertiary gluconate complex with the studied actinides.
- Brine types had a significant influence on actinide solubility.
- Higher ionic-strength brines tended to enhance the overall solubility of U, Th, Nd in $MgCl_2$ and $CaCl_2$ compared to NaCl brine.
- Poster presentation at: (1) Waste Management Symposia (WM-2021), and (2) International Symposium on Solubility Phenomena and Related Equilibrium Processes (ISSP-19)



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FIU Year 2 Projected Scope

- Study results from this task serves as the basis for a Master's thesis by Alexis Vento (July, 2021, Environmental Engineering). Alexis currently works at Stearns, Conrad & Schmidt, Consulting Engineers, Inc.
- Continue batch sorption experiments investigating the impact of GLU on the sorption of Nd(III), Th(IV), and U(VI) onto magnetite in WIPP-relevant brines such as $MgCl_2$, $CaCl_2$ and GWB and ERDA-6 using higher concentration of concentration of An ($[An]_{initial} = 1000\ \mu g/L$).
- Continue to support ongoing research on actinide through identification of minerals and ligands of interest to the WIPP (iron oxides, key contaminants with co-located lead) for risk assessment models for the WIPP re-certification.
- Visit LANL collaborator to discuss research plans and updates.

Alexis Vento
DOE Fellow Class of 2017

Task 6

Hydrology Modeling for WIPP

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Hydrology Modeling for WIPP

Site Needs:

- DOE-EM needs to improve the current understanding of regional and local groundwater (GW) flow near the WIPP to compute the water balance, and derive more accurate estimates of groundwater recharge to better predict the propagation rate of the shallow dissolution front and its potential long-term impact on repository performance.

Objectives:

- To develop a GW-basin model for the Nash Draw west of the WIPP using the DOE-developed open source ASCEM Amanzi Simulator (Advanced Simulation Capability for Environmental Management: Amanzi Simulator) to improve the current understanding of regional and local groundwater flow.
- Currently, ASCEM toolset is unable to account for land surface hydrology, which is essential for computing the water balance across multiple scales.
- The proposed work will therefore include utilization of the Advanced Terrestrial Simulator (ATS) code used for solving ecosystem-based, integrated, distributed hydrology. ATS builds on the multi-physics framework and toolsets (such as mesh infrastructure, discretizations, solvers) provided by Amanzi.
- ATS will provide surface process parameters (e.g., infiltration rate) for incorporation into the groundwater models within the ASCEM toolbox to facilitate sensitivity and uncertainty analysis of GW and SW flows.

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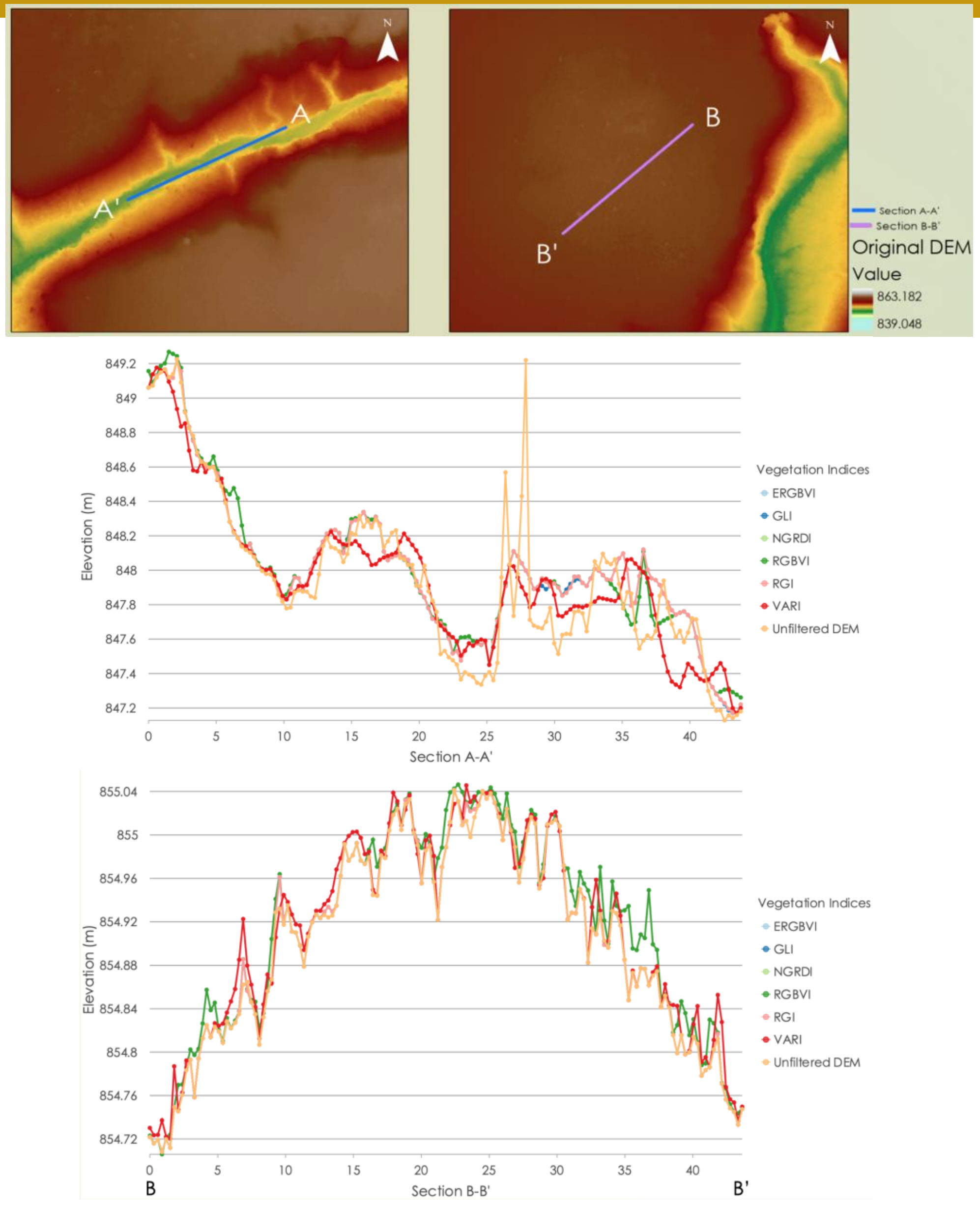
Subtask 6.1: Digital Elevation Model and Hydrologic Network

FIU Year 1 Research Highlights:

- RGB-based vegetation removal methods derived from lit. review tested to refine high-res DEM developed from drone imagery collected during pilot study in Basin 6 in 2020.
- DEM needed for LSM development and delineation of significant hydrological features (e.g., sink holes, brine lakes, gullies) that could contribute to regional GW recharge.
- Promising results with use of libLAS with Python to determine an optimum threshold value which separates the vegetation from the bare ground.
- Main issue was shadow effect due to time of day data was collected.
- Lit. review of shadow removal methods conducted and several applied with somewhat unsuccessful results.
- Proposed path forward:
    - Comparative analysis of vegetated areas on high-res DEM vs. satellite imagery (Landsat 8, Sentinel or NAIP)
        - Will require "scaling up" the DEM to the resolution of the satellite imagery for comparison
    - Comparative analysis of high-res DEM with NLCD vegetation density maps

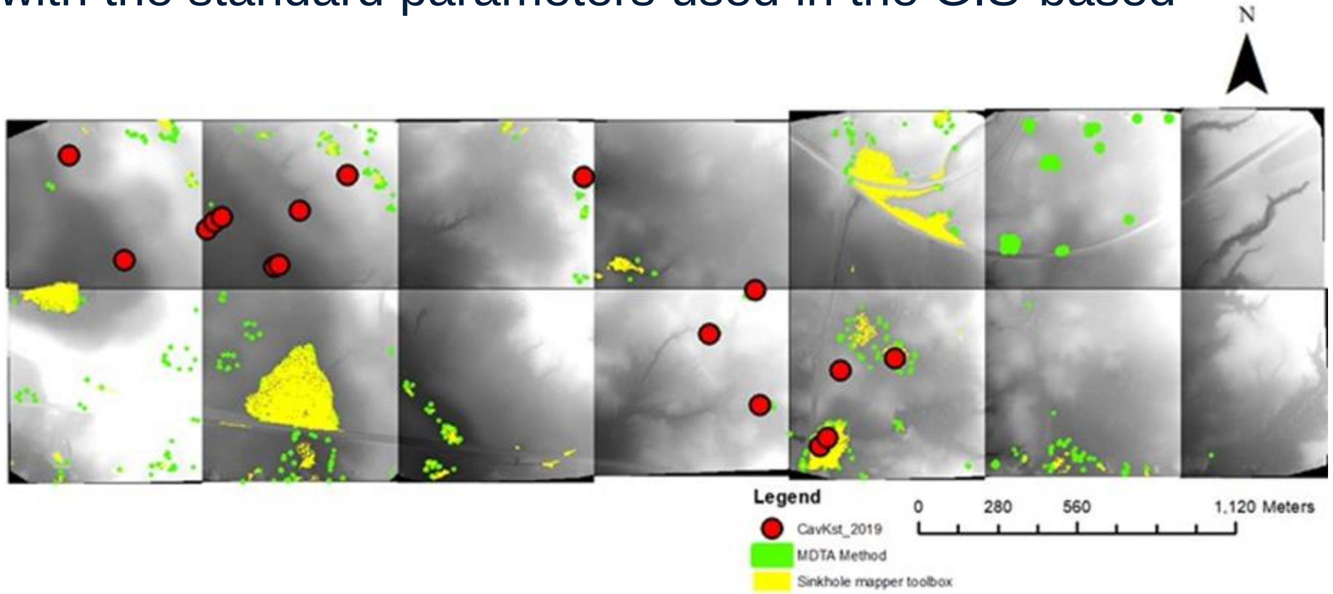


Section profile graphs of vegetation indices using ArcGIS and libLAS in Python.

Subtask 6.1: Digital Elevation Model and Hydrologic Network

FIU Year 1 Research Highlights:

- FIU's high-res DEM of the Basin 6 pilot study area was used to test two GIS-based sinkhole detection methods (MDTA & Sinkhole Mapper Toolbox) determined from peer reviewed literature.
- Test results were compared with a previous sinkhole inventory derived from GPS field mapping in Basin 6. (Goodbar et al, 2020)
- Results visualized using ArcGIS showed the sinkholes derived from the GIS-based detection methods (green & yellow areas) in many cases either overlapped or were in close proximity to the ground surveyed sinkholes (red dots). Numerous additional depressions were also identified with the standard parameters used in the GIS-based detection methods.
- Mapped sinkholes from the Sinkhole Mapper Toolbox method are currently being incorporated to refine the Basin 6 mesh using TINerator mesh generator, which will be used in ATS.



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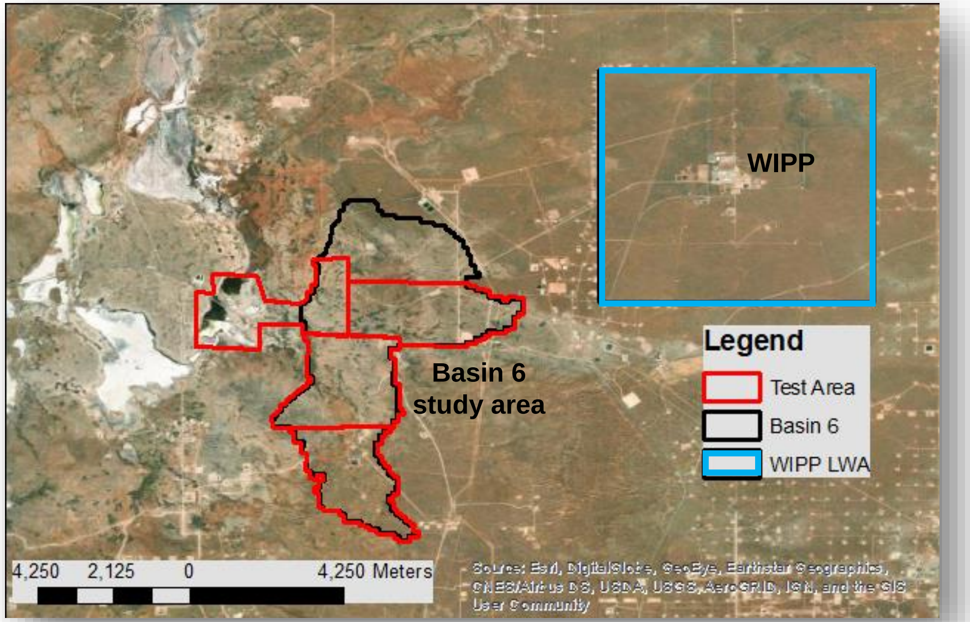
Subtask 6.1: Digital Elevation Model and Hydrologic Network

FIU Year 1 Research Highlights:

- FIU research team traveled to Carlsbad, NM (Aug. 2021) to collect complete imagery dataset for Basin 6 study area (~ 24 km^2).
- Pilot study area ~ 5 km^2
- FIU team was successful in capturing ~ 22 km^2. Site will be revisited early in FIU Yr 2 to complete survey.
- Final data set to be processed as per the established photogrammetry work flow.

FIU Research Team: Mackenson Telusma and DOE Fellows (Gisselle Gutierrez-Zuniga & Eduardo Rojas)



Basin 6 study area (completed survey area in red)

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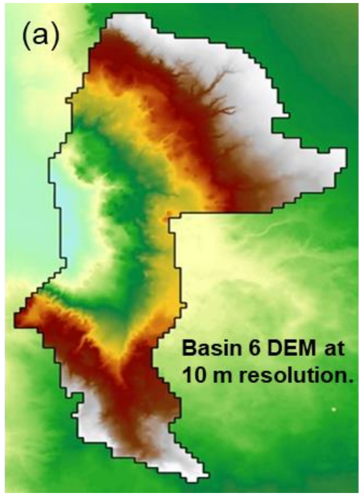
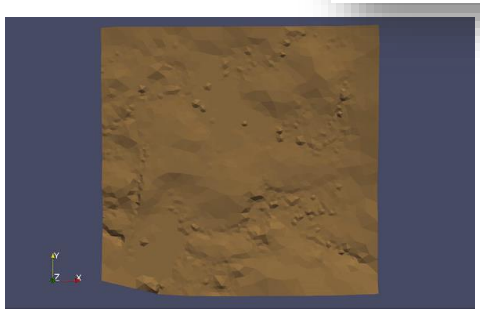
Subtask 6.2: Model Development

FIU Year 1 Research Highlights:

- FIU team trained on ASCEM toolset including tutorials for familiarization with Akuna GUI for GW model development.
- Existing Culebra MODFLOW model provided by CBFO from which several model inputs applied for preliminary GW model development.
- FIU also trained on data preprocessing tools (e.g., LaGriT) and creating data layers for the GW model including conversion of the MODFLOW inputs.
- Land surface models evaluated and ATS selected after consultation with PNNL, CBFO & LANL site collaborators.
- ATS training of FIU team initiated by Drs. David Moulton & Daniel Livingston (LANL).
- DOE Fellow continued training with LANL scientists as part of summer internship to become equipped with necessary skillset to support WIPP modeling work.
- FIU will maintain collaboration with LANL, CBFO and PNNL scientists to continue GW model and LSM development.



ATS Overland Flow scenario using Borden watershed example.



Five layer mesh of a part of Basin 6. Layer depths strongly exaggerated for effect.

FIU Year 2 Projected Scope

- Complete milestones and deliverables related to the Project 2 Task 6 modeling efforts delayed due to travel postponements to conduct field-work and loss of technical personnel.
- Complete Basin 6 field survey (~ 2 km^2) and execute processing workflow established in FIU Year 1 to generate a high resolution DEM of Basin 6.

Milestone/ Deliverable #	Milestone/Deliverable	Subtask	Orig. Due Date	Proj. Due Date
2020-P2-M9	Complete DEM development for Basin 6	6.1	8/2/2021	Reforecast to FIU Year 2
2020-P2-M12	Complete LSM development for Basin 6	6.2	9/28/2021	Reforecast to FIU Year 2
2020-P2-D5	Draft report on ASCEM groundwater model development	6.2	9/15/2021	Reforecast to FIU Year 2

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Task 7

Engineered Multi-Layer Amendment Technology for Hg Remediation on Oak Ridge Reservation (NEW)

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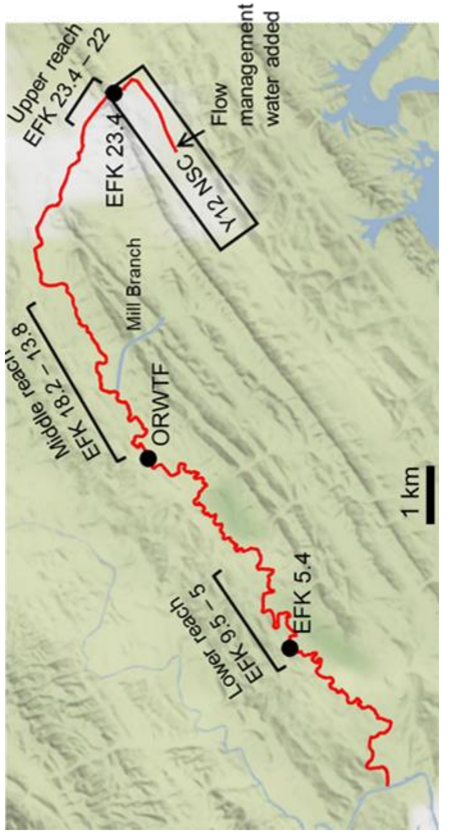
Task 7:Engineered Multi-Layer Amendment Technology for Hg Remediation on Oak Ridge Reservation (NEW)

Site Needs:

- The cleanup of **mercury** is a challenging task because of its persistent geochemistry across a the growing number of mercury-contaminated sites globally. Moreover, the existence of diffuse mercury sources further complicate technology development efforts for mercury remediation in freshwater ecosystems, such as the East fork Poplar Creek (EFPC), Oak Ridge, Tennessee (EFPC). As a case study, the EFPC ecosystem received large point-source discharges during the 1950s. Although upstream mercury discharges to EFPC have declined, mercury releases still persist from point sources and diffuse downstream sources, such as contaminated bank soils. Mercury fate and transport within EFPC ecosystem are driven by the strong interaction of aqueous mercury with dissolved organic matter (DOM, at ~3 mg/L), which renders mercury sorption to sorbents and removal from water column by strong reductant problematic.



East Fork Poplar Creek, Oak Ridge Tennessee

Objectives:

- To understand the fate of mercury in the presence of a suite of sorbent media for an improved prediction of organomercury species (MeHg) production in contaminated ecosystems
- Conduct adsorption experiments on suite of sorbents to identify the best combinations and placement of sorbent media for cost-effective remediation of mercury within EFPC ecosystem.

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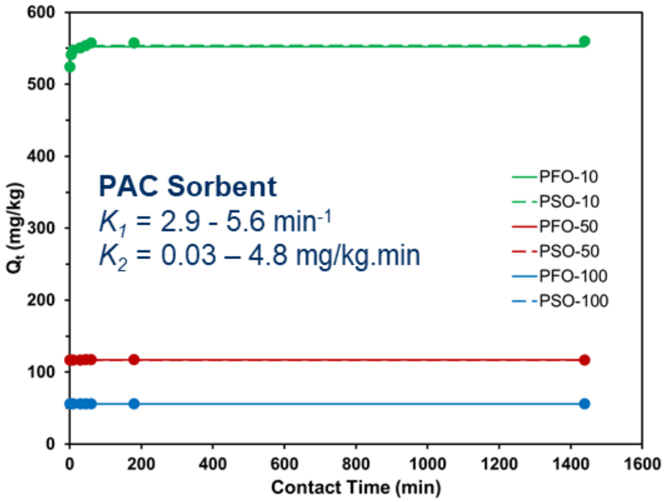
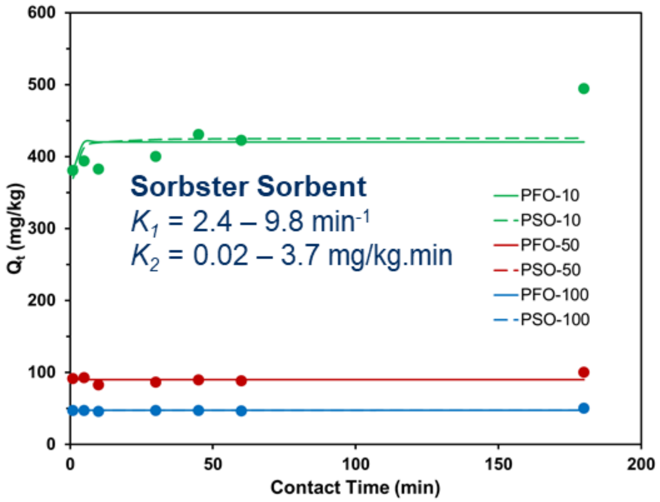
Task 7: Engineered Multi-Layer Amendment Technology for Hg Remediation on Oak Ridge Reservation (NEW)

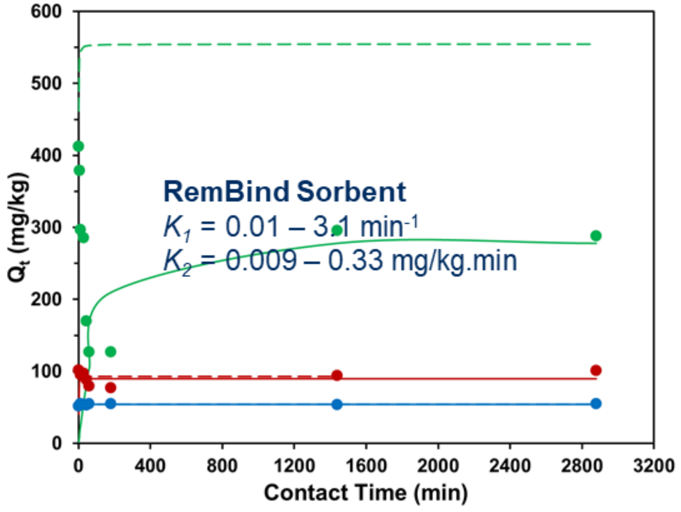
FIU Year 1 Research Highlights & Accomplishments:

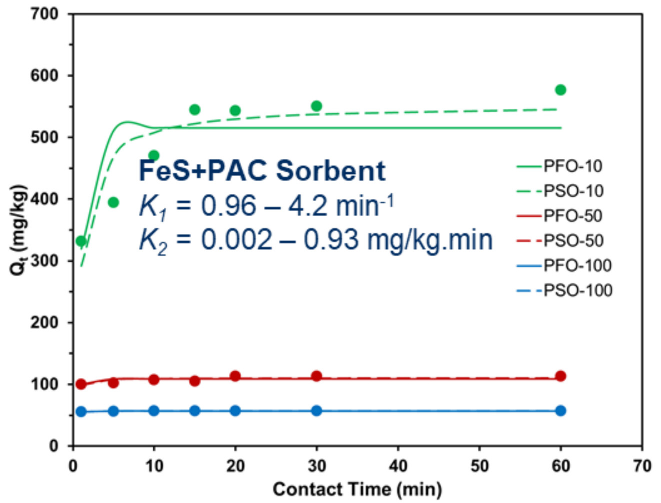
$$Q_t = Q_e\left(1 - e^{-k_1 t}\right) \Rightarrow \text{PFO}$$

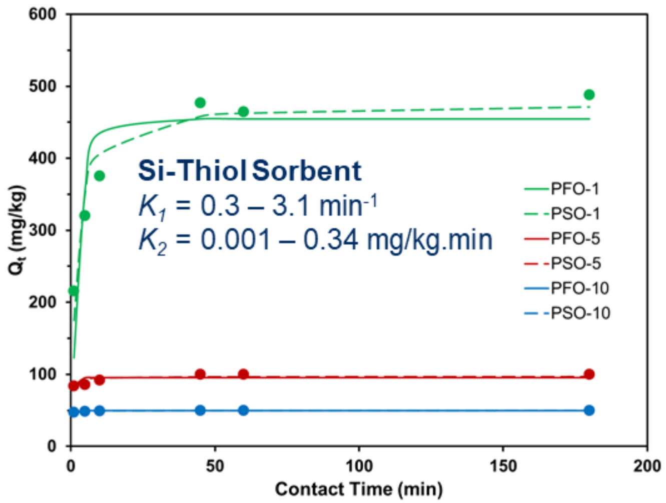
$$Q_t = \frac{Q_e^2 k_2 t}{1 + k_2 Q_e t} \Rightarrow \text{PSO}$$

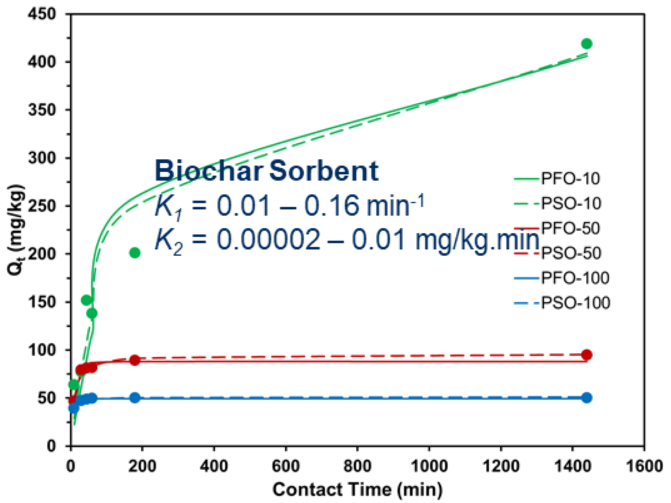












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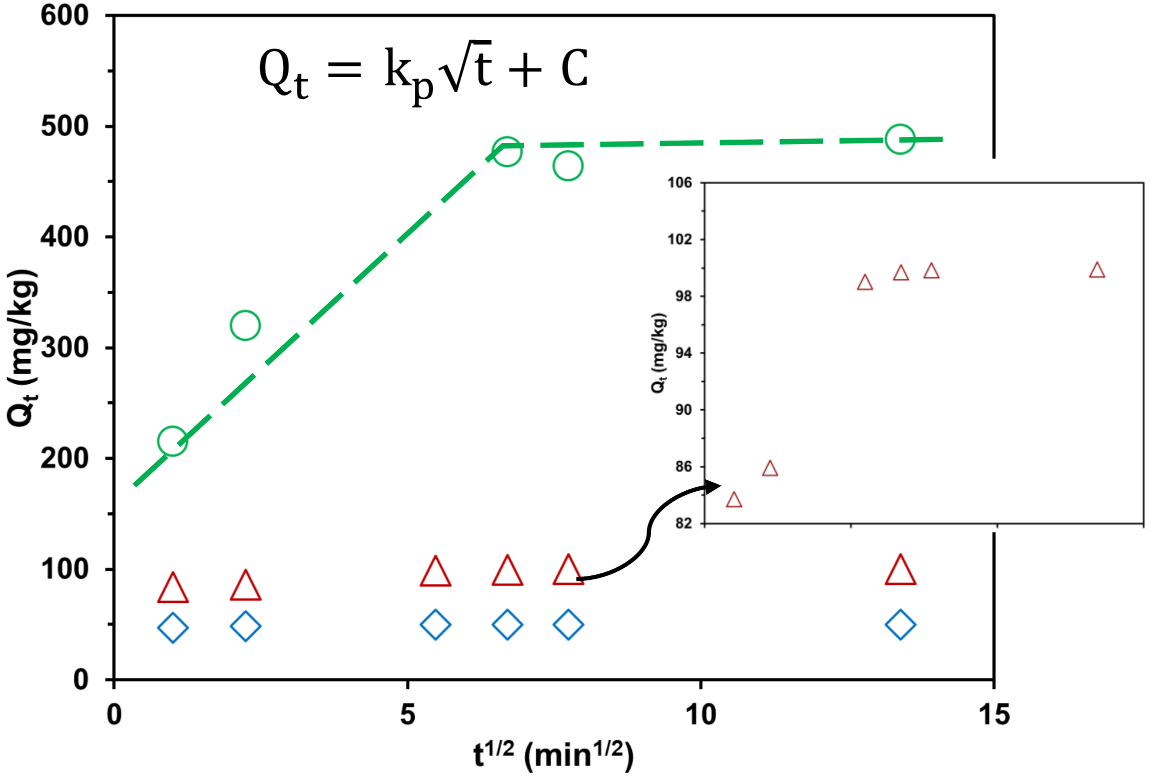
Task 7: Engineered Multi-Layer Amendment Technology for Hg Remediation on Oak Ridge Reservation (NEW)

FIU Year 1 Research Highlights & Accomplishments:



- For all evaluated sorbents adsorption is primarily controlled by film diffusion, i.e. external mass transfer of Hg^{2+} from the bulk solution to the external surface of the sorbent material through hydrodynamic boundary film or layer

- Completed adsorption kinetic studies and determined pertinent kinetic parameters for 8 sorbent media using the Pseudo-first order (PFO) and pseudo-second order (PSO) kinetic models.
- A conference abstract titled "Sorbent-based technology for mercury remediation in a freshwater aquatic system" was submitted to American Geophysical Union Fall meeting to held in December, 2021.

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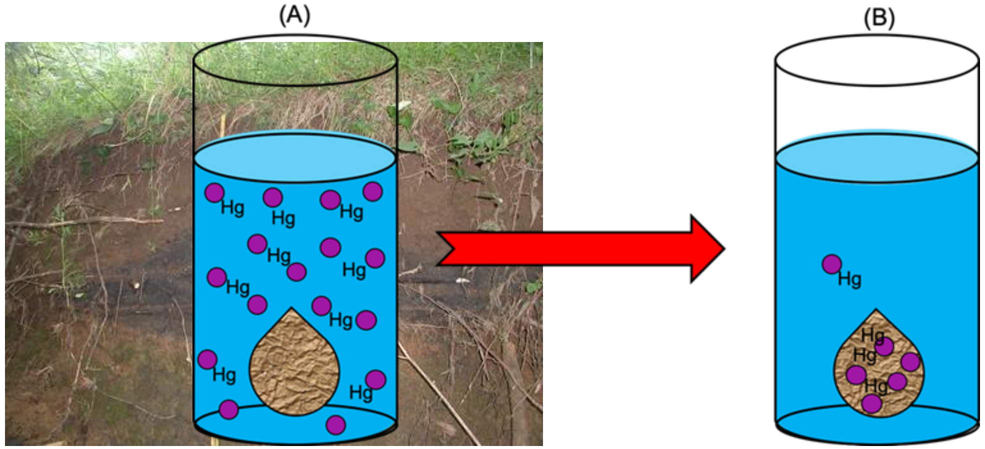
Task 7:Engineered Multi-Layer Amendment Technology for Hg Remediation on Oak Ridge Reservation (NEW)

FIU Year 2 Projected Scope

- Perform isotherm studies to determine the adsorptive capacity of select sorbent media in artificial creek water (ACW) and/or ACW amended with dissolved organic matter (DOM).
- Evaluate mercury species dynamic under conditions representative of EFPC using Geochemist Workbench program
- Characterize pristine and treated sorbent using microscopy and spectroscopy techniques (SEM-EDS and XRD analysis)
- Develop column studies to elucidate mercury sorption under conditions representative of EFPC site.



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FIU Year 1 Overall Accomplishments

Publications

- Di Pietro, et al., Solid phase characterization and transformation of illite mineral with gas-phase ammonia treatment (under review in the *Journal of Hazardous Materials*).
- Di Pietro, et al., Phyllosilicate mineral dissolution upon alkaline treatment under aerobic and anaerobic conditions, 2020. Applied Clay Science, v.189, p.105520
- Dickson, J., N. A. Conroy, Y. Xie, B. A. Powell, J. C. Seaman, M. I. Boyanov, K. M. Kemner, D. I. Kaplan. Surfactant-modified siliceous zeolite Y for pertechnetate remediation (2020). Chemical Engineering Journal, v. 402, p. 126268.
- Katsenovich, Y. P., R. Trimino Gort, R. Gudavalli, J. Szecsody, V. Freedman, and N. P. Qafoku. Silicon concentration and pH controls over competitive or simultaneous incorporation of iodate and chromate into calcium carbonate phases. Applied Geochemistry 128 (2021) 104941.

WM21 papers & (virtual) oral presentations:

- Zhou, Y., Alam, M., Lawrence, A., Yancoskie, A., Morales, J., Lagos, L., Looney, B. and J. Seaman. “Hydrologic Modeling and Storm Analysis for Technology Evaluation and Long-Term Monitoring in the Tims Branch Testbed, SC – 21247.” Proceedings of the Waste Management Symposia 2021, Phoenix, AZ, March 2021.
- Alam, M., Zhou, Y., Yancoskie, A., Lawrence, A., Morales, J., Charles, S., Lagos, L., Looney, B. and J. Seaman.“Sediment Transport Modeling under extreme storm events in the Tims Branch Testbed, Savannah River Site, SC – 21290.” Proceedings of the Waste Management Symposia 2021, Phoenix, AZ, March 2021.
- Dickson, J., A. Vento, Y. Katsenovich, A. K. Sockwell, J. S. Swanson, D. T. Reed. Organic Ligand Control on Mineral Stability in High Ionic Strength Matrices: Implication for Actinide Mobility In WIPP-relevant Environment. Waste Management 2021 Virtual Conference, Phoenix, AZ, March 2021.
- Gudavalli, R., K. De La Rosa, P. Pham, H. Gonzalez Raymat, B. Looney, Y. Katsenovich, L. Lagos. Low Cost Humate as an Amendment for Uranium Remediation. Waste Management 2021 Virtual Conference, Phoenix, AZ, March 2021.
- Kandel, S., Y. Katsenovich, R. Matthew Asmussen, A. K. Sockwell and R. Gudavalli. Effect of Grout Impacted Water on the Glass Dissolution Behavior at Various Temperature. Waste Management 2021 Virtual Conference, Phoenix, AZ, March 2021.
- Katsenovich, Y., R. Trimino Gort (DOE Fellow), R. Gudavalli, N. P. Qafoku, J. Szecsody, V. Freedman, L. Lagos, October 2020. Incorporation of Iodate in Calcium Carbonate at Variable pH and Si Concentrations. Presentation for the 57th Annual Meeting of the Clay Mineral Society, Oct 18-23, 2020.
- Katsenovich, Y., R. Trimino Gort, R. Gudavalli, N. P. Qafoku, J. Szecsody, V. Freedman, L. Lagos. Incorporation of Iodate and Chromate in Calcium Carbonate Phases at Variable pH and Si Concentrations. Waste Management 2021 Virtual Conference, Phoenix, AZ, March 2021.

Student Posters:

- Di Pietro, S. A., (DOE Fellow), Y. Katsenovich, H. P. Emerson. Illite Physicochemical Transformation upon NH3 Gas Treatment. Waste Management 2021 Virtual Conference, Phoenix, AZ, March 2021.
- Doughman, M. (DOE Fellow), Y. Katsenovich, L. Lagos, Competing Attenuation Processes for Mobile Contaminants in Hanford Sediments. Waste Management 2021 Virtual Conference, Phoenix, AZ, March 2021.
- Morales, J. (DOE Fellow), L. Bramer, L. Lagos, K. Waters. Investigation of Heavy Metal Biomarkers for the Assessment of Remediated Surface Waters. Waste Management 2021 Virtual Conference, Phoenix, AZ, March 2021.
- Pham, P. (DOE Fellow), R. Gudavalli. Characterization of KW-15 modified humic acid - a potential in-situ technology for uranium remediation at the SRS. Waste Management 2021 Virtual Conference, Phoenix, AZ, March 2021.
- Vento, A. (DOE Fellow), J. Dickson, Y. Katsenovich. Investigation and analysis of dolomite dissolution in variable ionic-strength systems relevant to the WIPP. Waste Management 2021 Virtual Conference, Phoenix, AZ, March 2021.
- Delarosa, K. (DOE Fellow), R. Gudavalli, Y. Katsenovich, P. Pham, L. Lagos. Effect of modified-HA on the Sequestration of Uranium in acidic groundwater at the Savannah River Site. Waste Management 2021 Virtual Conference, Phoenix, AZ, March 2021.
- Tuya, N. (DOE Fellow), R. Gudavalli, H. Gonzalez-Raymat, L. Lagos. Influence of Environmental Factors on Iodine Attenuation and Release in Savannah River Site Wetlands Sediments. Waste Management 2021 Virtual Conference, Phoenix, AZ, March 2021.
- Bustillo, O. (DOE Fellow), R. Gudavalli, L. Lagos. Interaction of Hydroxyapatite and Uranium in Groundwater at the Old Rifle Site to Facilitate Site Remediation. Waste Management 2021 Virtual Conference, Phoenix, AZ, March 2021.
- Charles, S. (DOE Fellow), M. Alam, Y. Zhou, A. Lawrence, B. Looney, J. Seaman. Examining the Variation in the Sediment Transport process under different Erosion and Precipitation Criteria. Waste Management 2021 Virtual Conference, Phoenix, AZ, March 2021.

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Technology Development and Deployment Road Map

Site	Technology	2020	2021	2022	2023	2024
Hanford	In Situ Sequestration	Fundamental Science to Support Technology Deployment	Technology Readiness for Feasibility Studies			
		Bench-scale testing	Bench-scale testing		Knowledge transfer to support evaluation of potential *in situ* VZ treatment technologies/treatability testing	
	Natural Attenuation	Bench-scale testing	Bench-scale testing	Bench-scale testing	Knowledge transfer to support evaluation of MNA/modeling	
	Glass	Bench-scale testing via SPFT	Bench-scale testing via SPFT	Bench-scale testing via SPFT	Bench-scale testing via SPFT	Knowledge transfer to support PA of IDF

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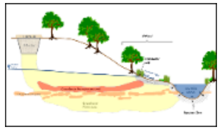
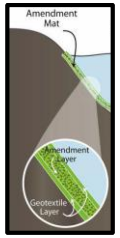
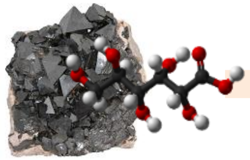
Technology Development and Deployment Road Map







Site	Technology	2020	2021	2022	2023	2024
SRS	Environmental factors controlling contaminants at SRS	Bench-scale experiments	Bench-scale experiments	Bench-scale experiments	Knowledge transfer for long term monitoring	
SRS	Evaluation of Humic Acid for uranium sequestration	Bench-scale experiments	Knowledge transfer for long term monitoring			
Mercury ORNL		Conceptual Design of Technology	Sorbents Development	In-house Testing	Site Testing	Site Deployment of Technology
WIPP		Knowledge Development	Development /Testing	Development /Testing	Development /Testing	Knowledge Transfer

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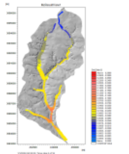
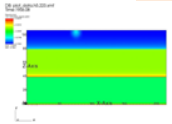
Technology Development and Deployment Road Map

Site	Technology	2020	2021	2022	2023	2024
SRS		Tims Branch: Integrated SW/GW Model Calibration	Sed. Transport Model Calibration/ Validation	Contaminant Transport Model Calibration/Validation	Contaminant Transport Model Calibration/Validation	Model Implementation/ Hand-over
SRS		Fourmile Branch: Conceptual Model Dev't	Conceptual Model Dev't	Integrated SW/GW Model Dev't & Calibration	Sed. & Contam. Transport Model Calibration/ Validation	Model Implementation/ Hand-over
WIPP		DEM, BASIN 6: Pilot Study DEM dev't	Basin 6 DEM dev't	Basin 6 DEM Hand-over		
WIPP	Amanzi-ATS	LSM, Basin 6: Numerical Model Assessment	Numerical Model Dev't	Numerical Model Dev't	Model Implementation/ Hand-over	
WIPP		ASCEM GWM, Basin 6: Numerical Model Dev't	Numerical Model Dev't	Model Implementation/ Hand-over		
WIPP				ASCEM GWM, WIPP (Nash Draw): Numerical Model Dev't	Numerical Model Dev't & Calibration	Model Implementation/ Hand-over
WIPP				LSM, WIPP (Nash Draw): Conceptual & Numerical Model Dev't	Numerical Model Dev't & Calibration	Model Implementation/ Hand-over

*DEM: Digital Elevation Model, LSM: Land Surface Model, GWM: Groundwater Model

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Thank You. Questions?