QUARTERLY PROGRESS REPORT

July 1 to September 30, 2016

Florida International University's Continued Research Support for the Department of Energy's Office of Environmental Management

Principal Investigator:

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Prepared for:

U.S. Department of Energy
Office of Environmental Management
Under Cooperative Agreement No. DE-EM0000598

Applied Research Center
FLORIDA INTERNATIONAL UNIVERSITY

Introduction

The Applied Research Center (ARC) at Florida International University (FIU) executed work on four major projects that represent FIU-ARC's continued support to the Department of Energy's Office of Environmental Management (DOE-EM). The projects are important to EM's mission of accelerated risk reduction and cleanup of the environmental legacy of the nation's nuclear weapons program. The information in this document provides a summary of the FIU-ARC's activities under the DOE Cooperative Agreement (Contract # DE-EM0000598) for the period of July 1 to September 30, 2016.

The period of performance for FIU Performance Year 6 under the Cooperative Agreement was originally August 29, 2015 to August 28, 2016. A no-cost extension was provided by DOE to extend the end of FIU Performance Year 6 to September 28, 2016 to allow additional time for DOE to review FIU's continuation award.

Executive highlights during this reporting period include:

Program-wide:

- The year-end research presentation overview to DOE HQ and DOE site and national laboratory points-of-contact to discuss the research progress and accomplishments as well as the proposed scope of work for the following year was completed on September 21, 2016. The project task plans were completed and submitted to DOE HQ on September 30, 2016.

***Project 1*: High level waste (HLW)/waste processing**

FIU is assisting DOE EM to meet the challenges of an aging high-level waste (HLW) infrastructure through: 1) the evaluation of infrared sensors that can assist in assessing the operating conditions of the double-shelled tanks (DSTs) and waste transfer components using the ability to measure tank temperatures and correlate these temperatures with the wall temperatures inside the tank; and 2) the development of robotic inspection tools that can assist in assessing the integrity of the DSTs and the waste transfer components by providing environmental and structural information in locations that are difficult or dangerous to access.

1. Recently, FIU has completed its initial testing of the IR sensor using a testbed that includes a small tank, thermocouples and a heater. The tank is heated up to various temperatures and readings of the wall temperature are obtained with the IR sensor from 3 different distances from the tank wall. Initial results indicate that there is some variation in the sensor output, up to 10% error. A model has also been generated that provides the tank temperature on the inside wall based on the measurements of the outside wall. A paper highlighting these results was submitted to the IMAPS conference and a summary document was provided to DOE-EM HQ on July 29.
2. FIU participated in the DOE National Lab Day on Capitol Hill in which our DOE Fellows student program and robotics research was showcased. DOE Fellow, Gene Yllanes, and the program director (Dr. Lagos) had the opportunity to participate in this event and brief the Secretary of Energy (Dr. Moniz) and other members of Congress on the research and development of a number of robotic systems including our miniature

rover, peristaltic crawler and inspection platform. FIU's robotic technologies were also displayed and showcased at the National Cleanup Day, a DOE EM event that followed the DOE National Lab Day on Capitol Hill.

Project 2: **Environmental remediation (ER)**

FIU is assisting DOE EM to meet the challenges of managing the environmental restoration of subsurface contamination in soil and groundwater. FIU is investigating: 1) the effect of ammonia gas on the uranium subsurface sequestration process at Hanford; and 2) development of an integrated hydrology and contaminant transport model to simulate flow velocity and depth over time, and to estimate spatiotemporal distribution of sediment and contaminants in the Tims Branch watershed during extreme atmospheric events.

1. A publication based on this research and entitled, "The effect of Si and Al concentrations on the removal of U(VI) in the alkaline conditions created by ammonia gas," written in collaboration PNNL, was accepted for publication by the journal *Applied Geochemistry*.
2. To support the hydrology and contaminant transport modeling research, ARC staff and students travelled to SRS for a week in August to conduct fieldwork which involved the collection of *in situ* data such as flow and water quality parameters from Tims Branch stream and its major tributary. This activity provided FIU undergraduate and graduate STEM students (DOE Fellows) with an opportunity to receive technical training on various field and laboratory procedures for collecting water samples, measuring flow velocity, quantifying water quality parameters (pH, turbidity, temperature, etc.), and generating multiple stream cross section profiles.
3. A publication based on this research and entitled, "Effects of Ammonium on Uranium Partitioning and Kaolinite Mineral Dissolution," is under revisions for publication in the *Journal of Environmental Radioactivity*.

Project 3: **Deactivation and decommissioning (D&D)**

FIU is assisting DOE EM to meet high priority D&D needs and technical challenges across the DOE complex through: 1) technology development, demonstration and evaluation; 2) managing the vast amount of waste forecast information for planned treatment and disposal across the DOE complex; and 3) preserving and transferring D&D knowledge and information to assist future D&D projects and the future workforce.

1. Standardizing and implementing proven processes to refine and better synchronize DOE-EM technology needs, requirements, testing, evaluation, and acquisition by development of uniformly accepted testing protocols and performance metrics is an essential component of these efforts. FIU is participating in the ASTM International's Executive Steering Committee and leading the ASTM International E10.03 Subcommittee in developing standardized testing protocols and performance metrics for D&D technologies. The subcommittee has completed the development of two new draft standard specifications on fixative technologies: a) strippable/removal coatings, and b) permanent coatings and fixatives. The standard specifications outline the performance, mechanical, chemical, and physical requirements expected of the technology with the associated performance criteria.

2. FIU is investigating the use of intumescent coatings to mitigate the release of radioisotopes during fire and/or extreme heat conditions that can potentially occur at a DOE contaminated facility/building. FIU visited SRNL on August 8-9, 2016, and provided a joint presentation with SRNL research scientists to SRS 235-F facility personnel, including project managers as well as safety and fire division representatives, on the potential of adapting intumescent coatings as standalone fixatives to assist with the overall safety basis of the site. The brief was exceptionally well received, and there was general concurrence to further the research through a scaled demonstration in a radioactive environment

3. FIU is performing a series of tests to subject test coupons of intumescent coatings to increasing temperatures using a muffle furnace along with adhesion and impact testing of these test coupons on various types of substrates in support of SRS 235-F D&D requirements. Utilizing the testing protocols outlined in ASTM D3359, Standard Test Methods for Measuring Adhesion by Tape Test, FIU conducted a series of adhesion tests on 4"x4" stainless steel coupons prepared under environmentally controlled conditions at 72ºF and 43% humidity. Adhesion tests were conducted before and after subjecting the prepared test coupons to extreme heat conditions in a muffle furnace at temperatures between 600-800ºF for 15 minute periods.

***Project 4:* STEM workforce development**

FIU created the DOE Fellows Program in 2007 to assist DOE EM to address the problem of an aging federal workforce. The program provides training, mentorship, and professional development opportunities to FIU STEM students. The DOE Fellows provide critical support to the DOE EM research being conducted on high impact/high priority research being conducted at FIU.

1. Ten (10) DOE Fellows completed their 10-week summer internship assignments at LANL, SRNL, PNNL, WRPS, NETL, and DOE-HQ (Maryland), which were conducted from June 6 to August 12, 2016. The summer internship technical reports will be submitted to DOE and posted to the DOE Fellows website (http://fellows.fiu.edu) once the site review and approval process is complete.

2. FIU participated in the DOE National Lab Day on Capitol Hill on 9/13/16. FIU showcased the DOE Fellows student program and the research that is being conducted in the tasks related to the development of robotics. Three systems were showcased, including the miniature rover, peristaltic crawler and the platform. Each was displayed to demonstrate how students are utilizing the skills learned at FIU on real-world engineering problems. DOE Fellow Gene Yllanes represented the Fellows program and STEM students at this event.

3. The DOE Fellows program and FIU's robotic technologies were also was represented at the National Cleanup Day, a DOE EM event that followed the DOE National Lab Day on Capitol Hill.

Project deliverables and milestones during this reporting period include:

***Project 1*: High level waste (HLW)/waste processing**

- The deliverable for Task 18.3.1, which was a summary document for the initial testing of the infrared sensor, was completed and submitted to DOE HQ on June 29, 2016.
- The deliverable for Task 17.1.1 which was a summary document related to the modelling of HLW mixing processes was completed and submitted to DOE HQ on August 28, 2016.

***Project 2:* Environmental remediation (ER)**

- Milestone 2015-P2-M5 for Task 3, complete input of the MIKE SHE model configuration parameters for the simulation of saturated zone (SZ) flow, was completed on July 27, 2016 and a memo was sent to the relevant SRNL/SRS and DOE-HQ contacts.

***Project 3:* Deactivation and decommissioning (D&D)**

- FIU provided a decision brief to Andrew Szilagyi and John De Gregory with DOE EM-13 on recommended technologies to test for FIU Performance Year 7 on May 11, 2016, as part of a larger briefing on FIU's current and future D&D research activities.
- FIU completed a deliverable on a review of potential robotic technologies for application at the SRS 235-F Facility and sent it to DOE and the site on 8/12/16.
- FIU completed a draft infographic on knowledge management (highlighting D&D KM-IT as an example) and sent it to DOE for review on 8/8/2016.
- FIU completed a metrics progress report on the outreach and training activities for D&D KM-IT and sent it to DOE on 8/15/16.

***Project 4:* STEM workforce development**

- No milestones or deliverables were due for this quarter.

The program-wide milestones and deliverables that apply to all projects (Projects 1 through 4) for FIU Performance Year 6 are shown on the following table.

Task	Milestone/ Deliverable	Description	Due Date	Status	OSTI
Program-wide (All Projects)	Deliverable	Draft Project Technical Plan	10/16/15	Complete	
	Deliverable	Monthly Progress Reports	Monthly	Complete	
	Deliverable	Quarterly Progress Reports	Quarterly	Complete	
	Deliverable	Draft Year End Report	10/14/16	On Target	OSTI
	Deliverable	Presentation overview to DOE HQ/Site POCs of the project progress and accomplishments (Mid-Year Review)	02/29/16*	Complete on 04/07/16	
	Deliverable	Presentation overview to DOE HQ/Site POCs of the project progress and accomplishments (Year End Review)	08/31/16*	Complete on 9/21/16	

**Completion of this deliverable depends on availability of DOE-HQ official(s).*

Project 1
Chemical Process Alternatives for Radioactive Waste

Project Manager: Dr. Dwayne McDaniel

Project Description

Florida International University has been conducting research on several promising alternative processes and technologies that can be applied to address several technology gaps in the current high-level waste processing retrieval and conditioning strategy. The implementation of advanced technologies to address challenges faced with baseline methods is of great interest to the Hanford Site and can be applied to other sites with similar challenges, such as the Savannah River Site. Specifically, FIU has been involved in: analysis and development of alternative pipeline unplugging technologies to address potential plugging events; modeling and analysis of multiphase flows pertaining to waste feed mixing processes, evaluation of alternative HLW instrumentation for in-tank applications and the development of technologies to assist in the inspection of tank bottoms at Hanford. The use of field or *in situ* technologies, as well as advanced computational methods, can improve several facets of the retrieval and transport processes of HLW. FIU has worked with site personnel to identify technology and process improvement needs that can benefit from FIU's core expertise in HLW. The following tasks are included in FIU Performance Year 6:

Task No	Task
Task 17: Advanced Topics for Mixing Processes	
Subtask 17.1	Computational Fluid Dynamics Modeling of HLW Processes in Waste Tanks
Task 18: Technology Development and Instrumentation Evaluation	
Subtask 18.1	Evaluation of FIU's Solid-Liquid Interface Monitor for Estimating the Onset of Deep Sludge Gas Release Events
Subtask 18.2	Development of Inspection Tools for DST Primary Tanks
Subtask 18.3	Investigation Using an Infrared Temperature Sensor to Determine the Inside Wall Temperature of DSTs
Task 19: Pipeline Integrity and Analysis	
Subtask 19.1	Pipeline Corrosion and Erosion Evaluation
Subtask 19.2	Evaluation of Nonmetallic Components in the Waste Transfer System

Task 17: Advanced Topics for HLW Mixing and Processing

<u>Task 17 Overview</u>

The objective of this task is to investigate advanced topics in HLW processing that could significantly improve nuclear waste handling activities in the coming years. These topics have been identified by the Hanford Site technology development group, or by national labs and academia, as future methods to simulate and/or process waste streams. The task will focus on long-term, high-yield/high-risk technologies and computer codes that show promise in improving the HLW processing mission at the Hanford Site.

More specifically, this task will use the knowledge acquired at FIU on multiphase flow modeling to build a CFD computer program in order to obtain simulations at the engineering-scale with appropriate physics captured for the analysis and optimization of PJM mixing performance. Focus will be given to turbulent fluid flow in nuclear waste tanks that exhibit non-Newtonian fluid characteristics. The results will provide the sites with mathematical modeling, validation, and testing of computer programs to support critical issues related to HLW retrieval and processing.

<u>Task 17 Quarterly Progress</u>

Subtask 17.1: Computational Fluid Dynamics Modeling of HLW Processes in Waste Tanks

In this quarterly, analysis of shear dependency in turbulent flow of Bingham fluid was extended to flow with wide range of Reynold numbers. First, method of resovled Simulations with Re = 20000, Re = 15000, and Re = 10000 were conducted and grid independence of results was tested. Results, as is shown in Figure 1-1, indicate slight differences in the profile of axial velocity for all Reynolds numbers. Slightly larger significances were observed between the course and fine meshes when the Turbulent Kinetic Energy (TKE) was observed.

Additional investigations regarding the shear dependency was performed for the flow of the Bingham fluid inside a pipe. It was observed that use of the variance of the rms values of the velocity in RANS resulted in a TKE which was significantly smaller than the TKE obtained from the PDE equations of k and ε (turbulent dissipation rate, TDR) (Figure 1-1). For this reason the TKE and TDR obtained from the PDE equations were used for investigation of shear rate dependency at small scales.

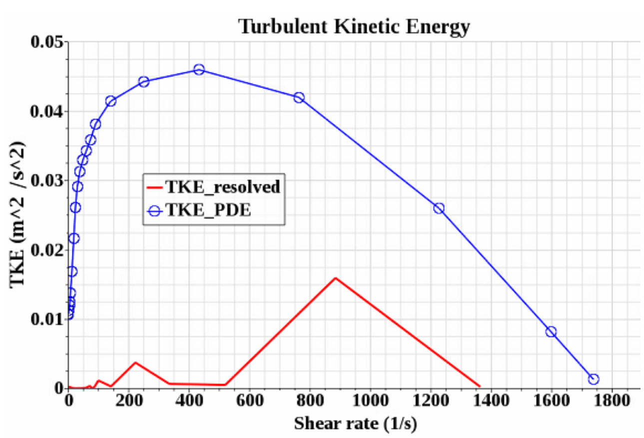


Figure 1-1. Comparison between the TKE-shear profile obtained from the gradient based (resolved approach) and the solution to the PDE equations.

Further, FIU extended the investigation of the shear dependency at small scales to flows with lower Reynolds numbers, but still in the turbulent regime. A comparison between TKE-Shear profiles for different Reynolds numbers is shown in Figure 1-2. This figure shows similar variation of TKE with shear rate for different Reynolds numbers. The comparison indicates that with an increase of the flow Reynolds number, maximums of shear rate and TKE moved to higher values. However, the difference between the maximum of shear rate and the maximum of TKE was multiple orders of magnitude for all Reynolds numbers.

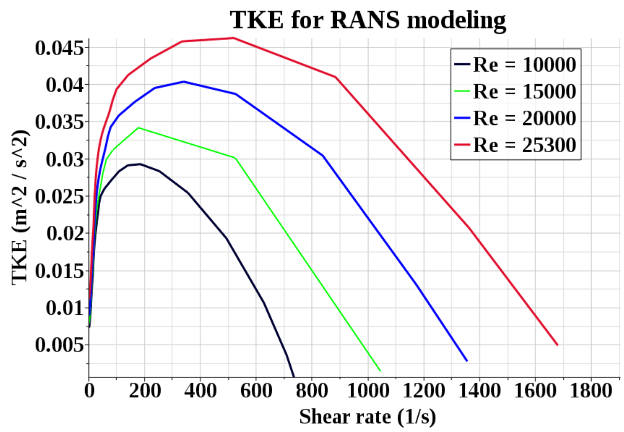


Figure 1-2. Variation of turbulent kinetic energy versus shear for different Reynolds numbers.

A similar shear dependency analysis was performed for this range of flow Reynolds numbers. Variation of shear rate against the u_{rms}/η was investigated and the result is shown in Figure 1-3. These results indicate similarity between profiles for different Reynolds numbers. In addition, the maximum of shear rate and the maximum of u_{rms}/η are very close in each profile.

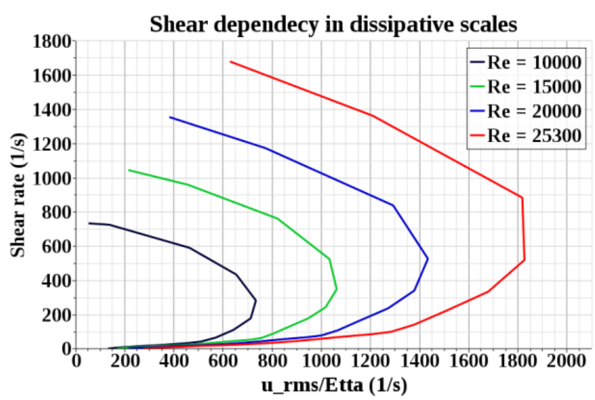
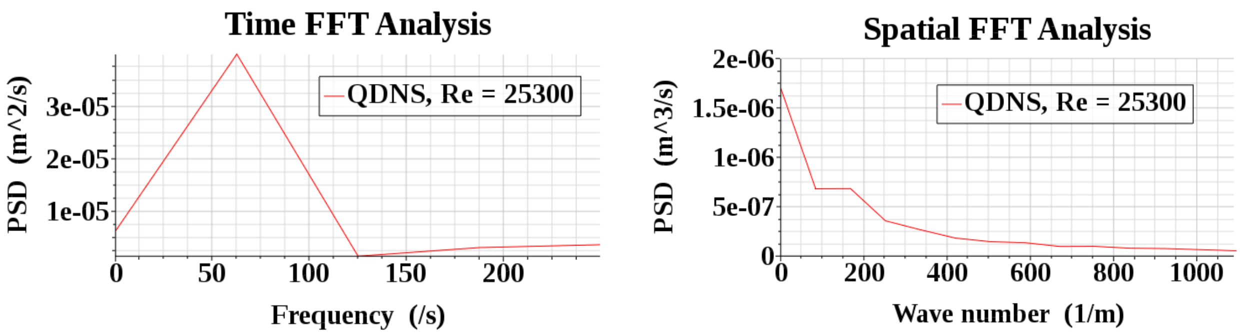


Figure 1-3. Variation of shear rate versus u_{rms}/η for different Reynolds numbers.

In order to access the FFT of the results in both frequency and space domains, FIU installed the latest version of the STARCCM+ on the FIU-HPC. Figure 1-4 shows the analysis where peak of the power spectral density happens at a frequency of almost 70 hertz and wave number of 0 m^{-1}. The location of this pick is inconsistent with the location of the pick of the typical profile of energy spectrum density for turbulence, which is not at zero wave number, as published in the literature. Further investigation revealed that the unit of the PSD on the vertical axis was not the same as the unit for the profiles in the literature which lies in the principle of colocations.

Additional research is underway to manually find a consistent profile, as the software cannot project beyond the specified parameters.



(a) (b)

Figure 1-4. Power spectral density vs. frequency in QDNS simulations.

A similar analysis of shear dependency was performed for the QDNS simulations. In the QDNS simulation, as shown in Figure 1-5, an abrupt reduction of the TKE profile was observed in the small shear rate. Conversely, a gradual reduction of TKE was observed for the RANS modeling. In addition, both the maximum of shear rate and TKE are smaller in the QDNS simulation which can be related to the boundary condition of the flow. Figure 1-5 also shows the dependency of shear on the variation of the u_{rms}/η parameter. The profile was plotted on both a vertical probe close to the outlet of the pipe and the outlet, as shown on the right diagram. Here, the profile is more flat as compared to the RANS simulation and the maximums on the vertical and axial axis are not close.

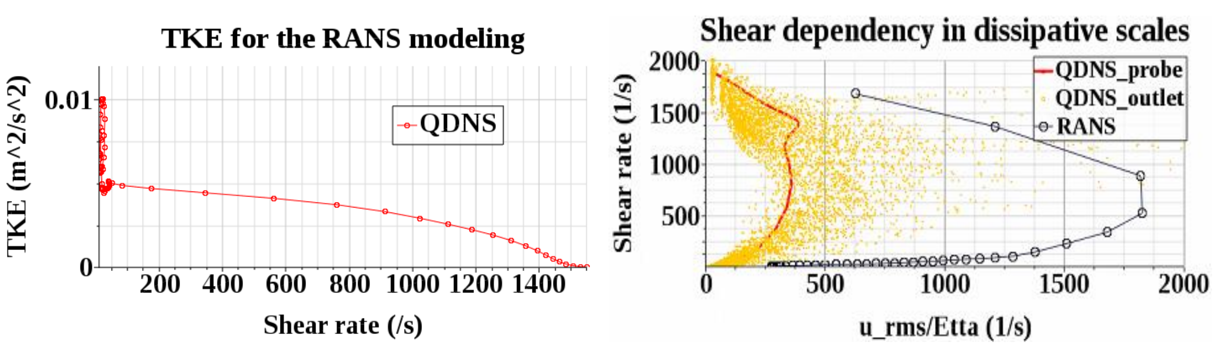


Figure 1-5. Calculation of scalars in QDNS simulation, TKE vs Shear rate (on left) and shear dependency (on the right).

Application of the periodicity condition at the same time with turbulence specification at the inlet of the computational domain (only permissible by the Synthetic Eddy Model, SEM) has been a significant limitation in the course of QDNS simulations. For this reason, a possible approach is to use the time average profile of velocity at the inlet of the computational domain and use fully developed interfaces between the inlet and outlet of the domain. In this approach it is not necessary to wait for development of the velocity profile from a uniform profile assigned at the inlet. The most suitable profile is the profile obtained from the experiment (as is published in the literature) and imposed turbulence specifications, for example length scale and intensity of fluctuations at the inlet.

For this work, a 3D profile was constructed from the 2D experimental profile using the rotation matrix defined as $R_z(\theta)$ (shown in Eqn. 1), where θ was varied in increments of 20°.

$$R_z(\theta)=\begin{bmatrix}\cos\theta & -\sin\theta & 0\\ \sin\theta & \cos\theta & 0\\ 0 & 0 & 1\end{bmatrix} \qquad \textbf{Eqn. 1}$$

Figure 1-6 shows the constructed 3D inlet profile from a 2D experimental profile used in the simulations so far. This profile is related to the low Re= 25300 and was applied at the boundary of the computational domain, as shown in Figure 1-7. Simulations using the constructed profiles are in progress and the results of this analysis will be provided in upcoming reports.

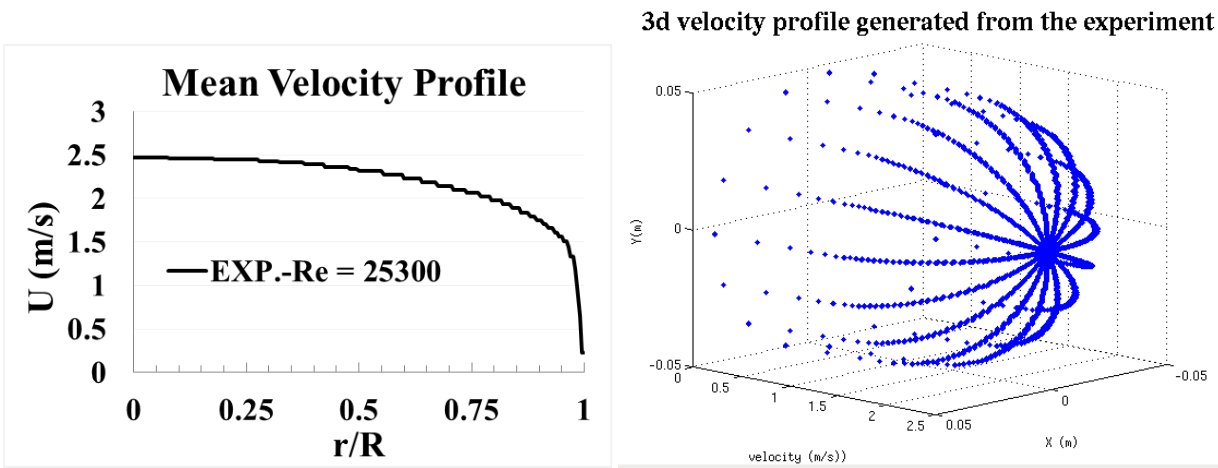
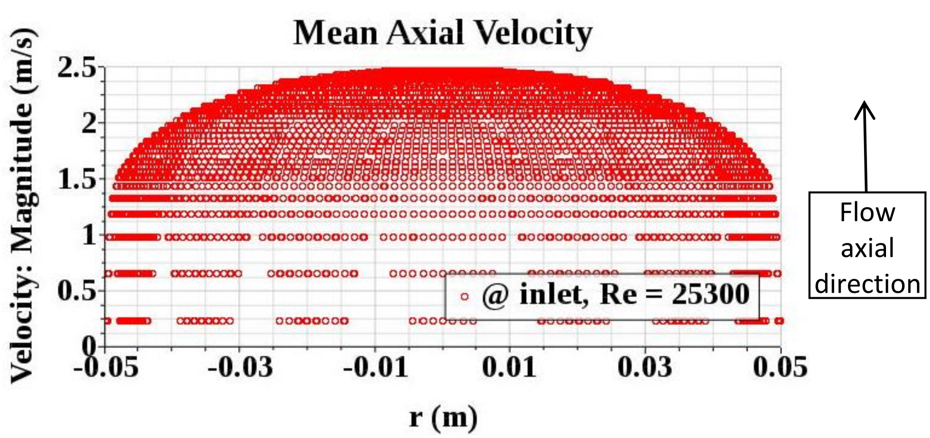


Figure 1-6. Construction of 3-D velocity profile at the inlet (left); 2-D profile of axial velocity (right). 3-D axial velocity profile constructed by Matlab. Experimental data of Escudier et al. (1996).



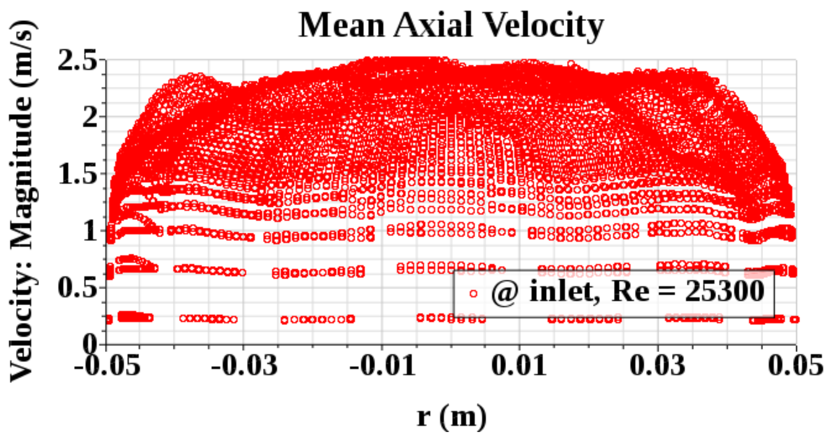


Figure 1-7. Application of 3-D velocity profile at the inlet. Top: profile before imposing turbulence condition; Bottom: profile before imposing turbulence conditions.

Q-DNS simulations using 3D inlet velocity constructed from 2D experimental data

A three dimensional inlet velocity, which was constructed based on a two dimensional experimental data profile, was used in QDNS simulations of a Bingham fluid inside a pipe. Turbulent quantities were obtained and used for validation purposes and additional investigations. Discrete Fourier Transform (DFT) analysis was performed using scripts in Matlab order to find spectra of the energy in space (wavenumber) and frequency domains. In addition, an abstract was submitted to the Waste Management Conference and a summary report was submitted to the DOE regarding research conducted over the past year.

For the Q-DNS simulation, the computations domain consisted of 454,000 cells. FIU followed the Moin et al. (1996) recommendation and the smallest spacing used was between three and four times the Kolmogorov length scale, i.e., $4*\eta$ < maximum $(\Delta x,\Delta y,\Delta z) < 3*\eta$. Thus, the number of cell elements was based on the $1/64\times Re^{9/4}$ <# cells< $1/27\times Re^{9/4}$ rule, where $Re = \rho u^* D / \mu_W = 1160$. The size reduction is very important since full capture of the entire length scales of the present turbulent flow in a cube of size D×D×D (m^3) , where D is the diameter of the pipe, requires a number of cells equal to $Re^{9/4}$ or approximately 7.85 million cells in a very small computational cell.

The results of the QDNS simulation are shown in Figure 1-8. The results are displayed for approximately a second and show steady profiles of volume-averaged viscosity and velocity and instantaneous velocities plotted at 5 locations in the computational domain.

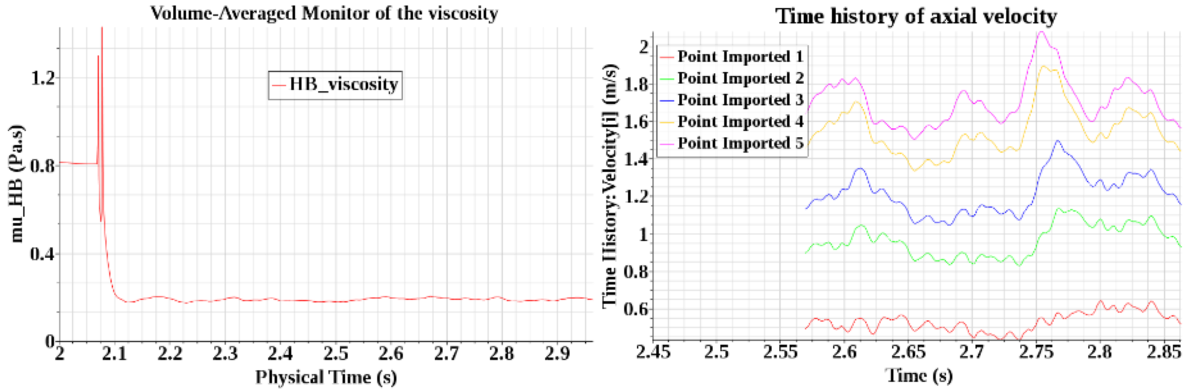
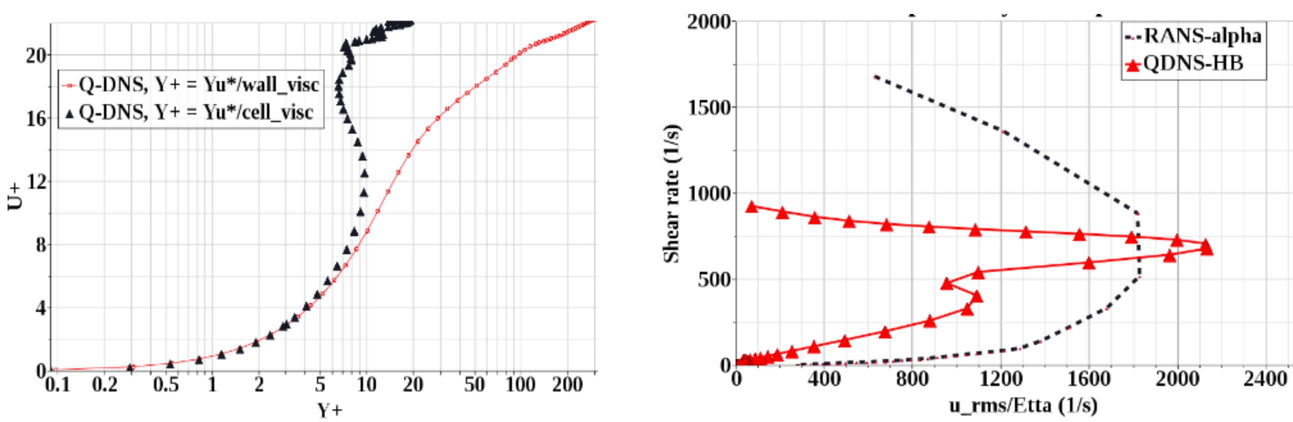


Figure 1-8. Turbulent quantities calculated from Q-DNS simulations. Left: non-dimensional velocity verses non-dimensional wall distance. Right: shear dependency in turbulent flow for Q-DNS and RANS.

Another important factor to consider is the turbulence velocity profile at a probe close to the exit of the computational domain. FIU used the method of Wilson and Thomas (1987) to construct the non-dimensional wall distance. In this method, the viscosity at the wall is used to construct the non-dimensional wall distance instead of using viscosity at each computational cell. Figure 1-9(a) shows the effect of this modification by illustrating the differences between profiles obtained based on the wall viscosity and local viscosities. In this figure, the red line shows the correct profile for a turbulent flow.

Later, the dependency of the shear to length and velocity scales in dissipative eddies was investigated for the QDNS simulation using the modified inlet velocity. Turbulent velocity profile and shear dependency for the Q-DNS simulation results are shown in Figure 1-9(b). The shear dependency shows that the maximum of the u_{rms}/η in RANS and Q-DNS simulations are close to each other. The QDNS results here are much closer to the RANS compared to the Q-DNS results obtained previously with a uniform inlet velocity profile.



(b) Shear dependency

(a) Turbulent velocity profile

Figure 1-9. Turbulent quantities calculated for the Q-DNS simulation results using modified inlet velocity profile. Left: The non-dimensional velocity against non-dimensional wall distance. Right: Shear dependency in turbulent for Q-DNS as compared to the RANS.

Figure 1-10 shows the spectra of the turbulent kinetic energy obtained for 5 points on a vertical line at the exit of the pipe. The red line shows the decay with power of -5/3 which is related to the inertial eddies. The spectra complies with the -5/3 rule in the inertia range and shows the region of fast decay of the energy which is related to the dissipative range. However, oscillations are present in the fast decay region, which may be related to insufficient temporal and spatial information. Longer simulations with finer mesh are in progress. FIU is also investigating export options available in STAR-CCM+ in order to be able to export and average the velocity profile at the probe located at the outlet instead of using a few sampling points. Currently, the long processing time associated with the regular method of data export and import on probes takes unnecessarily long periods of time which can be shortened by reading data in Tecplot.

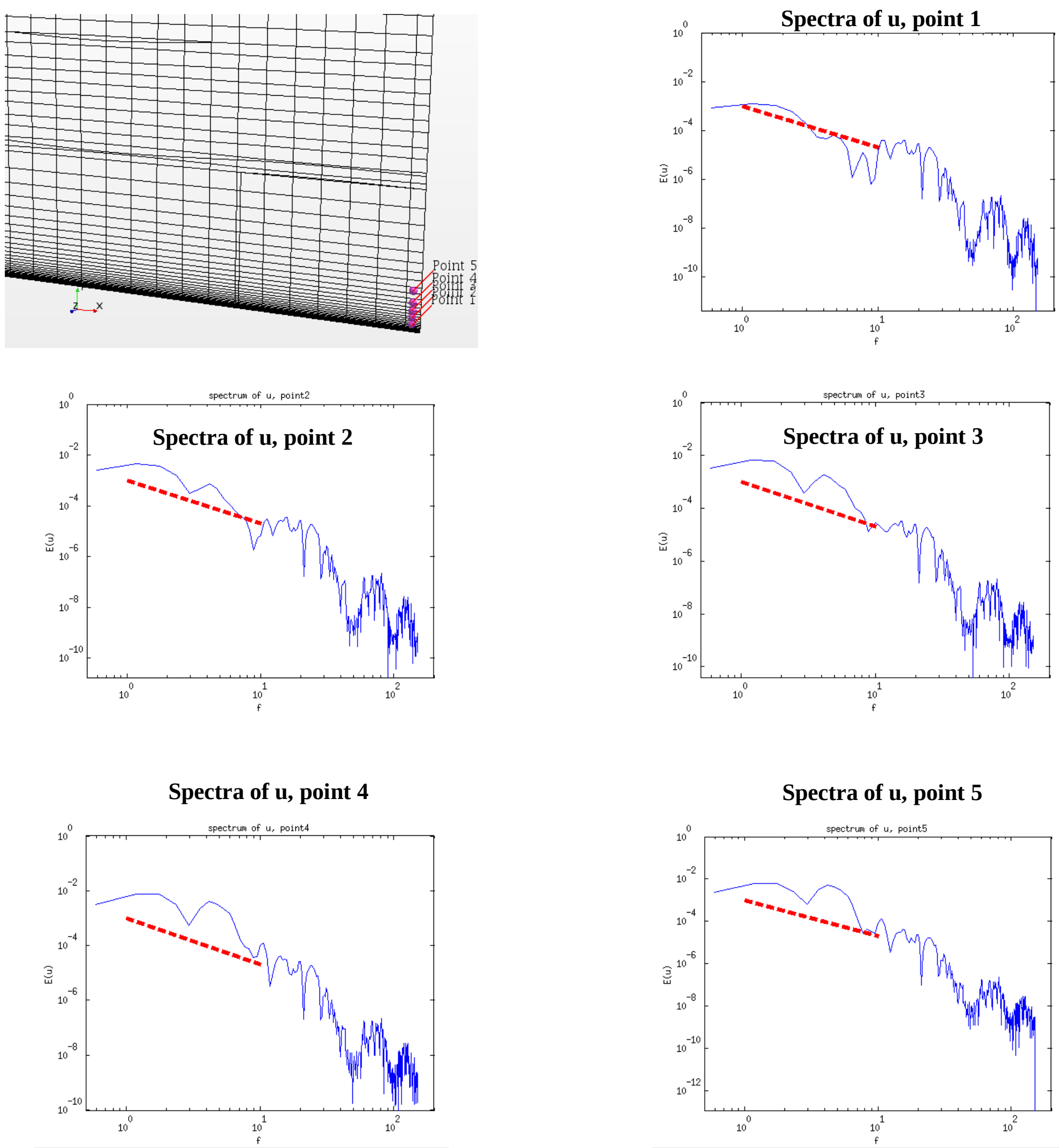


Figure 1-10. Location of sampling points in the computational domain and the power spectra of the turbulent kinetic energy obtained at the sampling points. The red line shows the decay with power of -5/3 which is related to the inertial eddies.

Considering the spectra that was obtained earlier, similar Matlab coding is being developed to create spectra in energy-wave number space. Another important step in the analysis of the spectra is the method to separate the scales. A review has been initiated on the methods that are used in the literature, as well as the method that is used in the large eddy simulation that filters the scales. Effort is also underway to separate the scales using the two-point correlations and compare it with the separation based on the energy spectra.

FIU also conducted a literature review on existing simulation studies conducted in the ParaFlow code. In addition, a fine three-dimensional mesh was created to study the effect of grid spacing on the quality of energy spectra.

Literature Review on existing simulation studies conducted in the ParaFlow code.

Several process vessels will hold waste at various stages within the Hanford Waste Treatment and Immobilization Plant (WTP). These vessels have mixing system requirements to limit hydrogen gas accumulation and ensure that pump transfer and normal operations occur (Rector et al., 2012). The WTP Pretreatment Facility requires a uniform feed from each waste tank that consistently matches tank average concentrations during the extraction process. This acceptance criterion requires an accurate method for determining the tank average concentration through a limited number of samples during mixing. Computational fluid dynamics (CFD) modeling can be used to provide a meaningful prediction of suspended solids behavior to guide both sampling (in terms of sampling location) and extraction processes. For this application, a reliable CFD code with formal verification and validation (V&V) is needed (SRNL-PNNL, 2013).

In addition, another key uncertainty in the waste feed delivery system is a potential variation in undissolved solids (UDS) transferred in individual batches in comparison to an initial sample used for evaluating the acceptance criteria (Wells et al., 2011). Variation in UDS can lead to pipeline plugging, which has been identified as a significant issue for the WTP, according to Rector et al. (2009). This uncertainty is due to a challenging and perhaps one of the more limiting WTP waste acceptance criteria parameters, which is the critical velocity of the slurry. Critical velocity is defined as the velocity of the slurry above which particulates will remain mobilized in the carrier solution and be transported down the pipe. Critical velocity is important for WTP receipt to ensure that solids in HLW feed will remain suspended and not accumulate in plant piping. The CFD modeling work of Rector et al. (2009) shows capabilities of obtaining detailed distributions for settled and suspended solids.

Wells et al. (2011) introduced metrics for waste operations. Operations are particle settling, mobilization, suspension, and pipeline transfer. The metrics include particle settling velocity (U_t), critical shear stress for erosion of particles (τ_c), cloud height (H_c), effective cleaning radius (ECR), and pipeline critical transport velocity (U_c). Among these, transfer concentration is the primary metric used for DST sampling and batch transfer performance, according to Lee (2012) and Wells et al. (2013). Equations that describe models for each metric, including Archimedes number, jet-suspended impeller speed, and jet velocity, that are needed to achieve a certain degree of solid suspension for each metric, can be found in reports of Wells et al. (2011) and Rector et al. (2009).

Available experimental data

The solids in some of the HLW tanks at Hanford include a large fraction of sub-micron particles, including aluminum hydroxides such as Boehmite and Gibbsite, which can form particle gels and give rise to non-Newtonian fluid behavior. In some cases, the fluid will exhibit shear-thinning behavior, where the viscosity decreases as a function of fluid shear rate. In other cases, the fluid will behave like a Bingham plastic. At low shear stresses, this type of suspension sets up like a solid. When the shear stress exceeds a specified yield stress, the suspension begins to flow like a fluid.

A rotating jet pump is a submerged mixer pump which has a suction line, a return line, and two opposing jet outlets. The suction and return lines are connected to suction and pressure ports of an outside slurry pump, respectively. In ParaFlow simulations, modeling the inlet suction line is not mentioned; however, a modification to the return to the top of the liquid was included in the presentation. Yet this is not obvious if the return line mentioned in the presentation is from batch transfers or from the outside slurry pump.

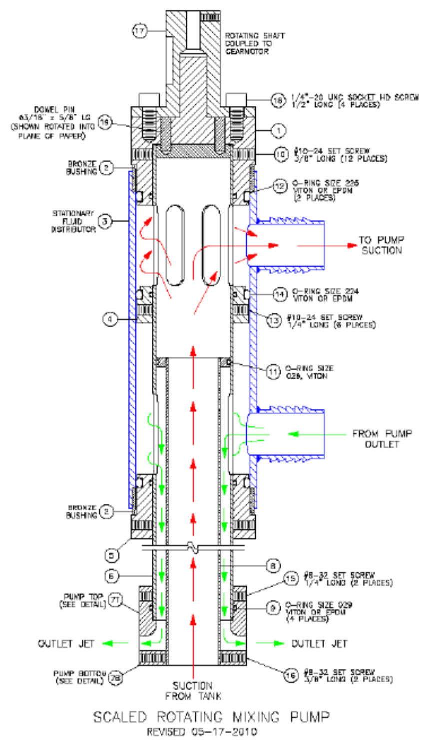


Figure 1-11. Schematic of the mixer jet pump.

A series of scaled experiments were conducted by Woodworth and Townson (2010) to better understand the re-suspension behavior of different types of waste. Obtaining results of this report is in progress, since data obtained from these tests were used for validation of the most recent results of ParaFlow.

According to a document from SRNL-PNNL (2013), jet mixing has only been performed in a few Hanford DSTs, and the only prototypic waste feed delivery mixing test that has been performed is AZ-101. Full-scale test results for solids particle bottom motion and vertical suspension are available in a technical report from Carlson et al. (2001). In addition, Wells et al.

(2013) reported results for scaled tests according to the Small Scale Mixing Demonstration (SSMD) program using base, complex, and single component simulants and for different test conditions. These results are accessible and usable for comparison to results from future CFD simulations.

Existing CFD work on simulation of processes in DST

The ParaFlow program is based on the incompressible version of the implicit lattice kinetics method developed at PNNL which is similar in many respects to the lattice-Boltzmann method. The ParaFlow takes advantage of some of the strengths of the lattice-Boltzmann method, while improving stability for high-speed flows (Rector et al., 2010). In ParaFlow, solid-liquid waste processing applications are modeled using multiple continuum phase fields, one for the liquid phase and one for each type of suspended particle with a corresponding size, material type, and density. In addition, a separate continuum field is used to represent the settled solids, or sediment, on the tank bottom. The surface topology of the sediment changes as a function of time and the particle composition of the sediment can vary as a function of location. Applicability of ParaFlow was demonstrated for a number of multiphase flows, including critical velocities in horizontal pipelines and both coarse- and fine-scale simulation of ultrafiltration associated with caustic leaching, according to Rector et al. (2010).

ParaFlow was used to simulate mixing and suspension in the DST tanks of the Hanford Site. In 2010, Rector and his colleagues at PNNL conducted a scaled simulation for a single component simulant (zirconium oxide). They demonstrated a capability in simulating the metrics of flow in a DST using the ParaFlow code. Later in 2013, ParaFlow was used to conduct scaled and full simulations of flow in a DST. Wells et al. (2013) investigated scaling behavior for different simulants in high solid loading and obtained reasonable agreement with experimental data for different metrics using specific scaling parameters. Most recently, FIU received results from PNNL for small-scale and full-scale simulations of complex simulant with typical solid loadings. ParaFlow simulation results are in good agreement with experimental data for effective cleaning radius (ECR) and transfer UDS concentration. Experimental results used in validation of the ParaFlow simulation is yet to be obtained from literature.

Challenges in the simulation of different flow metrics include reproduction of rotating fluid jet and a constantly changing sediment layer. Rotating fluid jets created by mixer jet pumps (as shown previously in Figure 1-11) are modeled in ParaFlow using rotating cylindrical regions centered on each jet support column, with a boundary interface between each rotating region and the rest of the tank, which is stationary. Creation of similar mechanisms for a simple mixing flow is under investigation in STAR-CCM+. In the case of the sediment layer, variation of a solid surface is a function of solids settling and jet erosion. The rate of sediment growth due to sedimentation is a function of hindered settling velocity; the rate of sediment erosion is based on the difference between the local fluid normal and shear stresses, a specified yield stress, and local solids loading. Accurate predictions require recalculation of the grid surface distance and surface normal vectors.

Turbulence at the vicinity of jet nozzles in DSTs may exhibit anisotropy behavior. For this reason, both RANS-k-ε and Reynolds Stress models may be used to compare results with experimental data. A similar approach was used by Rector et al. (2010). These researchers used a RANS k-e turbulence model in their preliminary simulation of pulse jet mixture in ParaFlow, which is based on an assumption of isotropic turbulence. Later, they used Reynolds stress solver as they expected anisotropy of turbulence where the pulse jet strikes the floor of the tank.

Despite successful application of ParaFlow in simulation of complex multiphase flow in DSTs, a few limitations have been reported in literature. Convergence difficulty was reported through utilization of a ring boundary condition, according to Rector et al. (2013). These must be fixed before using ParaFlow for additional DST mixing applications. In addition, the implicit lattice kinetics method is based on a uniform Cartesian lattice grid and modifications are required to optimize accuracy and efficiency of the simulations where fluid jets are present. As a remedy, a hierarchal grid structure has been used where a specified number of grid blocks are subdivided into octrees (eight blocks, each with the same number of lattice grids as the original coarse block) with half the lattice spacing and time step. This subdivision can occur on multiple levels.

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Task 18: Technology Development and Instrumentation Evaluation

Task 18 Overview

The objective of this task is to assist site engineers in developing tools and evaluating existing technologies that can solve challenges associated with the high level waste tanks and transfer systems. Specifically, FIU is assisting in the evaluation of using a sonar (SLIM) developed at FIU for detecting residual waste in HLW tanks during pulse jet mixing (PJM). This effort would provide engineers with valuable information regarding the effectiveness of the mixing processes in the HLW tanks. Additionally, the Hanford Site has identified a need for developing inspection tools that provide feedback on the integrity of the primary tank bottom in DSTs. Recently, waste was found to be leaking from the bottom of the primary tank in AY-102. FIU will assist in the development of a technology to provide visual feedback of the tank bottom after traversing through the refractory pad underneath the primary tank.

Task 18 Quarterly Progress

Subtask 18.1: Evaluation of FIU's SLIM for Estimating the Onset of Deep Sludge Gas Release Events

For this quarter, the source of error in the volume calculation algorithm was further studied. Shown below are 3 sonar images of objects (brick, plate and rings of sand) that were imaged in the past. The volume of these objects were analyzed in Matlab and shown to vary from below 5% to over 500%. The figure below depicts a brick that was imaged in 2014 with the 3D sonar and shown in the commercial sonar image display software; the following figure is an image of a flat plat imaged in 2016.

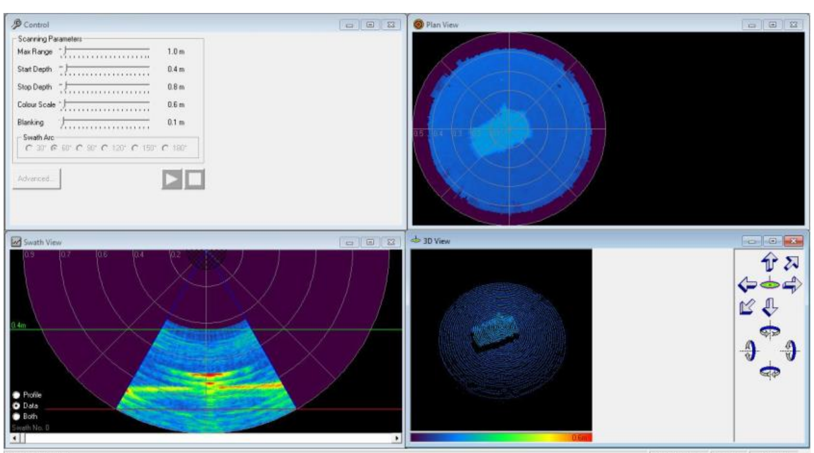


Figure 1-12. Sonar image of a brick in a test tank at FIU.

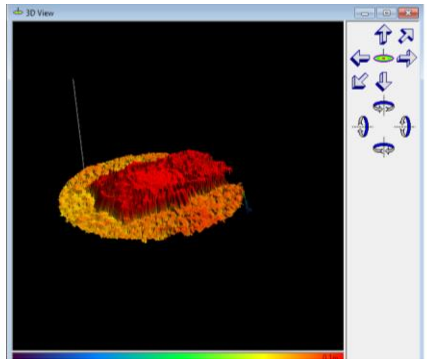


Figure 1-13. Image of a flat plate used to determine height and volume accuracy of the 3D sonar.

Finally, the figure below is an image of 3 metal rings filled with sand which showed great improvement in shape detection, height and volume measurements than with rectangular objects.

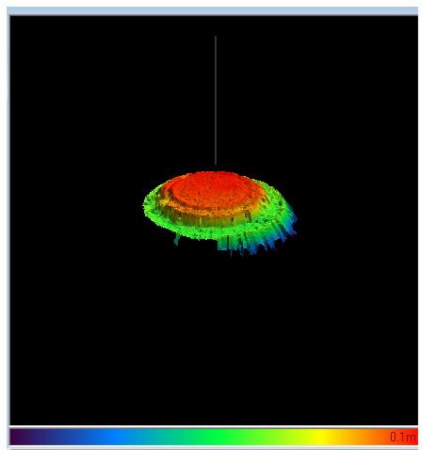


Figure 1-14. Sonar image of sand inside 3 concentric metal rings.

The rationale for developing the Matlab volume estimation algorithm was to decrease the error as measured by the 3D Mapper algorithm. The following figure is an image of a brick after filtering to remove sonar ping scatters off floating particles which result in false volume shown as tall, sharp peaks (left) and imaging of the brick with the 3D mapper (right).

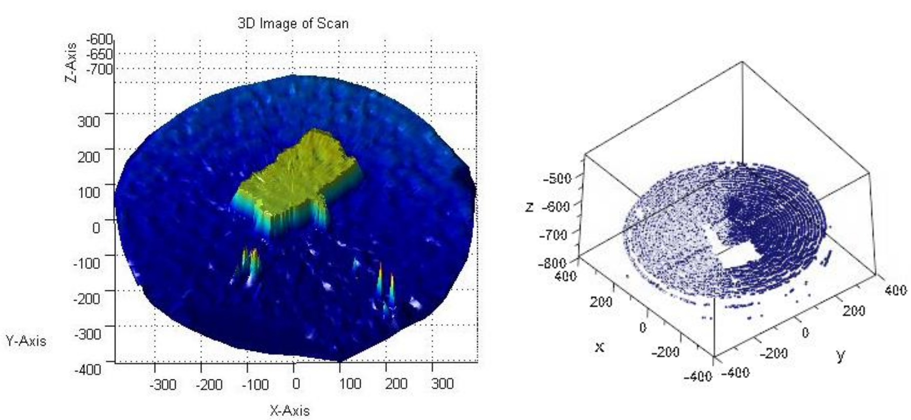


Figure 1-15. Filtered and post-processed sonar data of brick on a tank floor (left) and sonar image of tank floor with a brick in 3D mapper (right).

It was determined that the volume calculations of the 3D Mapper was often 4-6% for high resolution (e.g., 200 2-D swaths that take 40 seconds to collect) whereas the volume was 7-9% overestimated when rapid scanning was used with 6 to 20 swaths. This error arises due to the interpolation of the objects between swaths. Volume errors were larger with objects with sharp corners and edges like bricks, and smaller (2-5%) for smooth, slowly varying shapes such as settled solids in tank bottoms.

The impetus for using the Matlab volume calculation algorithm was originally related to having more accuracy for rapid scanning of settled solids on mixing tank floors. This is a separate need from the Deep Sludge Gas Release Events (DSGREs) need currently being addressed. It is expected that the Matlab algorithm would more be accurate than the 3D Mapper when proper baselining of the Z=0 plane is implemented. For flat floors with an object and no sand, the Matlab algorithm calculates volume to better than 3%. In imaging real tank floors with settled solids, this baseline issue can result in large volume errors as described above (5-500%).

In conclusion, the 3D Mapper algorithm can be used for imaging tank settled waste for DSGREs at Hanford. When the correct baselining of the Matlab volume estimation is completed at some future date, it may be used instead of the 3D Mapper.

There was discussion by Hanford engineers when they last visited FIU about the deployment of the sonar into tanks with only shallow liquid levels over many feet of solids. A deflated air bladder was attached to the half of the 3D sonar where the cable connects. The sonar with attached bladder was able to deploy through a 3 inch pipe. When the bladder inflated, it expanded outward and did not expand significantly toward the sonar head. A tube was used to fill the bladder and raise the sonar to float on the liquid surface. The sonar weight (9 lbs plus 2 lbs cable) required an air bladder that inflates to a volume of 5000 cm^3 or more. The bladder used was inflated to ~7500 cm^3 measured from water displacement. The sonar was able to image the tank floor with the large air bladder attached. This simple test was done to identify if an air bladder alone could be used to float the sonar. Three small propellers could be attached to the bladder which would allow for the sonar to be steered around the tank waste surface.

Subtask 18.2: Development of Inspection Tools for DST Primary Tanks

<u>Peristaltic Crawler</u>

The main activities for the peristaltic crawler were focused on the construction of the full-scale mockup of the ventilation riser of the DSTs, designing the instrumentation module and finalizing the structural analysis of the full-scale sectional mockup. In addition, the design of a portable control box for field deployment has been initiated.

The new mockup of the air supply lines will be used to evaluate the performance of the peristaltic crawler, operating under similar conditions as the proposed inspection at Hanford. Figure 1-16 below shows the layout, dimensions and pictures of the new mockup constructed at FIU-ARC.

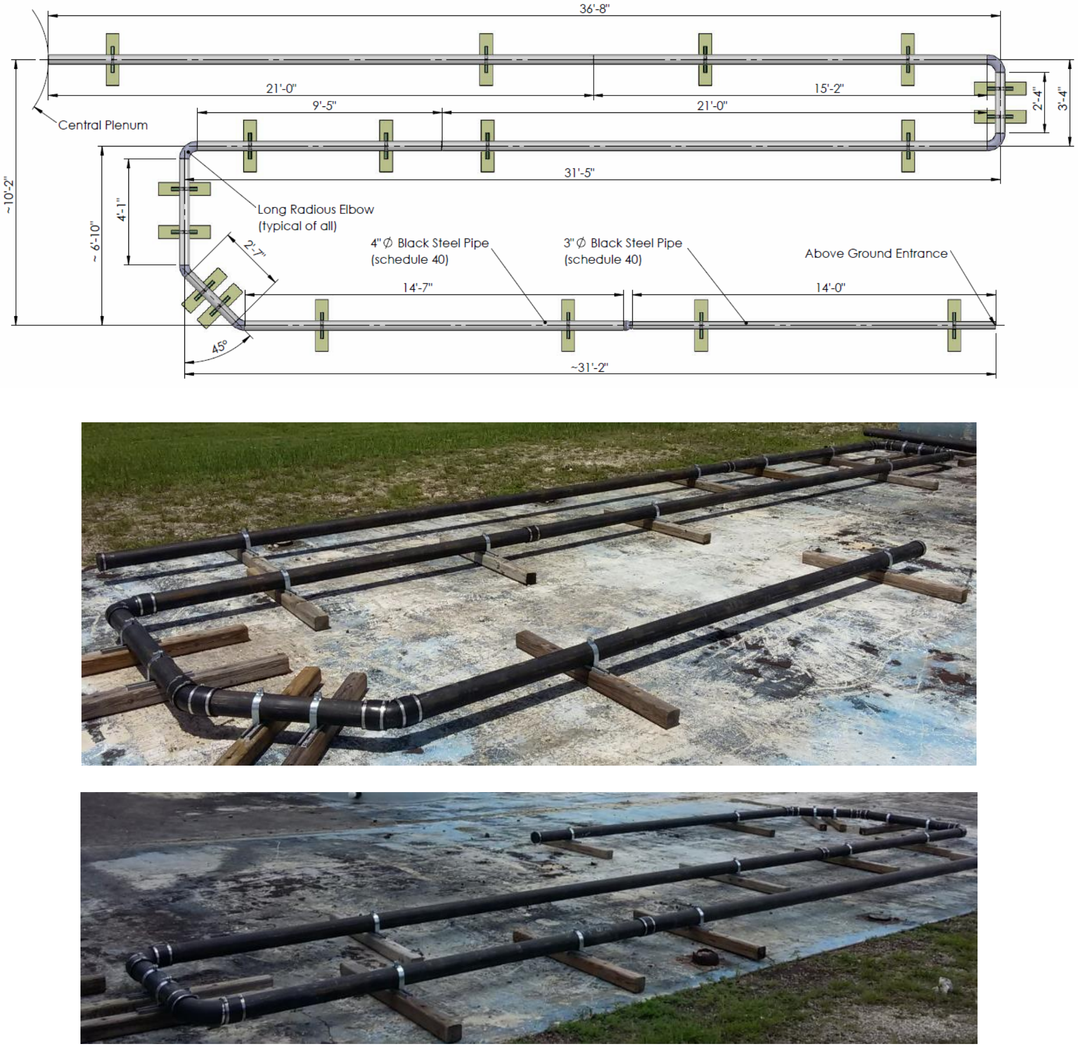


Figure 1-16. Ventilation riser mockup.

The instrumentation module, illustrated in Figure 1-17, will be used to monitor the dynamic performance of the crawler during full scale tests. An additional module is being designed to carry

- an embedded computer,
- a tether load cell, and
- additional sensors (temperature, humidity and radiation).

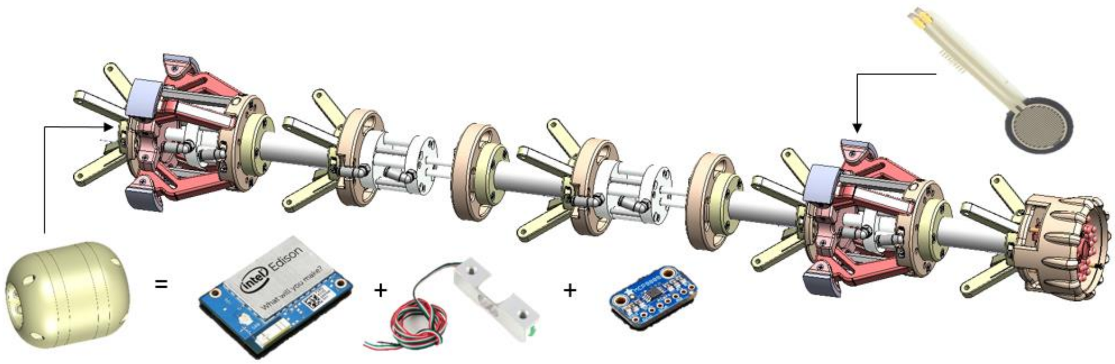


Figure 1-17. Components of the new instrumentation module.

During preliminary tests, it was observed that the acquired sensors for the pads seemed unreliable and they significantly increased the complexity of the module. Hence, the plans to use the force sensitive sensors planted in the pads of the gripping mechanism have been postponed. Their integration will be resumed once the preliminary full scale tests are successfully completed.

Also, the structural analysis of the full scale sectional mockup of the DST was completed. Figure 1-18 shows the finite element analysis of the remaining two modules, the knuckle and the vertical side wall. The modules are shown structurally sound. Currently, we are in the process of procuring the structural elements required for constructing the mockup.

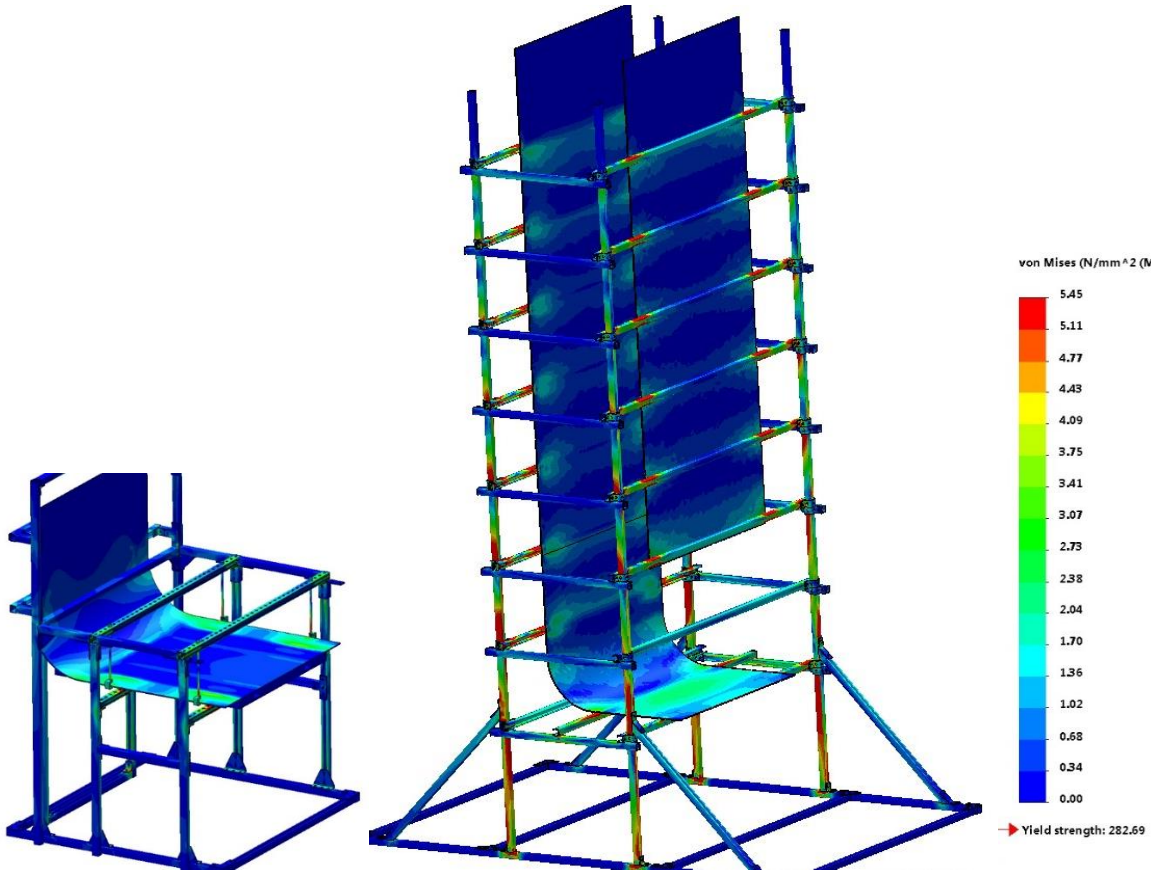


Figure 1-18. Structural analysis of the knuckle (left) and the vertical wall modules.

In addition, during this period, efforts were focused on the purchasing of all components necessary to build the full-scale sectional mockup, executing preliminary full-scale pulling tests to estimate the overall tether drag, and designing a portable control box for field deployment. In addition, FIU continued with the design of the instrumentation module, where issues with the component miniaturization and cabling management are still unresolved. FIU has also started investigating robotic technologies suitable for inspection tool deployment and sensor delivery.

Figure 1-19 shows a rendering of the updated design of the crawler. Additional extension springs were added to the suspension guides responsible for centering the module inside the pipeline.

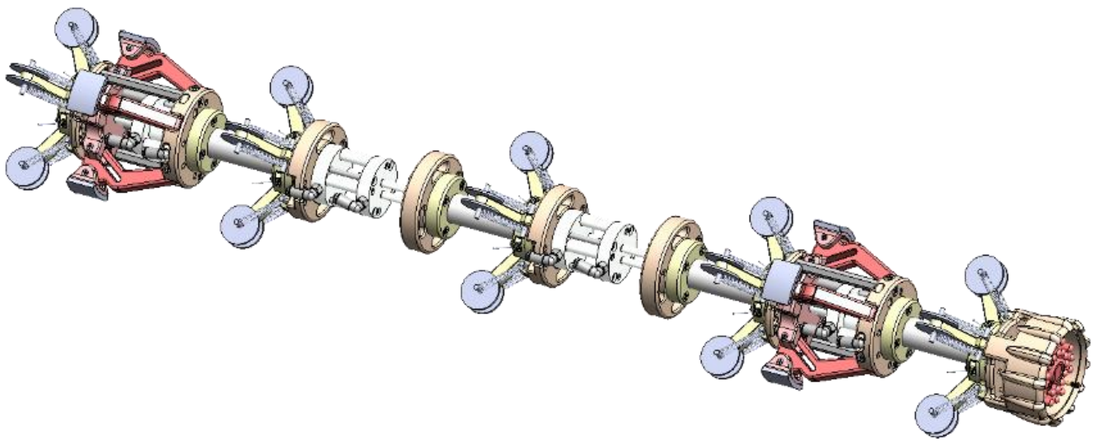


Figure 1-19. Crawler's most update design.

Figure 1-20 shows the strengthened suspension guides. The addition of extension springs were necessary to compensate for weak torsion springs used in the original design. Torsions springs with adequate size/strength ration were not off-the-shelf available.

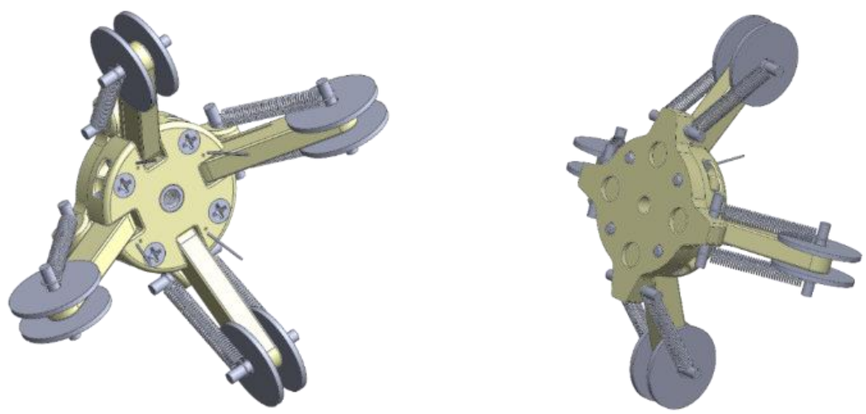


Figure 1-20. Strengthened suspension guides.

Figure 1-21 shows the preliminary pull tests being executed at the full-scale mockup of the DST's air supply risers. The tether was dragged through the entire pipeline, while the drag force was measured with a hand scale. During tests, the average recorded drag force was approximately 5 pounds, with eventual peak resistance up to 8 lbs. This drag level is significantly lower than the designed pull force of the crawler (40 lbs). However, tests need to be designed to address adverse pipe surface conditions, which might affect the device gripping force, such as the presence of water, rust and residue material.

Figure 1-21. Tether pull test.

Figure 1-22 shows a schematic of the portable control box, which is currently being designed and will be used for field deployment. The design is self-contained, which includes front panels that will provide:

a) quick disconnect for all pneumatic and electric lines,
b) pressure control,
c) pressure gauge (for troubleshooting),
d) internet and USB access, and
e) a touch screen interface.

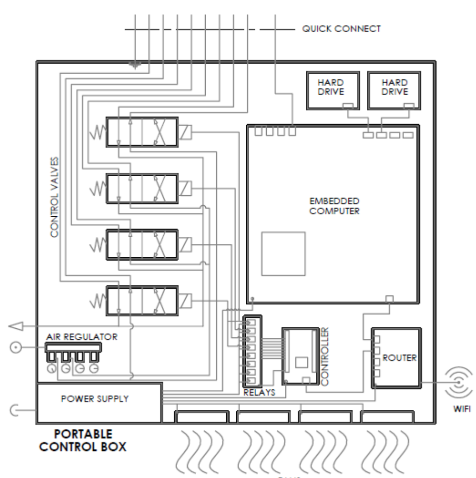


Figure 1-22. Portable control box.

The system will be remotely controlled by wireless devices; however, a touch screen will be convenient for eventual diagnostics.

FIU also began investigating robotic technologies suitable for inspection tool deployment and sensor delivery. FIU is surveying off-the-shelf products that are commercially available, such as robotic platforms and robotic arms suitable for the defined needs. In addition, FIU has also started designing in-house alternatives.

Figure 1-23 shows a small robotic platform currently being developed at FIU. The all-terrain platform has being design to perform inspection and autonomous tasks. To speed up the development process, FIU started the design from an off-the-shelf chassis, which could be later re-engineered accordingly to the specific need. The current focus is on the development of the power systems, controls and software.

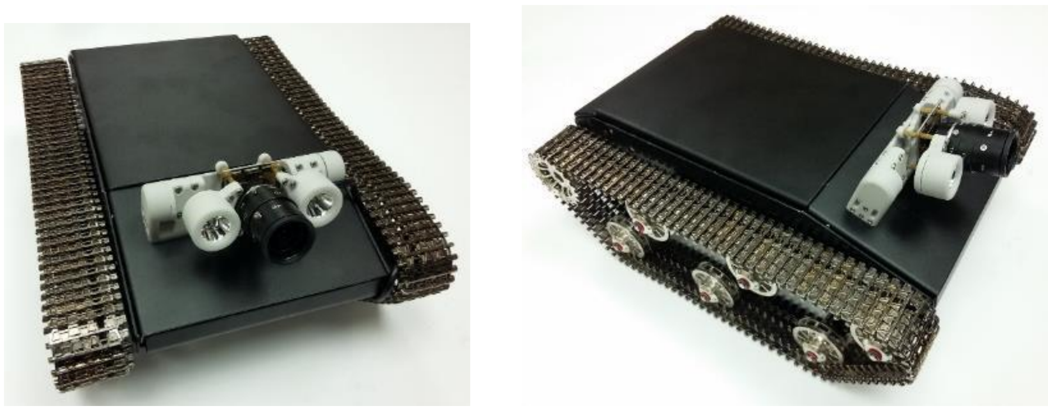


Figure 1-23. FIU's robotic platform.

The rover type robot is guided by a high resolution front camera. The camera, shown in Figure 1-24, can be controlled and aimed forward and backward, covering a 180° angle. The current version of the platform has been designed for three hours of continuous operation. However, the autonomy could be significantly improved by replacing the current DC bushed motors with brushless.

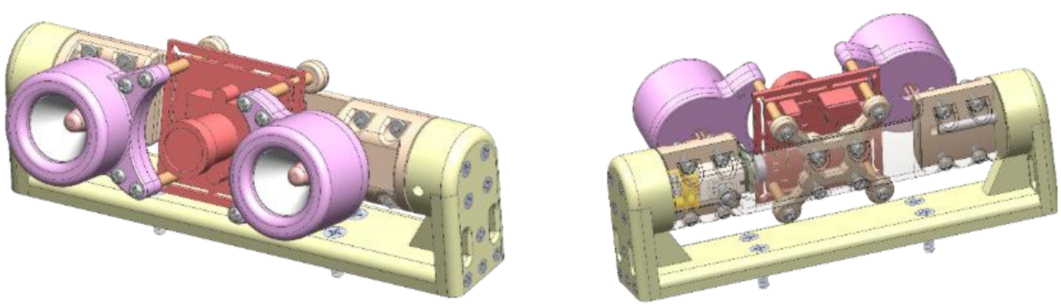


Figure 1-24. Rover's front camera.

FIU's robotic efforts and DOE Fellows have been featured at the National Labs on Capitol Hill day in September. A mock up that demonstrates the tools and controls being developed at FIU has been constructed and was used in the display on Capitol Hill. Figure 1-25 shows the robotic platform being tested under several circumstances in the mock up. The platform showed great maneuverability and can be modified for the deployment of the FIU inspection tools.

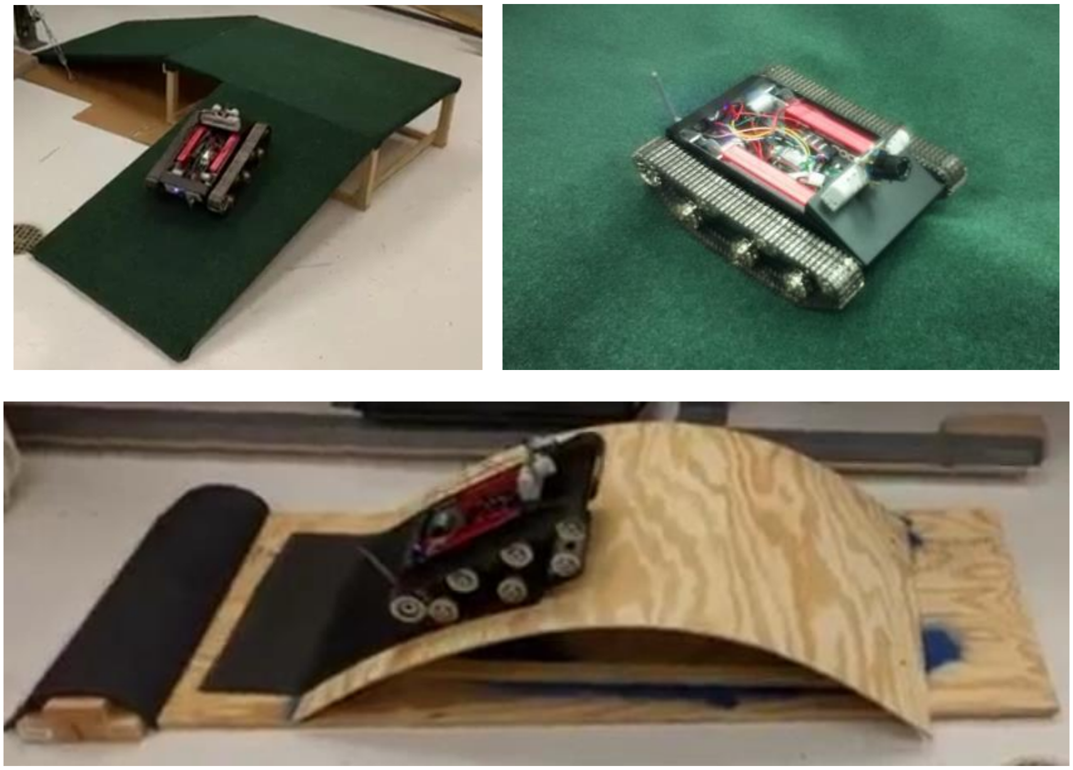


Figure 1-25. FIU's robotic platform.

In the last month of the quarter, efforts for the peristaltic crawler were focused on the development of a portable control box and an instrumentation model. The portable control box for the crawler will be used for field deployment. A schematic of the design is provided in Figure 1-26.

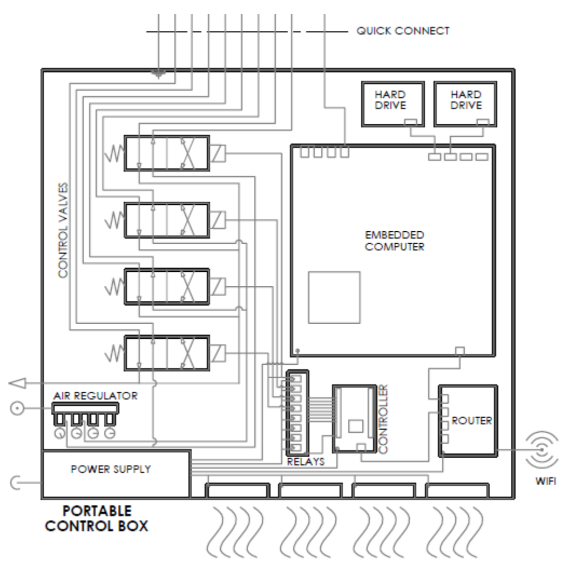


Figure 1-26. Control box schematic.

The design is self-containing, as shown in Figure 1-27, and will provide the following:

- quick disconnect for all pneumatic and electric lines,
- pressure regulator,
- pressure gauges,
- internet and USB access, and
- touch screen interface.

The box is currently being assembled, and is shown in Figure 1-28.

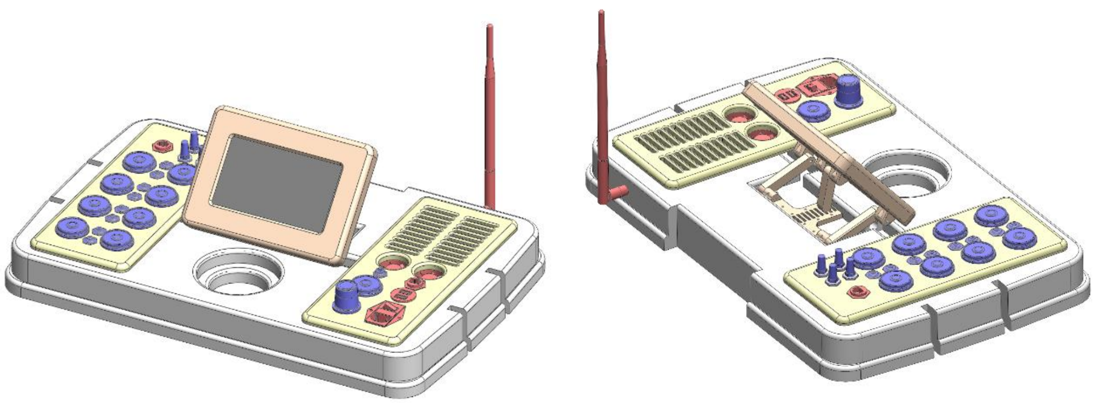


Figure 1-27. Control box design.

Figure 1-28. Control box.

Part of the issues with the component miniaturization of the instrumentation module was resolved; however, cable management is still a design challenge. Considerable space was gained inside the module with the use of a micro USB hub. The device, shown in Figure 1-29, does not have the typical connectors for slave USB devices. The wires are soldered directly on it, which allows connection to several USB devices, such as cameras and sensors, in a tiny space (36 mm x 20 mm). The hub also supports an external power supply which overcomes other issues asssociated with the low power avalible directly from the embeded computer use in the module.

Figure 1.29. Micro USB hub.

<u>Miniature Magnetic Rover</u>

For the miniature rover, FIU introduced design modifications and assembled a new version of the inspection tool, based on results from previous testing. The newest version of the inspection tool utilizes a complete redesign of the body, along with modifications made to the wheels. This modification to the body also employs a new way of managing the wiring needed to provide the control signal and power to the 4 motors that operate within it. It still uses the same basic concept of the previous version with the 4 driving motors, with the program for skid-steer drive. Figure 1-30 shows the solid works CAD design of the new version of the miniature rover.

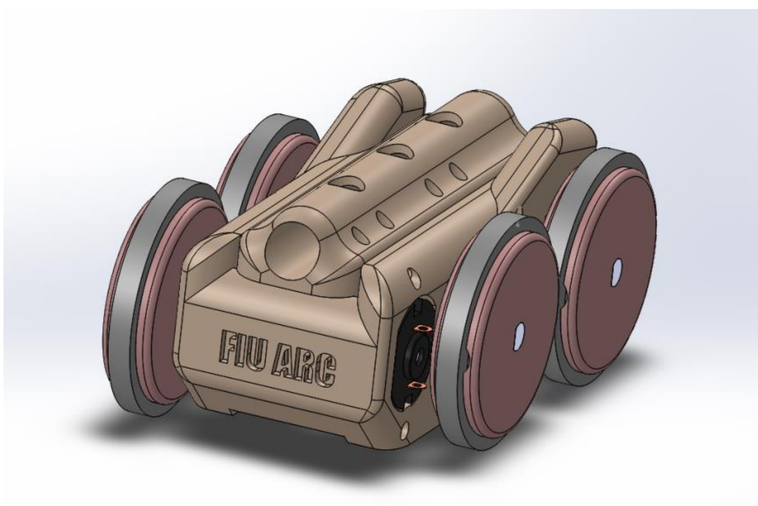


Figure 1-30. Solid works CAD model of the modified version of miniature rover.

The body is now less wide than the previous model, with the height and length still consistent to the previous version. A large problem with the previous version of the inspection tool was that the wheel axels would break due to a combination of displacement caused by the magnets in the body and the adhesion mechanism that were used to attach wheels to the body. The millimeters that were saved in the body of the new version of the inspection tool were added to thicken the wheels. By thickening the wheels we were able to add heat set inserts and set screws to them to ensure that they would not break off during operation. Figure 1-31 demonstrates exploded view that reflects the details of these modifications that have been introduced.

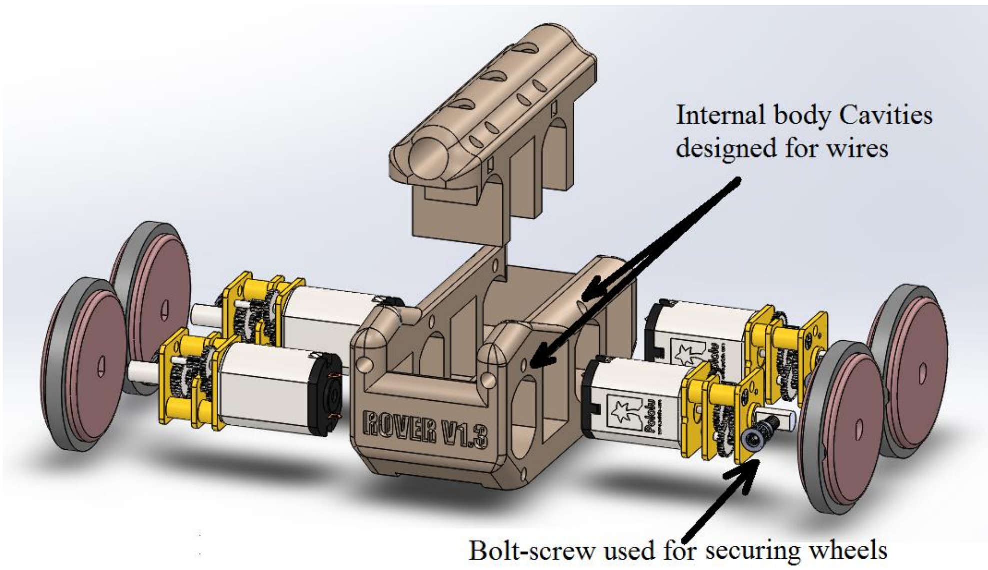


Figure 1-31. Exploded view of modified design of miniature rover.

The new version of the tool uses the same gauge of wiring as the previous; however the wiring now runs through a series of internal cavities within the body itself. By running the wiring through the body (rather than having it spread out among the top as in the previous model) we are able to reduce contact of the wires against the surface of what the rover is rolling on. This is important because this helps lessen the chance of any wiring getting stuck on any debris that may be in the tank. Figure 1-32 shows the 3D printed parts and the assembly of the new version.

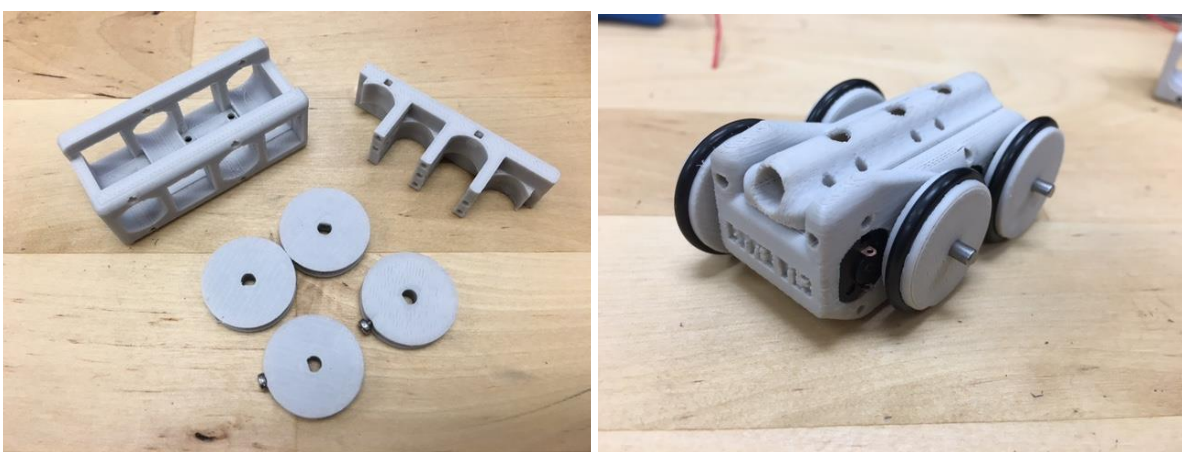


Figure 1-32. (a) 3D printed body, wheels and bracket (b) assembly of miniature rover.

FIU also made further adjustments to the design of the inspection tool. Modifications were made to the wheels to prevent them from displacing while in motion, through the addition of set screws that run through the wheel to attach directly to the shaft of the motor. The body of the unit was also reworked, reducing the length and width by 6 mm and 5 mm, respectively. In addition to its size reduction, the body was redesigned to allow for the wires to run through it, providing a more organized cable management system. Adapters were added to the ends of the wires in the newest version of the inspection tool, allowing for the easy removal/attachment of test units to the tether system. In the previous design, prototypes needed to be directly soldered to the tether, whereas this new system allows FIU to attach and detach units freely.

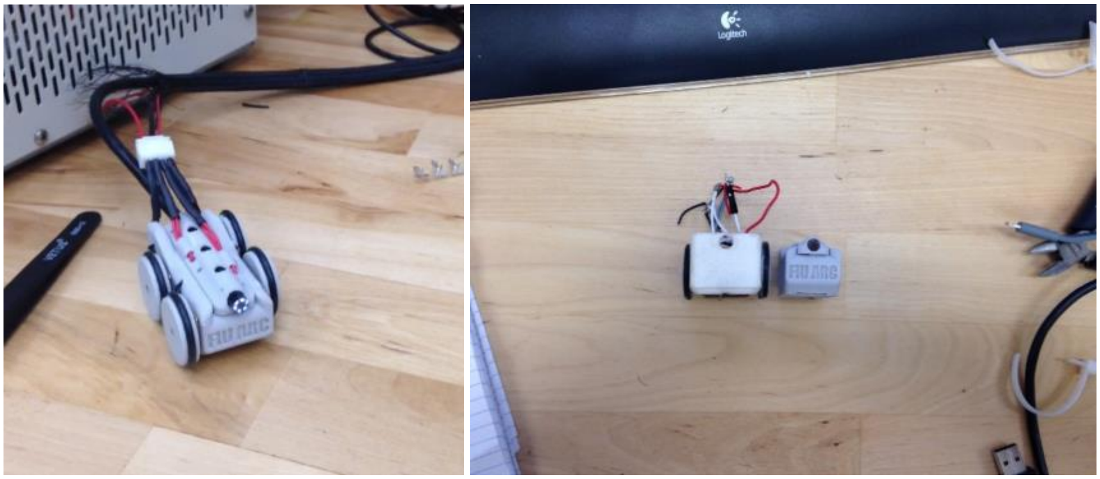


Figure 1-33. Recent version of the inspection tool (left), comparison of size with older version (right).

The tether was also reworked, replacing the stitched outer casing with the smoothness of an Ethernet cable. The wiring for both the camera and the inspection tool itself was run through this new smooth tether, with an adapter being made for the end to attach easily to the inspection tool. Previous tests have shown that the drag forces created between the old tether and the exemplar annulus material was the primary factor that limited the length the rover could travel. The smoother wire glides much easier along the material and is a significant improvement. The new casing also has a much thinner diameter than the previous, which will allow FIU to build a smaller cable management system for the release/retraction of the inspection tool.

Figure 1-34. New tether which utilizes a smooth casing.

Initial testing was also initiated on the current design of the cable management system during the last month. In the next few months, FIU will begin development of a “smart” program that can release/retract the tether in communication with the inspection tool itself, in addition to continuing the effort to reduce the size as much as possible. While the current design of the system resembles that of a crank/wheel, FIU is exploring other options to reconfigure it, including designs similar to those used in fishing reels.

Figure 1-35. Current design of cable management system to retract/release tether for the inspection tool.

During this quarter, testing also began for the use of the Ethernet cable with the system. It was concluded that it would be best to not combine the negative terminals of the motors to one wire, as the inspection tool does not function as efficiently with this combination of wires (the torque was greatly reduced). Testing was also done on a new type of camera, one that is much smaller than its predecessor. This camera uses 3 wires versus the 5 wires used by the previous camera and will therefore have a total of 7 wires to connect to the tether.

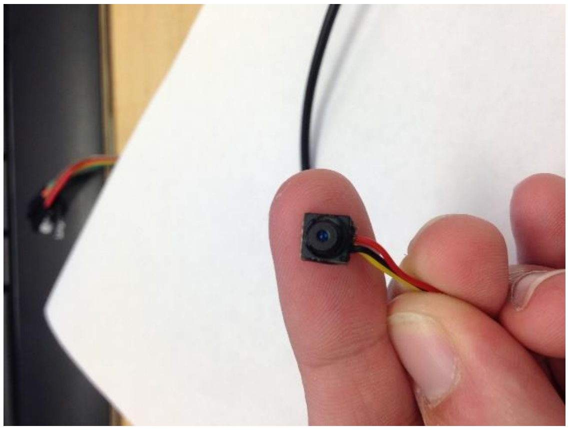


Figure 1-36. New camera to be used in the inspection tool.

The design of the body of the inspection tool was affected by the change in the cameras. In the pursuit of a more compact/radiation hardened design, the unit was reworked to contain the wiring internally. The previous design (which had the connector to the tether exposed in the back of the tool) was scrapped, with the new version placing the connector within the unit itself.

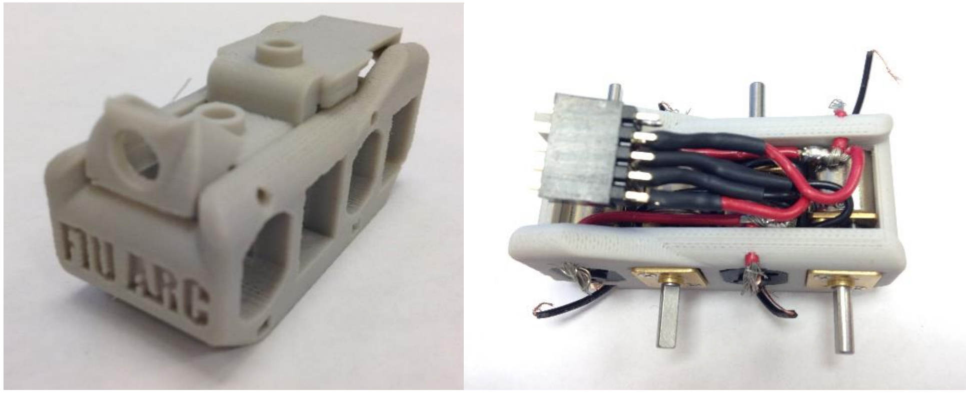


Figure 1-37. Design modifications made to contain the wiring/connector for the inspection tool internally.

Subtask 18.3: Investigation Using an Infrared Temperature Sensor to Determine the Inside Wall Temperature of DSTs

During this performance period, a milestone summary document (FIU-ARC-2016-800006470-04c-245) has been drafted and submitted, data analysis for the baseline tests has been conducted and thermal simulation models have been developed using Solid-works software. In addition, a second phase of testing was initiated using a plate with ½ inch thickness along with enhanced thermocouples and data acquisition systems. A conference paper was also submitted to and accepted by the iMaps (International Microelectronics Assembly and Packaging Society).

During the previous performance period, initial experiments were conducted to obtain thermal measurements from a carbon steel plate (0.875in) thickness using thermocouples. During this period, the results obtained were analyzed for two test cases.

Temperature as a function of sensor height and test piece length is plotted in Figure 1-38 for the sample tests 1 and 2, respectively. It is evident from the graphs that the temperature contours represent similarity with changes in height. This shows that height is not a very significant parameter for the sensor in the given range (2in to 24in). Also, in both the graphs, there is a peak value for temperature at 6in length and then a gradual reduction. This is due to the maximum temperature near the heating coil underneath the test piece. The gradual reduction in temperature away from one end of the test piece is due to the heating effect occurring as a result of the side mount electric coil heater.

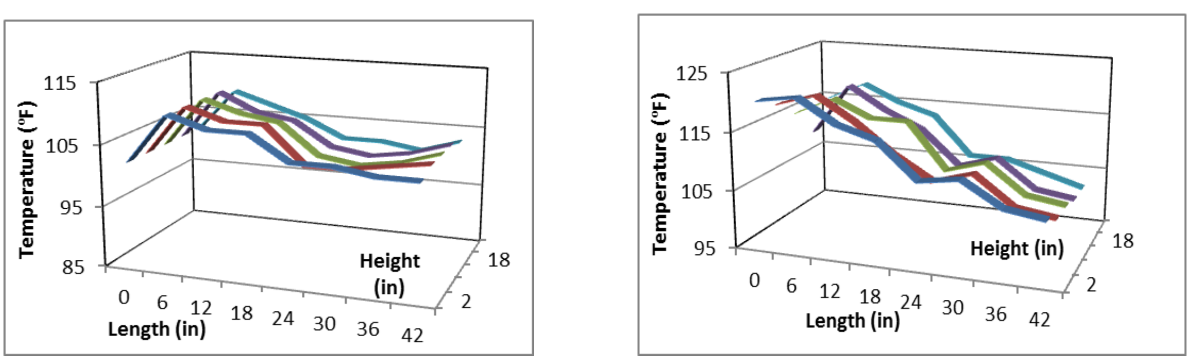


Figure 1-38. (a) Temperature contours (Test 1), (b) Temperature contours (Test 2).

In addition to the experimental tests, thermal modeling has also been conducted to verify and predict the temperature profiles for the test piece. Heat transfer based modelling and simulation has been conducted using Solidworks. The test piece is modeled for convective heat transfer on both sides assuming air and water as the convective fluids. Natural convection is assumed. Conduction heat transfer is considered inside the solid test piece. A sample set of simulation results are shown in Figure 1-39. The air side temperature is fixed at 100 ºF and the heat transfer analysis is performed to obtain the bulk mean temperature of water on the other side. Figure 1-39a represents the heat transfer through the plate/wall and 39b represents the detailed temperature profile along the cross section of the plate/wall.

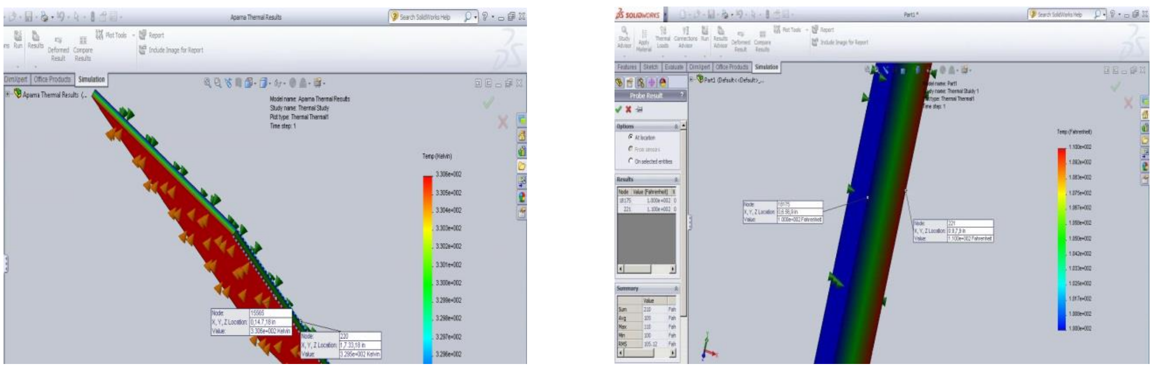


Figure 1-39. (a) Heat transfer through the plate/wall, (b) temperature profile (plate cross section).

The temperature range used for the tests was 90-130ºF which was primarily due to the type of heater used. In future, actual temperature range as specified for the DST's (120-170ºF) will be used with new heating options.

During the second month of this quarter, the equipment for the second phase of testing has been acquired, installed and initial testing has begun. The mockup for testing included a 1/2 inch thick carbon steel plate floating on the water inside a stainless steel tank, similar to the previous test set-up. The plate was suspended in the water using struts, rods, c-clamps and nuts and bolts. The tank was covered with an ultra-flexible foam rubber pipe insulation to reduce the heat transfer by convection. A new 4000 W immersion heater (Tempco TAT 40002) has been procured and tested for heating water in the tank. The new set-up is shown in Figure 1-40.

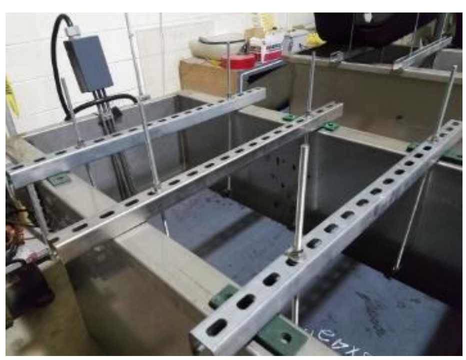


Figure 1-40. Experimental set up with ½-inch-thick plate.

A new data acquisition (DAQ) system from Omega has been acquired; the software has been installed and tested using thermocouples. The DAQ system (OM-DAQ-USB-2401) is suitable for 8 differential or 16 single ended analog inputs. It is user programmable for Type J, K, T, E, R, S, N, B thermocouples or voltage input and comes with customized windows compatible software. It provides a 12-volt DC output for sensor excitation. Figure 1-41 shows the DAQ system attached to thermocouples and the dashboard with data displays of temperature.

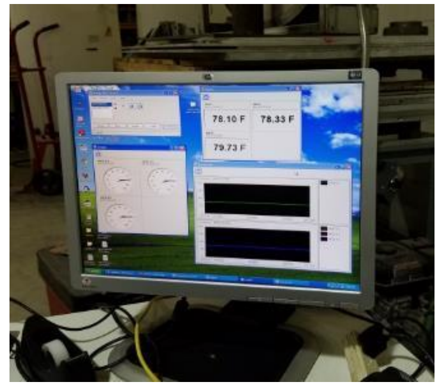


Figure 1-41. DAQ system with thermocouples (left), DAQ dashboard with data displays (right).

An initial set of experiments was conducted using the new tank set up and the omega DAQ system. During the tests, temperature measurements were taken through manual contact between the thermocouples and the test piece. Raytek sensor readings were also obtained at the same points on the surface of the plate. The results obtained were similar to the first phase of testing. The next step was to fix thermocouples to the inner wall (in contact with water) and obtain thermal measurements on both sides of the plate. Attaching thermocouples to the metal plate exposed to water was a challenge and so different methods were investigated.

During the third month of this quarter, the process of permanently fixing the hermitically sealed thermocouples onto the inner surface of the plate (in contact with water) has been investigated to obtain real-time temperature measurements for continuous monitoring. Also, another DAQ system from national instruments has been installed and tested as an additional DAQ system for data gathering.

Two approaches were used to fix the thermocouples to the plate: a thermally conductive epoxy (OB-101) from omega and an ultra-wear resistant slippery tape made of plastic. OB-101 is a two-part epoxy containing resin and a catalyst which exhibits important characteristics necessary for accurate, fast, reliable temperature measurement. The notable features include good adhesion and strength, high temperature rating, high thermal conduction, high electric insulation, thixotropic consistency, fast cure, and easy application. The working time/pot life is 30 minutes at room temperature.

The plastic tape is backed with the thermoplastic polymer PEEK and provides excellent wear and friction properties, plus insulation and good chemical resistance. General purpose applications include the use for sliding bearing surfaces, abrasion-resistant wire wraps, and high-heat applications. It is suitable for hard surfaces such as steel, ceramic, and glass. It resists high humidity and chemicals. It has 0.002" thick acrylic or silicone adhesive and a temperature range of -40° to 300° F.

Figure 1-42 shows the thermocouple glued to a test piece plate using the epoxy and attached to a single unit UTC-USM DAQ system attached to a computer. The measurements were accurate and continuous. Figure 1-42 also shows similar testing using the plastic tape with hot water in a cup for temperature measurements.

Both methods were able to provide continuous temperature readings but the tape was peeling off after a certain time due to humidity and temperature. Hence, the epoxy approach was selected.

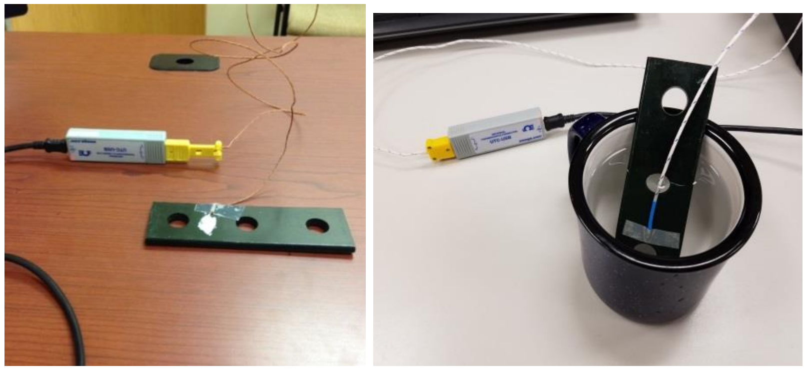


Figure 1-42. Experimental set up using epoxy (left) and thermoplastic polymer tape (right).

An in-house DAQ system from National Instruments (NI FP-2010 controller) along with thermocouple modules was also connected and tested to validate the accuracy of measured temperatures. Figure 1-43 shows the DAQ system with the thermocouple and pressure modules attached to the controller. The figure also shows the network diagram in Labview software for the thermocouple arrangement and real-time data logging.

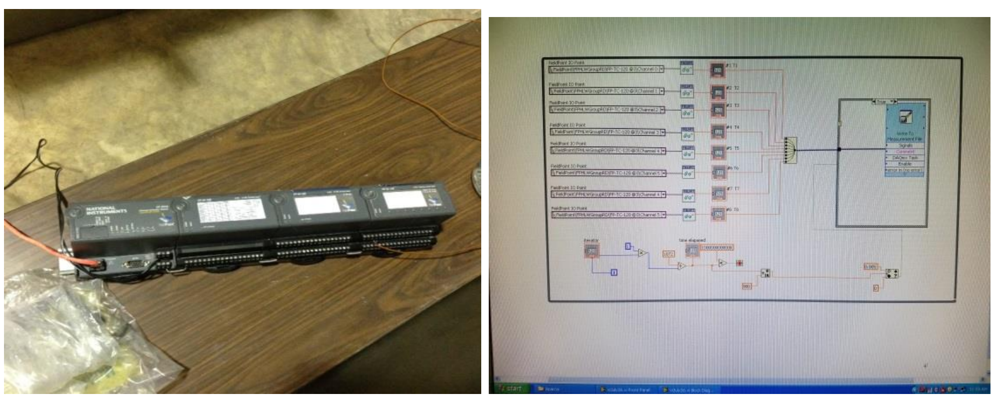


Figure 1-43. NI DAQ system with thermocouples (left) and DAQ dashboard with network diagram (right).

Currently, FIU is in the process of conducting the next phase of experiments with actual temperature range as specified for the DST's (120-170ºF) using the enhanced and validated DAQ systems and permanently fixed underwater thermocouples and the new 4000Watt water heater.

Task 19: Pipeline Integrity and Analysis

<u>Task 19 Overview</u>

The objective of this task is to support the DOE and site contractors at Hanford in their effort to evaluate the integrity of waste transfer system components. This includes primary piping, encasements, and jumpers. It has been recommended that at least 5% of the buried carbon steel DSTs waste transfer line encasements be inspected. Data has been collected for a number of these system components and analyzed. Currently, different ultrasonic transducer systems are being investigated for thickness data measurement to determine the actual erosion/corrosion rates so that a reliable life expectancy of these components can be obtained. An additional objective of this task is to provide the Hanford Site with data obtained from experimental testing of the hose-in-hose transfer lines, Teflon® gaskets, EPDM O-rings, and other nonmetallic components used in their tank farm waste transfer system under simultaneous stressor exposures.

Task 19 Quarterly Progress

Subtask 19.1: Pipeline Corrosion and Erosion Evaluation

During this performance period, procurement of the Permasense Guided Wave sensors has been completed and a basic pipe layout has been designed for initial installation and testing of the sensors.

In order to install the UT sensors, an initial pipeline system consisting of 3 and 4 inch straight sections, 3 and 4 inch curved sections (bends) and a reducer has been designed (Figure 1-44). The model will be built using carbon steel pipes, bends and a reducer supported by channel struts.

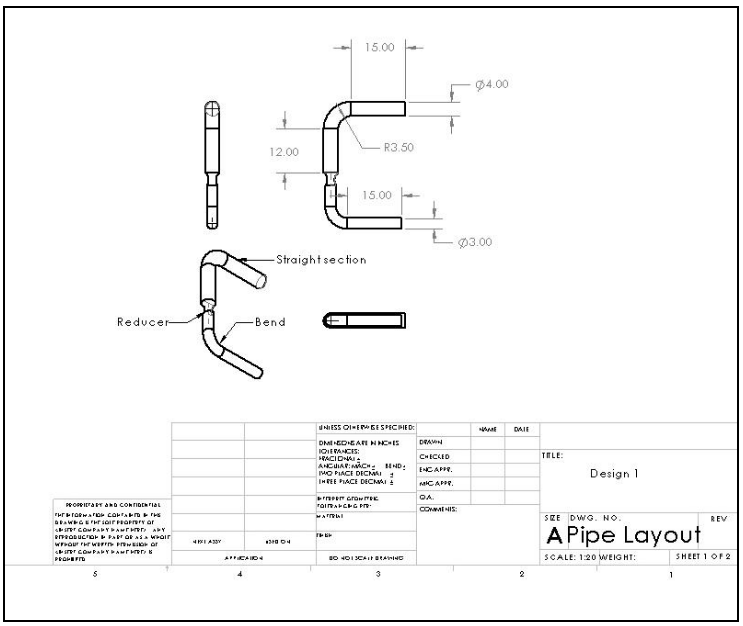


Figure 1-44. Schematic of the pipe layout.

The procured Permasense guided wave sensors are WT 210 series sensors and are accompanied by customized mechanical clamps for mounting on 2-, 3- and 4-inch pipe sections and elbows. FIU has received a total of 4 sensors. Figure 1-45 shows a typical sensor and the mechanical clamp. The sensors are connected via a wireless gateway system for data acquisition. The wireless system is termed WiHart and consists of an Emerson E1 420 Gateway and a few antennas and cables. The Emerson gateway is shown in Figure 1-46.

Figure 1-45. **Permasense WT 210 series sensor and mechanical clamp.**

Figure 1-46. **Wireless Gateway (Emerson).**

The initial installation of the sensors needs to be completed by Permasense trained personnel and hence, FIU is currently in the process of scheduling installation of the equipment and in receiving the required training for operation.

Subtask 19.2: Evaluation of Nonmetallic Components in the Waste Transfer System

This quarter's efforts included installing two stainless steel bulkhead fittings as replacements for the two polyethylene bulkhead fittings that cracked due to the high temperatures on loop #1. After the installation, the loop was refilled with a 25% solution of sodium hydroxide and checked for leaks. Once it was determined there were no leaks, all three loops and heaters were turned back on and the aging process resumed. Figure 1-47, Figure 1-48 and Figure 1-49 show sample data collected between July 9-11, 2016 for the pressure, flow rate and temperature respectively for each of the three loops. It was noted after observing the data, that one of the pressure transducers was faulty. A replacement was ordered and installed. Initial results from the flow rates show that there is a variance of 1.2 GPM between the three loops. This is likely due to slight variations in the pumps. Further investigation revealed that adjusting the ball valve settings can reduce this variance.

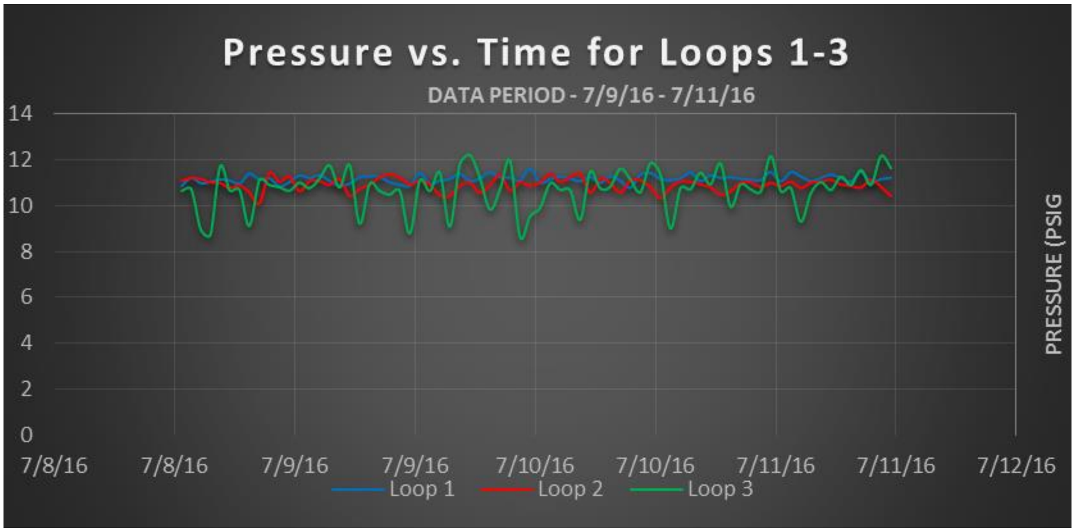


Figure 1-47. Sample pressure data.

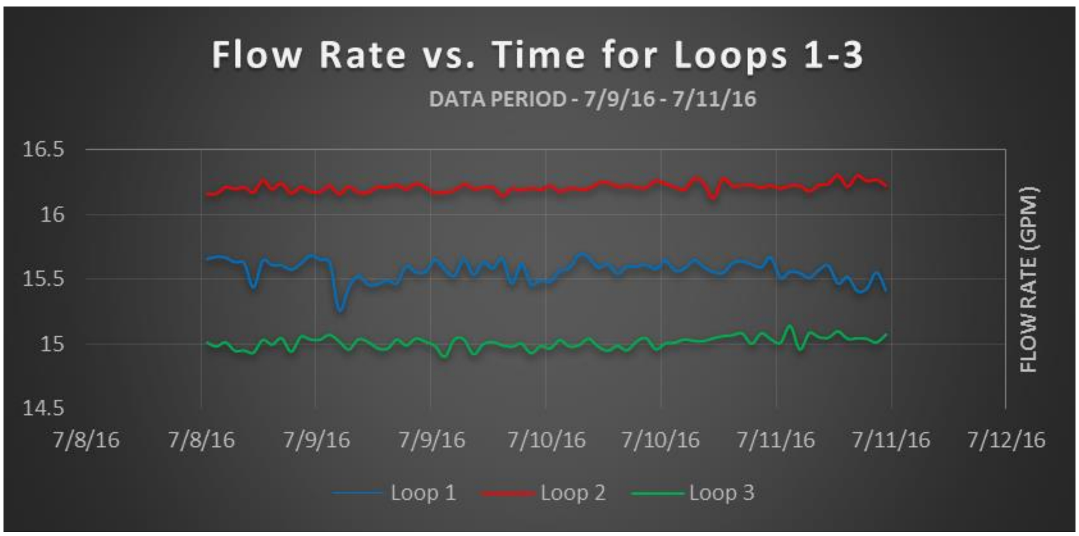


Figure 1-48. Sample flow rate data.

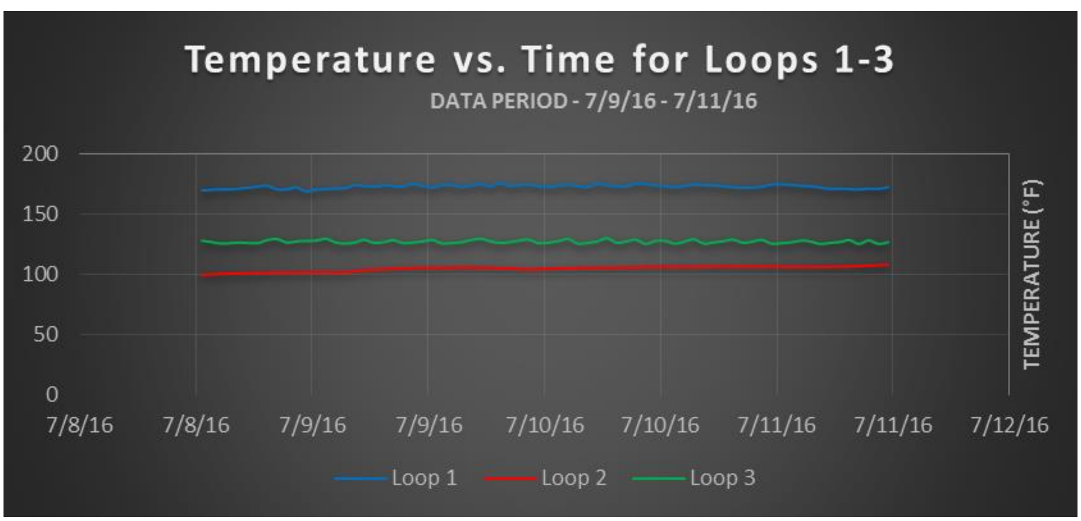


Figure 1-49. Sample temperature data.

As the test loops continue to run and age the hose-in-hose-transfer-lines (HIHTLs) and other nonmetallic components, efforts were focused on troubleshooting minor issues in the loop as they arose. This included replacing the pressure transducer on loop 3. After replacing the transducer and resuming the aging tests, a leak was detected from the loop 1 pump. The pump was taken apart for inspection and a crack was discovered in the motor adapter barrier (Figure 1-50). After consultation with the manufacturer, it was concluded that the crack was a result of high fluid temperature. The temperature of the fluid that was run through the pump was 180°F. Even though the pump has a maximum operating temperature of 180°F, the manufacturer recommended reducing the temperature to 175°F since FIU is running sodium hydroxide. The temperature of loop 1 was reduced to 175°F and a new pump was ordered.

Figure 1-50. Leaking pump.

The replacement pump arrived a few days later but it had a broken leg. For the benefit of time, the motor adapter barrier of the new pump was removed and placed on the old pump. The vendor was contacted and agreed to deliver a new pump free of charge. When the replacement pump arrived, it was discovered to also have a broken leg. The vendor was again contacted and agreed to deliver a new set of legs instead of an entire pump.

After replacing the pump and resuming the aging tests, a leak was detected from the cross piece on loop 3 (Figure 1-51). The leak was repaired and the aging tests resumed.

Figure 1-51. Loop 3 cross piece.

In the last month of this quarter, efforts were focused on writing the project technical plan and year-end report. Trouble shooting of minor issues in the loop was also addressed as the problems occurred. This included replacing the motor adapter barrier on pump number 1 after a crack developed that resulted in a leak. The cracked motor adapter barrier appears to be an issue with the Finish Thompson magnetic drive pumps when they are run at high temperatures. For that reason, FIU has purchased additional replacement motor adapter barriers as backups. FIU has also started looking into other pump options to replace the pump. A couple of minor leaks also developed in loop fittings that were easily repaired.

Milestones and Deliverables

The milestones and deliverables for Project 1 for FIU Performance Year 6 are shown on the following table. The deliverable for Task 18.3.1, which was a summary document for the initial testing of the IR sensor was completed and submitted to DOE HQ on June 29, 2016. The deliverable for Task 17.1.1 which was a summary document related to the modelling of HLW mixing processes was completed and submitted to DOE HQ on August 28, 2016. Additionally, the completion of milestone 2015-P1-M18.2.2 and it its corresponding deliverable was reforecast until 10/14/16 so that FIU could attend the DOE National Lab Day on the Hill on 9/13/16 and demonstrate the robotic technologies being developed at FIU. The reforecasted date was communicated to and concurrence received from the DOE EM project lead on 8/16/16. The project task plan was completed and submitted to DOE HQ on September 30, 2016.

FIU Performance Year 6 Milestones and Deliverables for Project 1

Task	Milestone/ Deliverable	Description	Due Date	Status	OSTI
Task 17: Advanced Topics for Mixing Processes	2015-P1-M17.1.2	Complete validation of impingement correlations	05/6/2016	Complete	
	Deliverable	Draft Summary Report for Subtask 17.1.1	08/28/2016	Complete	OSTI
	Deliverable	Draft Summary Report for Subtask 17.1.2	05/6/2016	Complete	OSTI
Task 18: Technology Development and Instrumentation Evaluation	2015-P1-M18.1.1	Complete test plan for evaluating SLIM's ability to detect a precursor of DSGREs	12/18/2015	Complete	
	Deliverable	Draft Test Plan for Subtask 18.1.1	12/18/2015	Complete	OSTI
	2015-P1-M18.3.1	Complete test plan for temperature measurements using IR sensors	12/18/2015	Complete	
	2015-P1-M18.2.1	Finalize the design and construction of the refractory pad inspection tool	02/26/2016	Complete	
	2015-P1-M18.2.2	Complete engineering scale mock-up testing	08/28/2016	Reforecast 10/21/16	
	Deliverable	Draft Summary Report for Subtask 18.2.1 and 18.2.2	08/28/2016	Reforecast 10/21/16	OSTI
	2015-P1-M18.2.3	Finalize the design and construction of the air supply line inspection tool	02/26/2016	Complete	
	Deliverable	Draft Summary Report for Subtask 18.2.3	02/26/2016	Complete	OSTI
	Deliverable	Draft Summary Report for Subtask 18.3.1	07/29/2016	Complete	OSTI
Task 19: Pipeline Integrity and Analysis	2015-P1-M19.2.1	Complete test loop set up	11/20/2015	Complete	
	2015-P1-M19.1.1	Evaluate and down select alternative UT systems for bench scale testing	03/11/2016	Complete	
	Deliverable	Draft Summary document for Subtask 19.1.1	03/11/2016	Complete	OSTI
	2015-P1-M19.2.2	Complete baseline experimental testing	03/25/2016	Complete	
	Deliverable	Draft Summary Report for Subtask 19.2.2	04/8/2016	Complete	OSTI

Work Plan for Next Quarter

Project-wide:

- Complete the Year End Report (YER) for FIU Performance Year 6 (August 2015 to August 2016).
- Revise the Project Technical Plan (PTP) for FIU Performance Year 7 (August 2016 to August 2017) based on comments received from DOE's review.

Task 17: Advanced Topics for Mixing Processes

- FIU will continue the literature review on the capability of STARCCM+ in simulating the modeling of rotating turbulent jet, solid mobilization, suspension, settling, transfer line intake, and pipeline transfer, and in particular models used in simulation of HLW mixing and transfer. Published data regarding simulant's properties (i.e., density and viscosity and boundary conditions) will be focused upon in order to complete the problem setup inside the STARCCM+.
- FIU will continue to address issues related to the modeling of the mixing process. Based on guidance from NETL, efforts will be focused on generating models for air spargers utilized in the mixing of non-Newtonian fluids.

Task 18: Technology Development and Instrumentation Evaluation

- The SLIM task is concluded and will not continue into FIU Performance Year 7 as the Hanford Site engineers have stated that the technology is not needed until 2018 or 2019 and is not a high priority for 2017.
- For the inspection tools, the manufacturing of the full-scale sectional mockup of the DST will be completed.
- For the peristaltic crawler, FIU will continue to validate the device in full-scale tests. The device's instrumentation module will be finalized and incorporated. Modifications will continue to be incorporated in the design as needed. FIU will also evaluate preliminary concepts for incorporating a cable management system.
- For the miniature magnetic rover, FIU will continue to investigate design modifications to allow for sharper turns in the refractory channels. The tether management system will also be tested. Modifications to the design and control of the tether management system will be made as needed. FIU will also continue to evaluate preliminary concepts for incorporating the unit onto a deployment platform.
- For the IR sensor task, FIU will complete the second phase of engineering-scale testing of the Raytek IR sensor. This phase will include automation of the process for real-time temperature measurements. Permanently fixed underwater thermocouples, enhanced data acquisition systems and efficient heaters will be used. The experiments will be conducted using plates with varying thicknesses and a typical temperature range as observed in the DST wastes (120-170 ºF). Also, sensitivity based studies for the IR sensor will be conducted. Further, advanced heat transfer based simulation models will be generated to

verify and validate the experimental results and to predict the waste temperatures inside the tanks away from the walls.

Task 19: Pipeline Integrity and Analysis

- For the ultrasonic sensor task, FIU will install the sensors on a mock-up test bed made of different sections of pipes. Permasense personnel will assist in the installation process including the software and provide the required training to the staff. Upon successful installation, initial bench-scale tests will be performed for validation of the sensor data. Further, the process of retrieval and reinstallation of the sensors on the full-scale sectional mock up being constructed at FIU-ARC will be investigated. Also, abrasivity based studies will be explored to simulate the erosion/corrosion effect on the pipe material.

- For the non-metallic materials task, efforts during the next quarter will include continuation of the aging of the specimens. Modifications to the test loop and controls will be made as needed.

Project 2
Environmental Remediation Science and Technology

Project Description

This project will be conducted in close collaboration between FIU, Hanford Site, Savannah River Site, and the Waste Isolation Pilot Plant (WIPP) scientists and engineers in order to plan and execute research that supports the resolution of critical science and engineering needs, leading to a better understanding of the long-term behavior of contaminants in the subsurface. Research involves novel analytical methods and microscopy techniques for characterization of various mineral and microbial samples. Tasks include studies which predict the behavior and fate of radionuclides that can potentially contaminate the groundwater system in the Hanford Site 200 Area; laboratory batch and column experiments, which provide relevant data for modeling of the migration and distribution of natural organic matter injected into subsurface systems in the SRS F/H Area; laboratory experiments investigating the behavior of the actinide elements in high ionic strength systems relevant to the Waste Isolation Pilot Plant; surface water modeling of Tims Branch at SRS supported by the application of GIS technology for storage and geoprocessing of spatial and temporal data;.

The following tasks are included in FIU Performance Year 6:

Task No	Task
Task 1: Remediation Research and Technical Support for the Hanford Site	
Subtask 1.1	Sequestering uranium at the Hanford 200 Area vadose zone by in situ subsurface pH manipulation using NH_3 gas
Subtask 1.2	Investigation of microbial-meta-autunite interactions - effect of bicarbonate and calcium ions
Subtask 1.3	Evaluation of ammonia fate and biological contributions during and after ammonia injection for uranium treatment
Task 2: Remediation Research and Technical Support for Savannah River Site	
Subtask 2.1	FIU's support for groundwater remediation at SRS F/H Area
Subtask 2.2	Monitoring of U(VI) bioreduction after ARCADIS demonstration at the SRS F-Area
Subtask 2.3	Humic acid batch sorption experiments into the SRS soil
Subtask 2.4	The synergetic effect of HA and Si on the removal of U(VI)
Subtask 2.5	Investigation of the migration and distribution of natural organic matter injected into subsurface systems
Task 3: Surface Water Modeling of Tims Branch	
Subtask.3.1	Modeling of surface water and sediment transport in the Tims Branch ecosystem
Subtask 3.2	Application of GIS technologies for hydrological modeling support
Subtask 3.3	Biota, biofilm, water and sediment sampling in Tims Branch

Task 4: Sustainability Plan for the A/M Area Groundwater Remediation System	
Subtask 4.1	Sustainable Remediation Analysis of the M1 Air Stripper
Subtask 4.2	Sustainable Remediation Support to DOE EM Student Challenge
Task 5: Remediation Research and Technical Support for WIPP	

Task 1: Remediation Research and Technical Support for the Hanford Site

<u>Task 1 Overview</u>

The radioactive contamination at the Hanford Site created plumes that threaten groundwater quality due to potential downward migration through the unsaturated vadose zone. FIU is supporting basic research into the sequestration of radionuclides such as uranium in the vadose zone, which is more cost effective than groundwater remediation. One technology under consideration to control U(VI) mobility in the Hanford vadose zone is a manipulation of sediment pH via ammonia gas injection to create alkaline conditions in the uranium-contaminated sediment. Another technology need for the ammonia remediation method is to investigate the potential biological and physical mechanisms associated with the fate of ammonia after injection into the unsaturated subsurface.

<u>Task 1 Quarterly Progress</u>

Subtask 1.1. Sequestering Uranium at the Hanford 200 Area Vadose Zone by In Situ Subsurface pH Manipulation Using NH_3 Gas

In the month of July, FIU completed a set of experiments with the sequential liquid extraction to investigate the stability of precipitates created after ammonia gas injections. A set of six duplicated filtered samples containing U-bearing precipitates were processed via the extraction protocol. Precipitates were crushed inside the vials before undergoing the sequential liquid extraction procedures to ensure that the solutes can diffuse from the solid to the liquid phase. In addition, the dilution factor for each step was 1:40 and the extraction solution volumes for each sample varied based on the weight of precipitate. All the supernatant solutions were collected after 30 min of centrifugation following each sequential extraction step.

The supernatant solutions collected after each sequential extraction step including wash solutions were analyzed for uranium via the KPA instrument. KPA analyses were conducted using different dilution factors (1:10 and 1:100). The highest dilution factor was needed for steps 3, 4 and 5. The results from the uranium analysis were used for mass balance calculations in order to validate U mass measured in each step. The extractions suggested the highest percentage of uranium extraction for steps 4, 5 and 6.

Figure 2-1 below shows the results of uranium detected by the KPA instrument and analyzing the results throughout the different steps of sequential extraction conducted on the six different duplicates of filtered samples. As a general tendency, steps 3, 4 and 5 account for more than 68% of the total uranium extracted in all six samples.

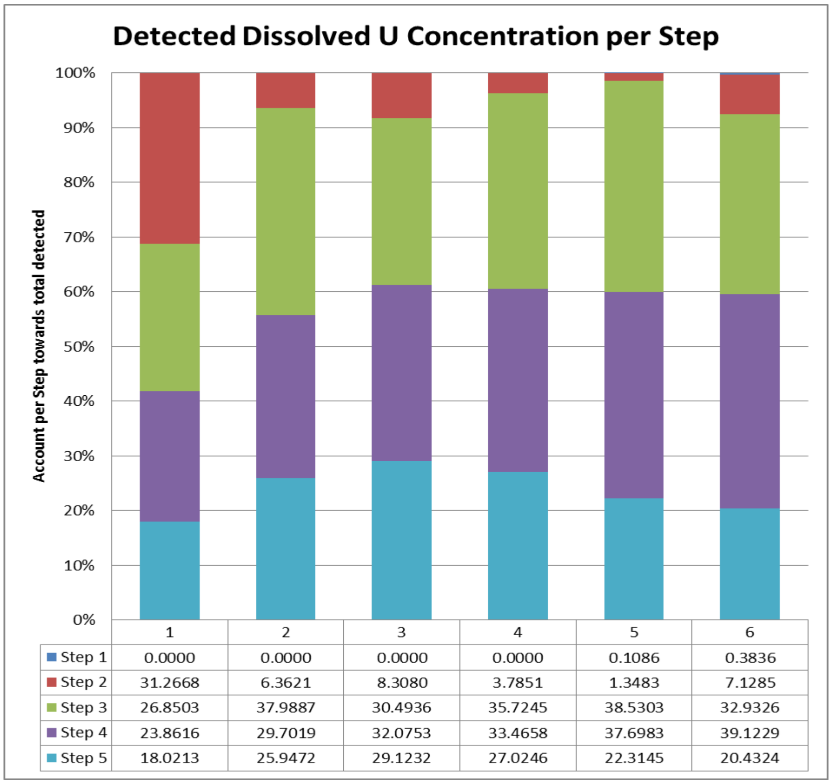


Figure 2-1. Uranium concentrations detected in each step of sequential extractions.

In the month of July, FIU started to prepare fresh/new U-bearing precipitates to continue with the sequential liquid extraction experiments to improve the mass balance for uranium extracted by sequential steps. To create precipitates, the following type and amount of salts depicted in Table 2-1 were prepared to generate 50mL of stock solution with target concentrations in the samples:

Table 2-1. Stock solution concentrations to prepare precipitates to continue with sequential extraction experiments.

Stock Solution	Salt Used	Molecular Weight of Salt (g/mol)	Stock solution Concentration (mM)	Amount to prepare 50 mL, g	Target Concentration in Samples (mM)		
Bicarbonate	$KHCO_3$	100.114	400	2.002	3	50	
Metasilicate	$Na_2SiO_3.9H_2O$	284.196	422.24	5.998	50		
Aluminum	$Al(NO_3)_3.9H_2O$	375.129	50	0.938	5		
Calcium	$CaCl_2.6H_2O$	219.08	500	5.477	0	5	10
Uranium Nitrate	$UO_2(NO_3)_2.6H_2O$	238.03					

Twelve (12) samples (6 original and 6 duplicates) were prepared using 50mM Si, 5mM Al, 3 and 50 mM of HCO_3 and 0, 5 and 10 mM of Ca. Concentrations of Si and Al were the same for each mixture.

The general procedure to prepare the 12 U-bearing precipitate samples was as follows: first, prepare 4 tubes of a 40 mL mixture containing Si and Al for all samples, add the corresponding amount of HCO_3 for the two groups of 6 samples containing two different targeting concentrations (3 and 50 mM), then measure pH and adjust to around 7-8 by adding small amounts (150-200 µL) of concentrated nitric acid (HNO_3). After this, ammonia gas was injected to the mixture in order to raise the pH up to 11 followed by distribution of the mixture to 12 centrifuge tubes corresponding to the 6 different samples and their duplicates. Finally, the corresponding amount of U and Ca were added to the different samples. The table below shows the amount of stock solution and DI water required to prepare 12 tubes of 10 mL mixed samples.

Table 2-2. Amount of stock solution and DI water required to prepare 12 tubes of 10 mL mixed samples amended with U

Amount of Stock Solution and DIW (uL) to Prepare 40 mL of Mixed Samples				10mL Mixed Samples Amended with Ca and U		
	$Na_2SiO_3 \cdot 9H_2O$ (50mM)	**4,737**	**uL**	**$UO_2(NO_3)_2.6H_2O$**	100	ppm
	$Al(NO_3)_3 \cdot 9H_2O$ (5mM)	**4,000**	**uL**	**$CaCl_2.H_2O$**	500	mM
#	**Sample**	***$KHCO_3$ (µL)**	**DIW (mL)**	****Ca (µL)**	**U (µL)**	**Mixed Samples (µL)**
1	3mM $KHCO_3$, no Calcium	300	30.963	0	200	9,800
2	3mM $KHCO_3$, 5mM Calcium	300	30.963	100	200	9,700
3	3mM $KHCO_3$, 10mM Calcium	300	30.963	200	200	9,600
4	50mM $KHCO_3$, no Calcium	5,000	26.263	0	200	9,800
5	50mM $KHCO_3$, 5mM Calcium	5,000	26.263	100	200	9,700
6	50mM $KHCO_3$, 10mM Calcium	5,000	26.263	200	200	9,600

* Varied from 3mM to 50mM
** Varied from 0mM, 5mM and 10 mM

FIU has continued conducting isopiestic measurements of U-bearing samples with the primary focus on the stability of the multicomponent uranium-bearing precipitates mimicking those created in sediments as a result of alkaline ammonia gas treatment in the vadose zone. The amount of water adsorbed on uranium-bearing precipitates was determined gravimetrically by the isopiestic method. Our results indicate that gravimetric measurements of moisture uptake as a function of increasing relative humidity can provide reasonable estimates of the deliquescence point of solid phases or its components. Water moisture uptake by uranium-bearing precipitates as a function of increasing relative humidity was measured at 25°C. This method can provide reasonable estimates of water quantity retained within precipitates for isopiestic measurements conducted in the range of water activities, $0 \le a_w \le 0.9$. During the experiment, FIU used the direct weighing method that has the following advantages:

- The mass of the sample is determined in comparison with standard weights. The result is not sensitive to errors in pressure measurement.
- With the direct weighing method, all the points on an isotherm are measured independently; so, the errors of earlier obtained data points do not affect the following

points. This allows for monitoring the weight of the sample over long time periods (Gruszkiewicz et al., 2000).

The uptake of water by solids suggests the dependence of the water retention by the precipitates as a function of water activity. The shape of most of the water adsorption isotherms obtained in the isopiestic experiments is generally similar for all solid composition tested. They are characterized by an increase in water retention in a range of a_w up to 0.75 and then a steep upward swing due to vapor condensation starting at a_w = 0.78-0.84. FIU also initiated desorption experiments by inserting in the chamber a crucible with concentrated sulfuric acid that adsorbs excessive water from solids.

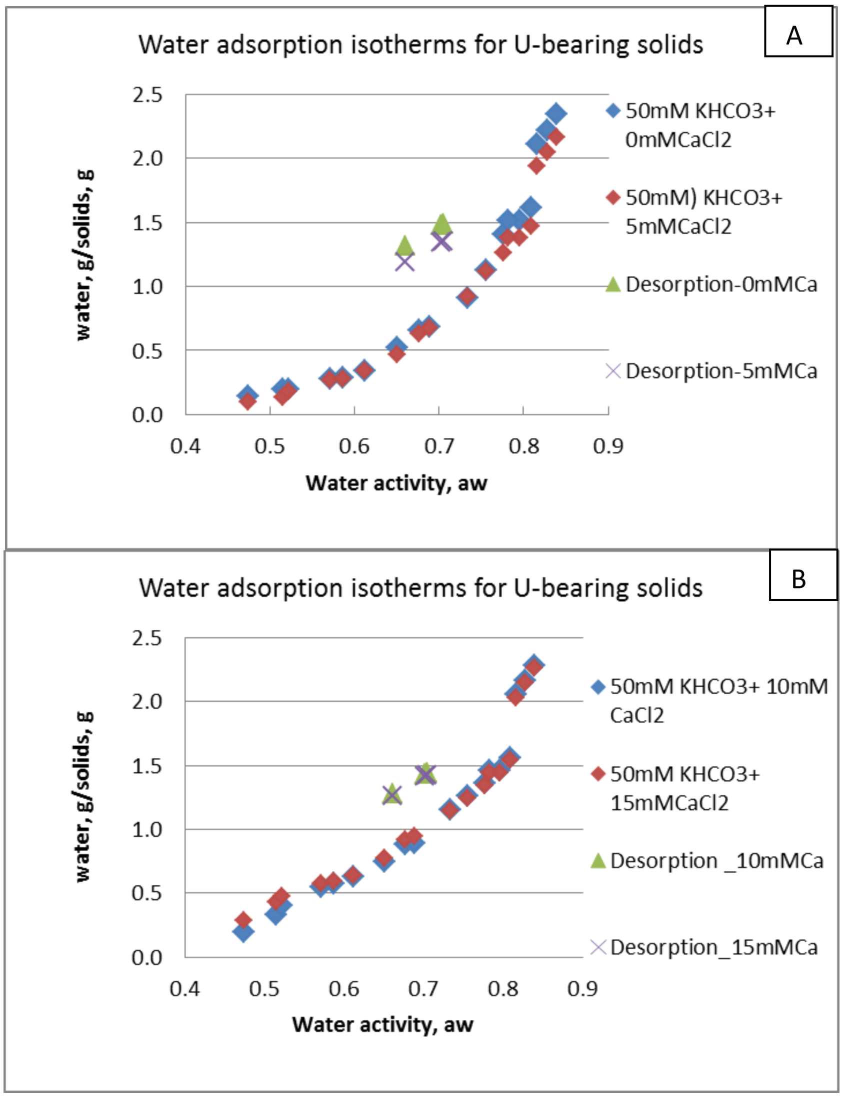


Figure 2-2. Water adsorption isotherms for U-bearing solids for the precipitates composed of 50mM Si, 50mM HCO_3, 5mM Al and Ca. a) 0mM Ca and 5mM Ca, b) 10mM Ca and 15mM Ca.

FIU also continued solid phase characterization of the precipitates prepared with elevated concentrations of U(VI). The samples produced by sequential extraction of solid uranium precipitate samples, which were errantly diluted in deionized water, were re-prepared using 1% nitric acid solutions. The preliminary KPA data garnered by analysis of the water-diluted samples provided insight into the highest dilution factors which would be required for the revised samples in order to keep the uranium concentration within the 0.1 to 100 ppb range preferred for KPA analysis.

The collected KPA data was graphed to display the mass of uranium removed with each extraction step. The results of this analysis were consistent with expectations in that the majority of uranium was removed in the acetate buffer (step 3) and acetic acid (step 4) extractions. In the low bicarbonate samples, the sequential extraction heavily favored the acetic acid step over the acetate extraction (Figure 2-3). The ratio between the two is much closer in the high bicarbonate samples (Figure 2-4).

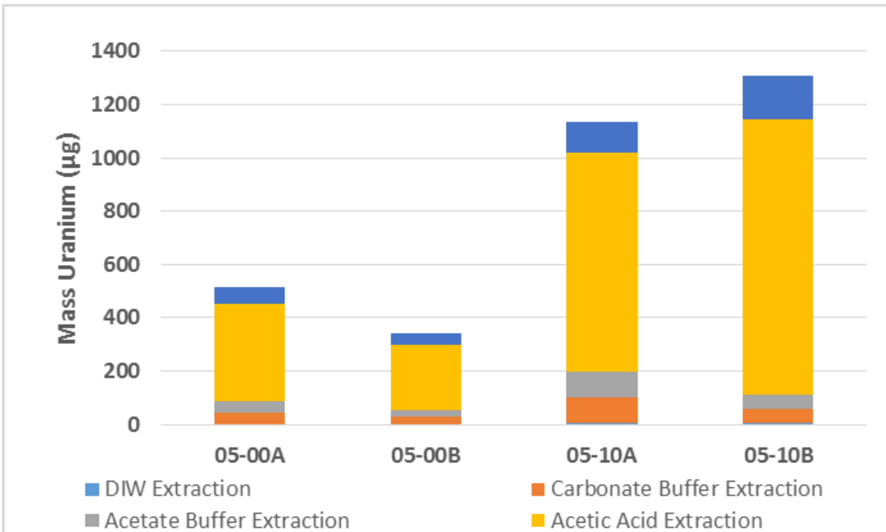


Figure 2-3. Sequential uranium extraction of the low bicarbonate (5 mM) sample precipitates.

Perhaps the most interesting trend shown in the sequential extraction was the greater total removal of uranium in the calcium-containing samples compared to the calcium-free samples. This finding is consistent with the previously reported trends as determined by supernatant analysis. In the aforementioned study, the trend in supernatant solutions showed an inverse relationship between the concentration of calcium in the synthetic pore water solution and the concentration of uranium retained in solution. The solid phase analysis agrees with these prior findings which suggested at the time, based on those supernatant concentrations, that the higher calcium samples would have proportionally more uranium in their solid phases. While the relative mass removed is low in all samples, the high bicarbonate samples show a particularly low removal in the carbonate extraction. The mass of uranium removed by deionized water extraction is near insignificant in all samples. Not factored in this data is the contribution made by the 5mL DIW rinse completed in between extractions, the analysis of which is ongoing.

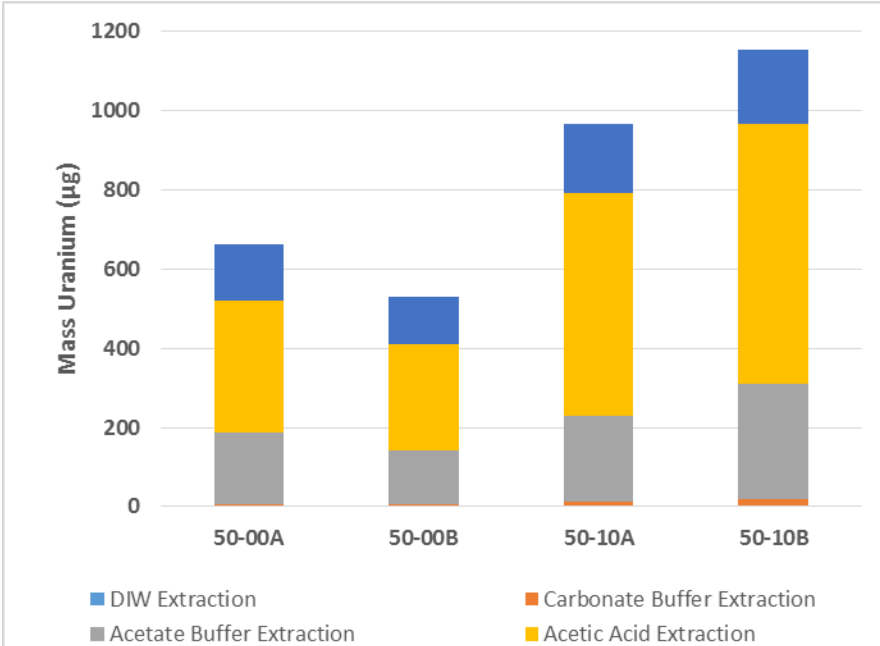


Figure 2-4. Sequential uranium extraction of the high bicarbonate (50 mM) sample precipitates.

The additional data from the imminent microprobe analysis of the epoxy-mounted solid samples that were shipped to Pacific Northwest National Laboratory for preparation and analysis is expected to provide significant clarification about the content of the samples. Paired with the sequential extraction data which is still being generated, these results will provide a thorough characterization of the uranium-bearing solid phase.

In the month of August, a manuscript was published in the Applied Geochemistry Journal by Yelena Katsenovich, Claudia Cardona, Robert Lapierre, Jim Szecsody, and Leonel Lagos, titled, “The effect of Si and Al concentrations on the removal of U(VI) in the alkaline conditions created by NH3 gas.” FIU also submitted an abstract for Waste Management 2017 titled, “Removal of U(VI) in the Alkaline Conditions Created by NH3 Gas” coauthored by Claudia Cardona, Yelena Katsenovich, Jim Szecsody, and Leonel Lagos.

The analysis of the data produced by the sequential extraction experiment on the samples with initial uranium mass of 5000 µg continued with the development of additional figures showing the distribution of the uranium analyte between the extraction phases (Figure 2-5). These figures reveal interesting trends in uranium distribution which, when compared to the target of the extraction solution (Table 2-3), allow for inferences into the phases most likely present in the samples.

Table 2-3. Extraction Solution and Target Phases

Step	Extraction Solution	Target
I	DDI-Water	Aqueous species
II	Carbonate Buffer	Adsorbed species
III	Acetate Buffer	Some carbonates
IV	Acetic Acid	Carbonates and hydrated silicates
V	Nitric Acid	Difficult to remove phases

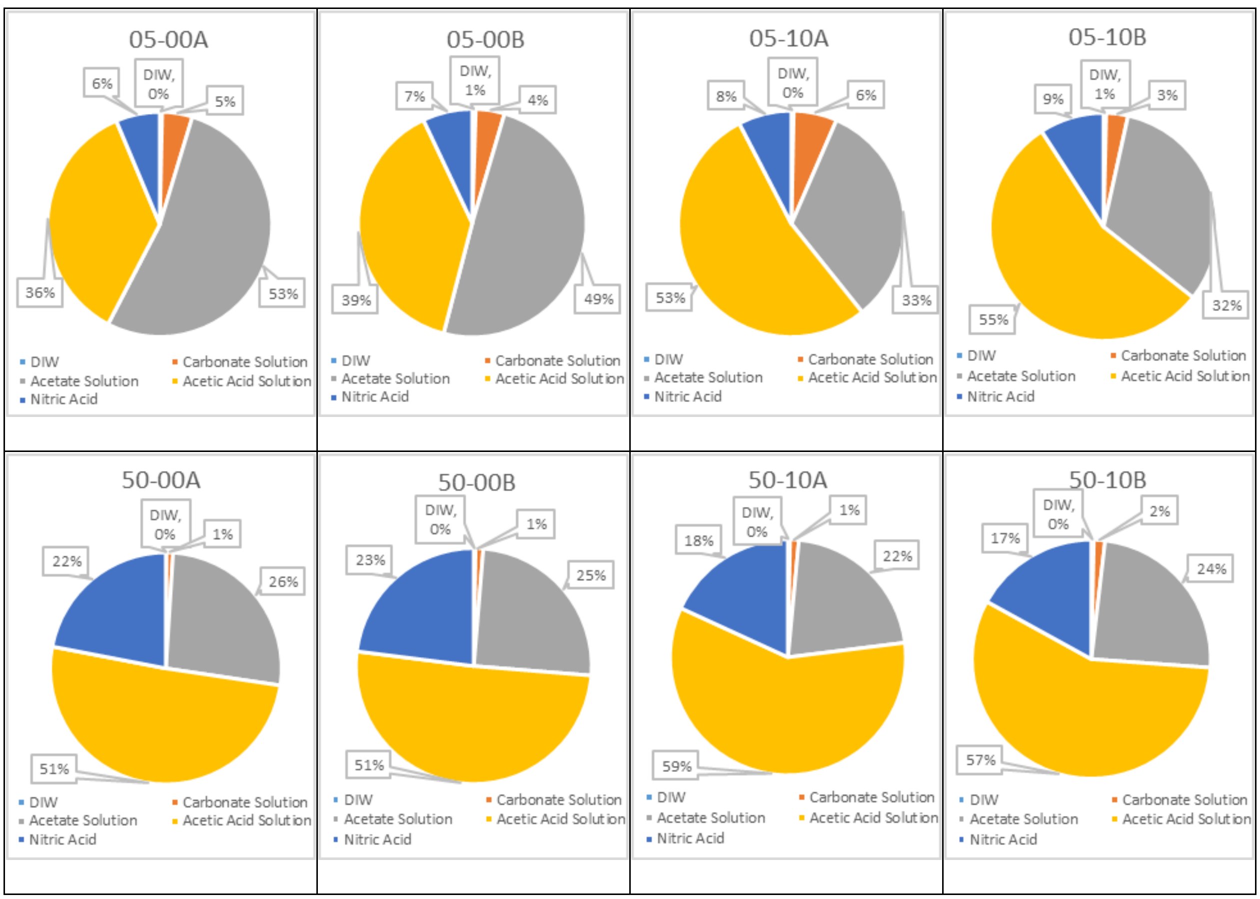


Figure 2-5. Sequential extraction uranium distribution data.

One of the most noteworthy qualities of the figures is the universally low relative abundance of uranium species extractable by deionized water in all of the samples. This suggests a complete lack of aqueous species readily soluble in water. This determination is reasonable when considering the lack of discernable crystalline uranium phases in the SEM imaging. It is reasonable to assume that both observations are likely due to the addition of the vacuum filtration step to the sample preparation, which was intended to minimize the errant formation of otherwise soluble precipitates by evaporation of residual supernatant. Though the high bicarbonate samples show a similarly sparse ratio of analyte was extracted by the carbonate solutions, which was meant to target adsorbed species, there is significantly more liberated in the low bicarbonate samples.

The most interesting dynamic in the sequential extraction is the relative abundance of uranium extracted by the acetate, acetic acid, and nitric acid solutions. In the low bicarbonate-zero calcium samples (05-00 A&B), the majority of uranium was removed in the 3rd step via acetate solution extraction, which targeted uranyl carbonates. With that exception, the dominant extraction phase throughout the experiment was the 4th extraction, the acetic acid solution, which targeted both uranyl carbonates and hydrated uranyl silicates. With the 05-00 exceptions, this step consistently selectively extracted more than half of the total removed uranium. The potency of this extraction step was especially prevalent in the high bicarbonate samples (50-00 A&B and 50-10 A&B), where the next extraction with the highest effect removed only 26% of the total extracted analyte.

Also notable for the high bicarbonate samples is that the relative mass of uranium extractable in nitric acid is doubled. The nitric acid extraction, which is unique in that it occurs at 95°C, is intended to target the uranium phases which are most difficult to extract. The significant increase in analyte in these samples suggests an increased presence of a specific variety of difficult to extract uranium species.

The analysis of the sequential extraction results is ongoing and will complement the results of the proposed electron microprobe analysis for their corresponding samples.

In the month of September, FIU started sequential extraction experiments on a set of twelve (12) newly prepared unfiltered U-bearing precipitate samples amended with 2 ppm of U(VI). The experiment is being performed following the same protocol that includes weak (carbonate) and relatively aggressive extractants (acetic and nitric acid) in order to access and leach uranium that would be present within the samples. To improve the mass balance calculations, FIU will accurately track the mass of the precipitates throughout the different extraction and corresponding rinsing steps. Also in the month of September, fresh precipitates in duplicate samples were prepared, which will be filtered as the main difference for further comparison to unfiltered U-bearing precipitates samples. These filtered samples, after a drying step, will also undergo sequential extractions to be able to compare the results with the unfiltered U-bearing samples.

In the month of September, FIU received polished uranium-bearing samples from Pacific Northwest National Laboratory to conduct microprobe analysis at FIU's Florida Center for Analytical Electron Microscopy (FCAEM) facilities.

In the FIU Performance Year 7, this subtask will be combined with subtask 1.3.1. The scope of work for this subtask was outlined in the Project Technical Plan submitted to HQ for review.

Subtask 1.2. Investigation on Microbial-Meta-Autunite Interactions – Effect of Bicarbonate and Calcium Ions

FIU continued with batch experiments that replicate the exact conditions (U, Ca and P concentrations along with three different bicarbonate concentrations) before inoculation with bacteria in the autunite mineral-free media.

Sampling events were scheduled every 3 days and a month of sampling was completed. The oxidative-reduction potential (ORP) and the pH for each sample were recorded at the beginning of each sampling event. Subsequently, aliquots were isolated for the determination of cell density by means of optical microscopy and Shewanella colonies were plated on agar plates and incubated at 25°C. Furthermore, 1 mL from each supernatant was filtered through a PTFE 0.2 µm filter, acidified and stored at 4°C for chemical analysis. Chemical analysis includes the determination of Ca and P by means of ICP-OES and the determination of U by means of KPA. Samples were subsequently centrifuged at 5,000 rpm for 5 min, after which the supernatant was discarded and the cell pellet was re-suspended in 2 mL of deionized water. The cell suspension is stored at -20°C for future protein content analysis by means of a bicinchoninic acid assay.

Once per week, sampling of abiotic controls (containing all elements and no bacteria) and controls (containing only uranium in DI water) took place. Aliquots of abiotic and control samples were treated in an identical way to the biotic samples.

The experiment is projected to last another 2 weeks, making the total sampling time 45 days.

FIU continued with the batch experiments to replicate the exact conditions (U, Ca and P concentrations along with three different bicarbonate concentrations) before inoculation with bacteria in the autunite mineral-free media.

Sampling was concluded and all of the samples for chemical analysis were stored at 4ºC, while cell suspensions were stored at -20°C for future protein content analysis by means of a bicinchoninic acid assay. FIU will initiate chemical analysis of the samples by means of KPA for U and ICP-OES for Ca and P. The fluctuation of pH as a function of time is presented in Figure 2-6.

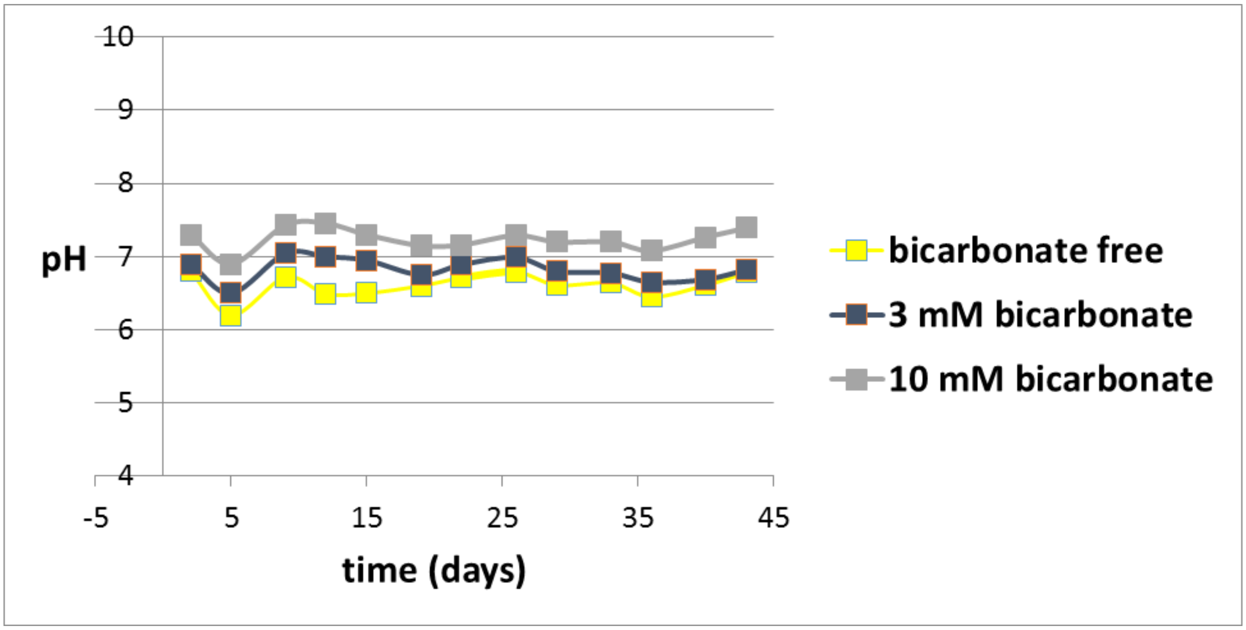


Figure 2-6. pH dependence on time for bicarbonate free biotic samples, as well as biotic samples amended with 3 and 10 mM bicarbonates.

As it can be seen in Figure 2-6, there is no significant pH fluctuation as a function of time for all three conditions studied (bicarbonate-free and samples amended with 3 mM and 10 mM bicarbonate) under anaerobic conditions. All of the samples were autunite-free. Furthermore, FIU is currently analyzing the results from cell counting by means of optical microscopy and plate counting as a function of time for all of the conditions studied.

After sampling was completed, three samples of precipitate were prepared for SEM/EDS analysis. The samples were vortexed and transferred to centrifuge tubes. The samples were centrifuged at 4000 rpm for 10 minutes. The supernatant was then removed and 1 mL of 2% glutaraldehyde solution was added to each solution. After two hours, the samples were centrifuged again and the resulting supernatant was removed. The solutions were then dehydrated in ethanol solutions of 35%, 75%, 90%, 95%, and 100% for 10 min each. Then, the samples were dehydrated in the 100% ethanol solution twice. The samples were then immersed in 100% pure hexamethyldisilazane followed by air-drying for 10 min. The dehydrated samples were then placed in the desiccators for future SED/EDS analysis.

Elemental analysis of Ca and P was performed by means of inductively coupled plasma atomic emission spectroscopy (ICP-OES). The concentration of Ca and P as a function of time for all three categories (bicarbonate free samples and samples amended with 3 and 10 mM bicarbonate) are presented in Figures 2-7 and 2-8.

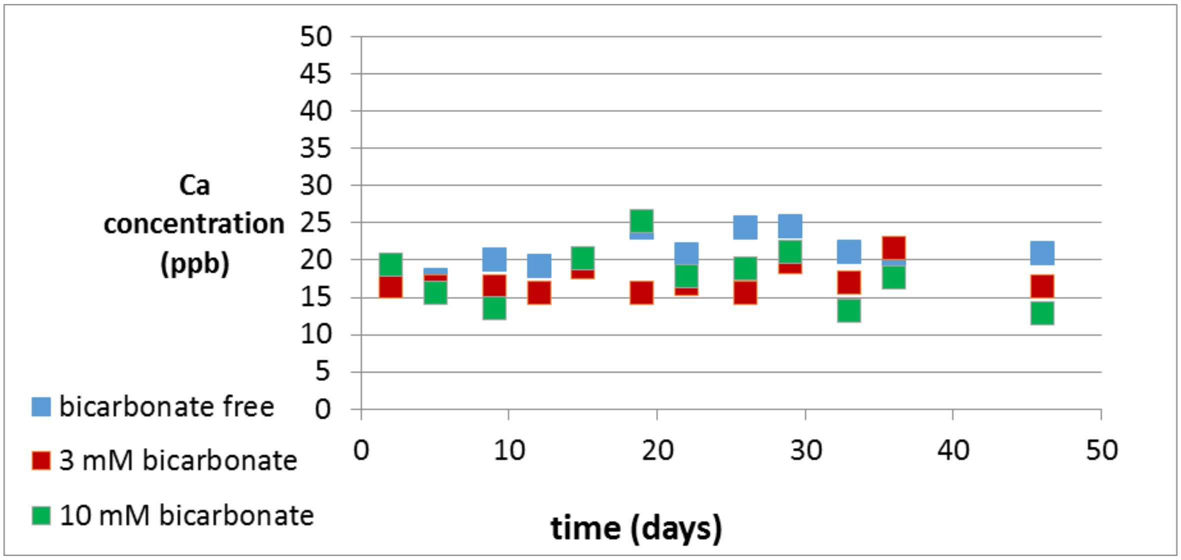


Figure 2-7. Concentration of Ca in the aqueous phase as a function of time for bicarbonate free, as well as samples amended with 3 and 10 mM bicarbonates.

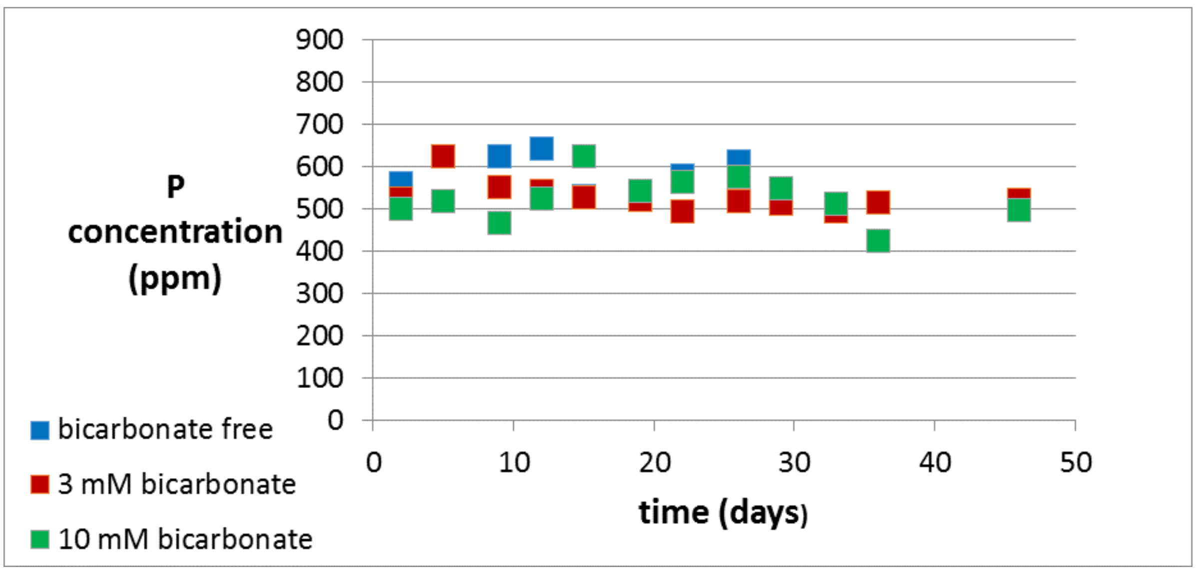


Figure 2-8. Concentration of P in the aqueous phase as a function of time for bicarbonate free, as well as samples amended with 3 and 10 mM bicarbonates.

For all samples, the levels of phosphorous in the aqueous phase remained stable and very close to the initial phosphorus concentration (500 ppm), denoting that phosphorous may have limited participation in the formation of secondary minerals. Furthermore, it seems that the bacterial population does not seem to be using significant amounts of phosphorus for its metabolic needs, despite the fact that phosphates have been cited in literature as a source of phosphorus for *Shewanella oneidensis* (Pinchuk et al., 2008; Pinchuk et al., 2010). The average concentrations of phosphorous in the aqueous phase were found to be 568±48ppm, 529±33ppm and 524±40ppm for bicarbonate-free samples and samples amended with 3 mM and 10 mM, respectively. On the other hand, calcium levels may be similar for all cases (21±2 ppm for bicarbonate-free samples and 18±2 ppm and 18±4 ppm for samples amended with 3 mM and 10 mM bicarbonate, respectively), but the concentration is close to half of the initial concentration introduced in the sample (40 ppm). This is an indication of calcium participating in secondary mineral formation and, consequently, removal from the aqueous phase.

Uranium analysis by means of a kinetic phosphorescence analyzer (KPA) is currently taking place, as well as protein analysis of the samples. The levels of oxygen in the glovebox throughout the experiment were recorded as 23 ppm.

Three samples of precipitate were prepared for scanning electron microscopy with energy-dispersive X-ray spectroscopy SEM/EDS analysis. The EDS function of the SEM/EDS system is currently not operational; the dehydrated samples were placed in the desiccators for future SED/EDS analysis.

References

Pinchuk, G.E., Ammons, C., Culley, D.E., Li, S.-M.W., McLean, J.S., Romine, M.F., Nealson, K.H., Fredrickson, J.K., Beliaev, A.S. 2008. Utilization of DNA as a Sole Source of Phosphorus, Carbon, and Energy by Shewanella spp.: Ecological and Physiological Implications for Dissimilatory Metal Reduction. *Applied and Environmental Microbiology*, **74**(4), 1198-1208.

Pinchuk, G.E., Geydebrekht, O.V., Hill, E.A., Reed, J.L., Konopka, A.E., Beliaev, A.S., Fredrickson, J.K. 2011. Pyruvate and Lactate Metabolism by Shewanella oneidensis MR-1 under Fermentation, Oxygen Limitation, and Fumarate Respiration Conditions. *Applied and Environmental Microbiology*, **77**(23), 8234-8240.

Subtask 1.3. Evaluation of Ammonia Fate and Biological Contributions During and After Ammonia Injection for Uranium Treatment

Subtask 1.3.1: Investigation of NH_3 partitioning in relevant Hanford minerals and synthetic porewater

During the month of July, a technical progress report that was submitted to DOE-EM entitled "Effects of Ammonia on Uranium Partitioning and Kaolinite Mineral Dissolution" and was reformatted for submission to the *Journal of Environmental Radioactivity* for potential publication. It is currently being revised for final publication based on reviewer comments. An oral presentation and Sci-Mix poster entitled, "Investigation of Ammonia Gas Treatment for the Immobilization of Uranium in the Presence of Pure Minerals," were presented at the American Chemical Society Fall Conference in Philadelphia, PA as a part of the Geochemistry of the Subsurface: CO_2 Sequestration, Unconventional Oil and Gas Extraction, Geothermal Reservoirs and Radioactive Waste Disposal track in August. In addition, a professional abstract was submitted and accepted for an oral presentation at Waste Management 2017 entitled, "Ammonia Gas Treatment for Uranium Immobilization at DOE Hanford's Site."

Furthermore, DOE Fellow, Silvina Di Pietro, traveled to Pacific Northwest National Laboratory (PNNL) for a ten week summer internship under the mentorship of Dr. Jim Szecsody. Although analysis of DOE Fellow Silvina Di Pietro's data from her summer internship is still in progress, she submitted an internship report on her work including preliminary data. Discussion of this data will not be included in this quarterly report, but interested parties are kindly referred to the internship report.

Batch equilibrium experiments are ongoing at FIU ARC investigating the effects of pH increase by either NaOH, NH_4OH or NH_3(gas) on uranium partitioning and mineral dissolution in the presence of calcite, muscovite and Hanford sediment in NaCl electrolyte. New results are presented below for calcite and muscovite in the presence of synthetic pore water and are compared with each of the minerals.

<u>Experimental Results:</u>

Saturated Equilibrium Batch Experiments

Triplicate samples were prepared with 5 g/L calcite or 25 g/L muscovite with 500 ppb U in synthetic pore water. Samples were adjusted and equilibrated at pH ~7.5 for ~3 days. Then, samples were treated with either 2.5 M NH_4OH or 2.5 M NaCl + 0.025 M NaOH. Figures 2-9 and 2-10 present the new data in terms of the K_d (in mL/g) and a surface area normalized K_d (in m^2/g).

For each of the minerals and the Hanford sediment, the U partitioning coefficient increases significantly with both base treatments. Further, the increase is apparent for partitioning coefficients normalized to mineral mass and mineral surface. In addition, the U removal from the aqueous phases appears to be slightly greater for the clays (kaolinite, illite and montmorillonite) and Hanford sediments for the NH_4OH treatment versus the NaOH treatment. It is possible that the differences in partitioning are due to differences in the exchange of NH_4^+ and Na^+ with the clay surface. Further, there are no apparent differences between the other minerals (muscovite, calcite, and quartz). Future work will include statistical analysis to confirm significant differences in base treatments.

Although the surface area normalization is based only on the initial BET surface area (i.e. the base treated samples were not checked again for surface area), there are important implications. First, the surface area normalization decreases the variability between the pure mineral results. For the mass normalized partitioning coefficients (Figure 2-9), the minerals span more than two orders of magnitude. However, the surface area normalized data (Figure 2-10), spans approximately one order of magnitude. Second, the sorption to the Hanford sediments is significantly decreased as compared to the pure minerals when normalized with surface area. This is likely due to the relatively small surface area of the sediments and the complex mixture of mineral coatings blocking sorption sites.

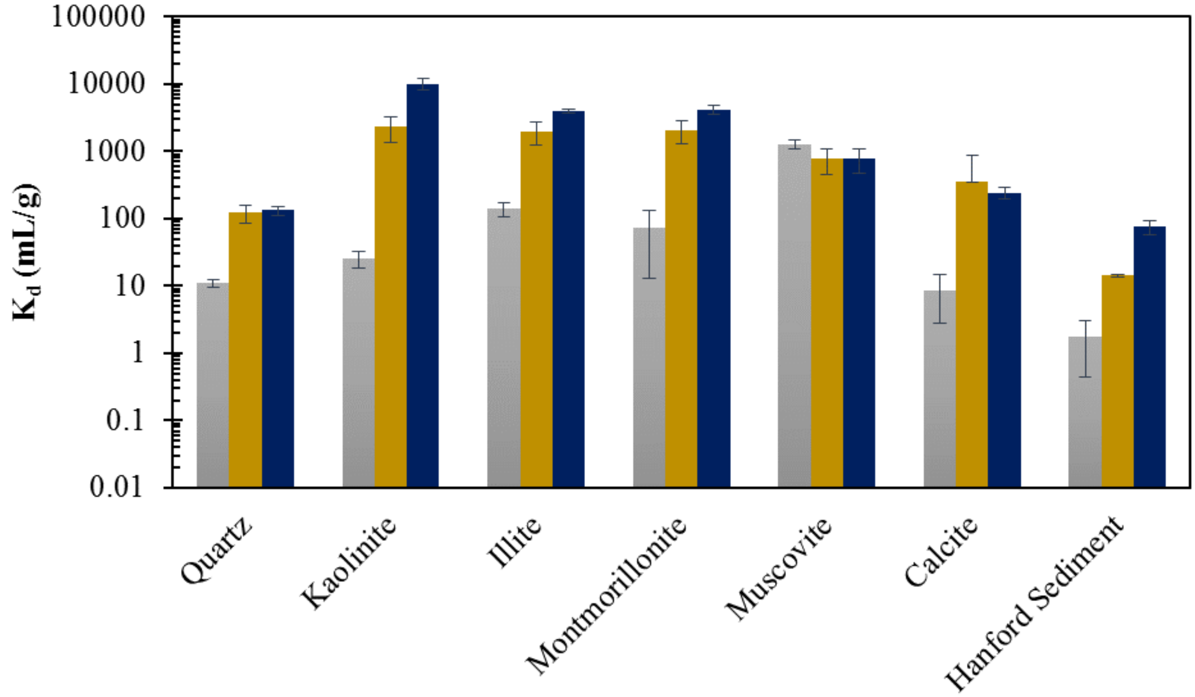


Figure 2-9. K_d (mL/g) for pure minerals and Hanford sediments for initial (gray), NaOH (yellow) and NH_4OH (blue) treated samples.

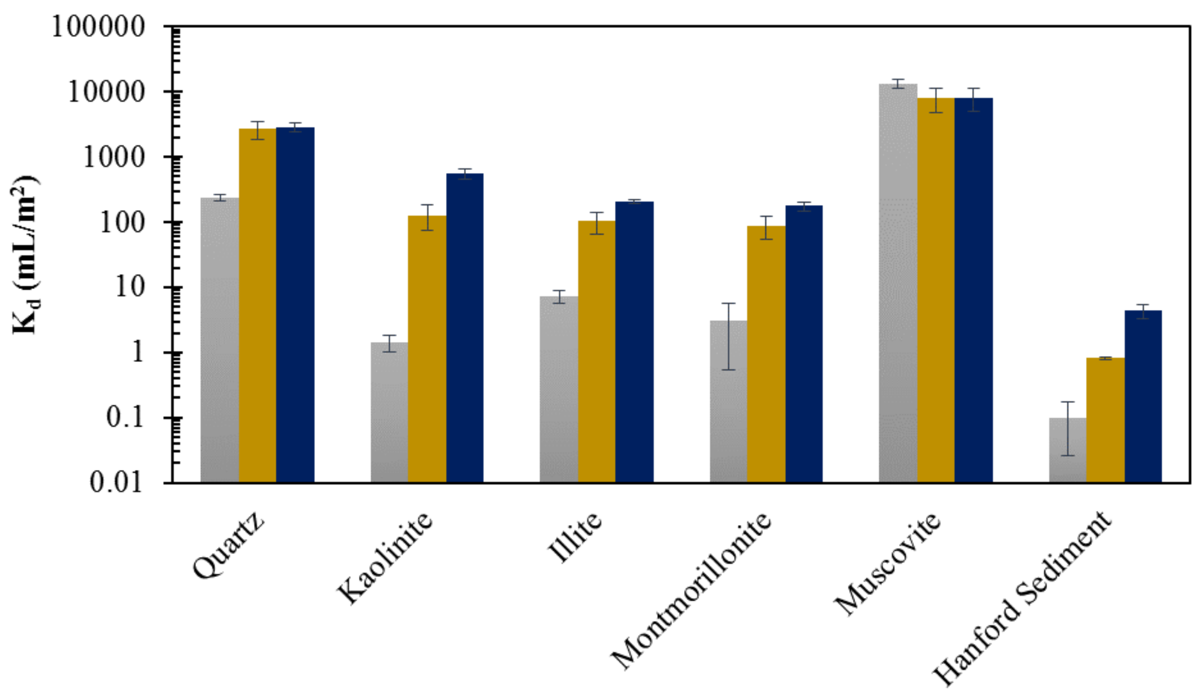


Figure 2-10. Surface area normalized K_d (mL/m^2) for pure minerals and Hanford sediments for initial (gray), NaOH (yellow) and NH_4OH (blue) treated samples.

Subtask 1.3.3: The influence of microbial activity on the corresponding electrical geophysical response after ammonia injections in the vadose zone

FIU initiated column experiments related to the spectral induced polarization (SIP) signatures of microbial activity designed to remediate uranium-contaminated vadose zone sediment. The columns have two current electrodes at either end and four potential electrodes running along the length. There are also three sampling ports positioned between each potential electrode pair. The current electrodes are made from a coiled Ag-AgCl wire. The potential electrodes use a straight wire encased in agar gel that makes contact with the sediment in the column. The tubing used for solution transport is hard Teflon as well as flexible silicone. Flow is powered by a peristaltic pump with a target flow rate of 50 mL/d for each column. There are four separate solutions, which have to be sparged with nitrogen in order to remove any dissolved gas which may form bubbles within the column. Each bottle of solution is connected to a bag full of nitrogen, which will prevent the solutions from equilibrating with carbon dioxide. Initially, only synthetic groundwater was used for the column saturation. Bacterial culture stock in glycerol have been shipped to FIU in dry ice and kept frozen to be used to inoculate the columns.

The experimental set up shown in Figure 2-11 allows for the collection of SIP measurements and enables correlation of the data with changes in the column pore water geochemical parameters. Initial SIP measurements have been taken and direct sampling of the pore water has been attempted. Difficulties during sampling have been encountered in the form of the port being plugged with sediment which prevents water from being collected. Currently, FIU is investigating ways to clear the ports for more consistent sampling. Geophysical measurements have also encountered difficulties due to air forming around the current and potential electrodes.

The four solutions currently used include the following:

- Column 1 has the base synthetic groundwater
- Column 2 has groundwater + 0.3 mM bicarbonate
- Columns 3 and 5 have synthetic groundwater + 1 g/L glucose, and
- Columns 4 and 6 have synthetic groundwater with 1 g/L glucose and 0.3 mM bicarbonate

Geophysical measurements have shown a decrease in the measured resistance in columns with 0.3 mM bicarbonate as bicarbonate ions diffuse throughout the column porewater.

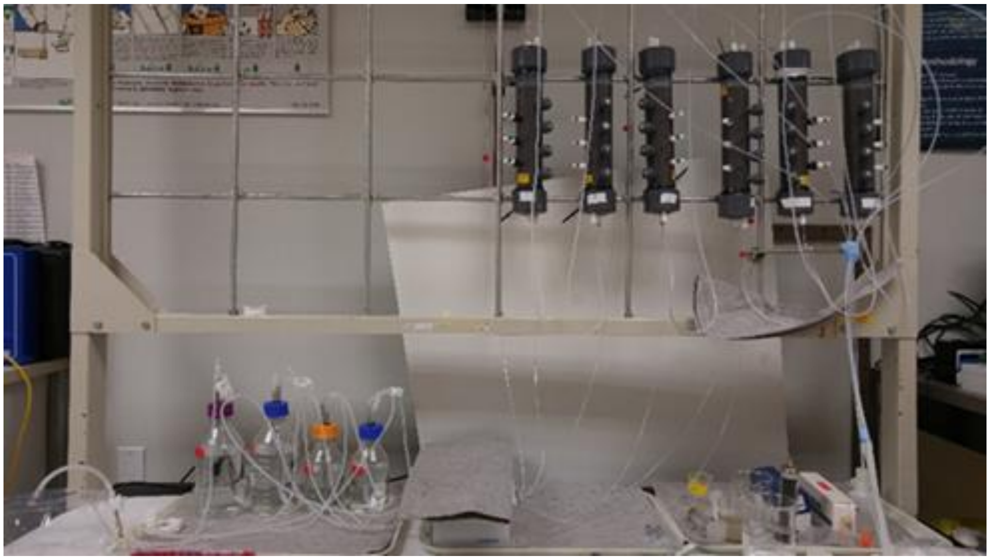


Figure 2-11. Experimental set up with six columns.

Difficulties during sampling have been encountered in the form of the port being plugged with sediment which prevents water from being collected. Currently, FIU is investigating ways to clear the ports for more consistent sampling.

Geophysical measurements have also encountered difficulties due to air forming around the current and potential electrodes. One strategy FIU has implemented is leaving syringes within the sample port (Figure 2-12). This has proven moderately effective in preventing sediment from plugging the ports. This strategy, however, has the downside of allowing air into the columns through gaps in between the port and needle; in order to counteract this, FIU has covered the connection between the needle and the port with Parafilm. A reduction in the amount of air entering the columns has increased the reliability of the geophysical measurements; however, some solitary bubbles can cause individual measurements of resistance to be artificially elevated.

Figure 2-12. Experimental columns with syringe and needles inserted in the sampling ports.

This task was included in the project technical plan for FIU Performance Year 7 and the research will continue focusing on laboratory-scale experiments to show the possibilities of using SIP for remote sensing of microbial effects at larger scales. The columns will be inoculated with microbes and monitored over time using geochemical, microbiological, and SIP analyses.

Task 2: Remediation Research and Technical Support for Savannah River Site

Task 2 Overview

The acidic nature of the historic waste solutions received by the F/H Area seepage basins caused the mobilization of metals and radionuclides, resulting in contaminated groundwater plumes. FIU is performing basic research for the identification of alternative alkaline solutions that can amend the pH and not exhibit significant limitations, including a base solution of dissolved silica and the application of humic substances. Another line of research is focusing on the evaluation of microcosms mimicking the enhanced anaerobic reductive precipitation (EARP) remediation method previously tested at SRS F/H Area.

Task 2 Quarterly Progress

Subtask 2.1. FIU's Support for Groundwater Remediation at SRS F/H –Area

FIU has concluded the experimental component of Task 2.1 and a publication draft is currently being prepared with the tentative title "Sodium silicate treatment to attenuate uranium mobility in acidic groundwater plumes". The draft will include the experimental results acquired over the past two years, as well as a literature review and interpretation of the results. Preliminary results of this task were presented by DOE Fellows, Ms. Christine Wipfli (Waste Management 2015 - Best Student Poster Presentation) and Mr. Alejandro Hernandez (Waste Management 2016 & Life Sciences South Florida STEM Undergraduate Research Symposium - Best Poster). More elaborate updates on this task will be presented as an oral presentation in the upcoming American Chemical Society Fall Meeting in Philadelphia, Division of Geochemistry, Session: Geochemistry of the Subsurface: CO_2 Sequestration, Unconventional Oil & Gas Extraction, Geothermal Reservoirs & Radioactive Waste Disposal. The paper being presented is entitled "Sodium silicate treatment to attenuate uranium mobility in the acidic groundwater plumes", authored by Vasileios Anagnostopoulos, Alejandro Hernandez, Christine Wipfli, Yelena Katsenovich and Miles Denham (Paper ID: 2512662). Dr. Vasileios Anagnostopoulos is also currently working on the completion of the PowerPoint presentation for the aforementioned conference.

FIU has concluded the experimental part of Task 2.1 and a publication draft is completed with a tentative title of "Sodium silicate treatment to attenuate uranium mobility in the acidic groundwater plumes." The manuscript will be placed under consideration for the special issue of *Journal of Chemical Technology and Biotechnology* after invitation by the Editors.

A new subtask 2.1 titled "*Investigation on the Properties of Acid-Contaminated Sediment and its Effect on Contaminant Mobility*" was included in the project technical plan for FIU Perfomrance Year 7 and preliminary preparations have commenced. Preparations included identifying the appropriate glassware and reagents to be used for the acidification of Savannah River Site soil in columns. Furthermore, literature related to the determination of ion exchange capacity in soils has been identified (Pansu and Gautheyrou 2006; Handbook of Soil Analysis, Sposito 2008; The Chemistry of Soils, van Reeuwijk 2002; Procedures for Soil Analysis). DOE Fellow Awmna Rana will be supporting this new task under the guidance of Dr. Vasileios Anagnostopoulos.

Subtask 2.2. Monitoring of U(VI) Bioreduction after ARCADIS Demonstration at F-Area

FIU submitted an abstract on the results for this task to the WM2017 conference titled, “Iron behavior in microcosms simulating bioreduction in Savannah River Site sediments,” coauthored by Yelena Katsenovich and Miles Denham (SRNL) and a former DOE Fellow Aref Shehadeh. This abstract was accepted as an oral presentation for WM-2017. FIU is developing a draft summary of the results for the application of this technology under SRS environmental conditions. Updated GWB simulations for minerals saturation indexes conducted for open and closed systems are presented in Figure 2-13.

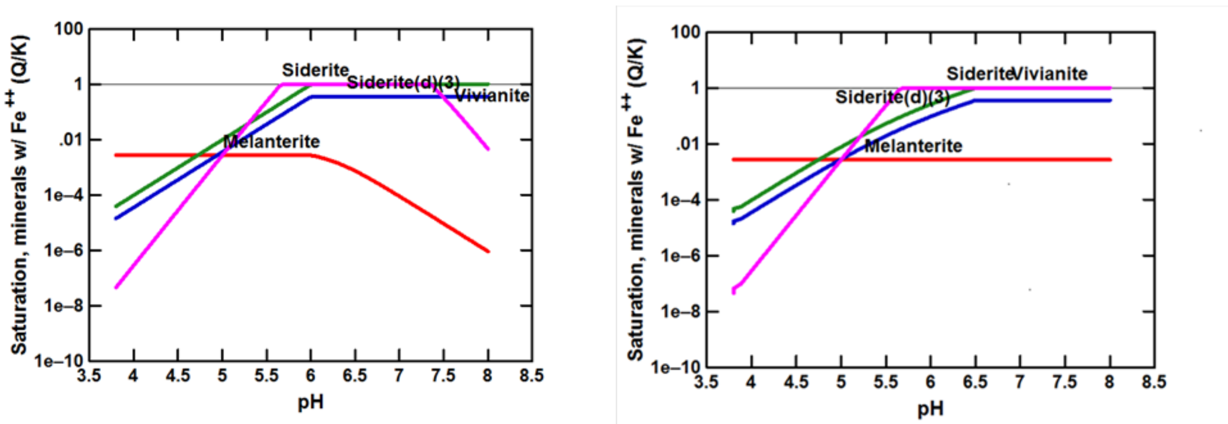


Figure 2-13. GWB simulations conducted for open (right) and closed systems (left).

Simulations were conducted in the mode “allowing precipitation“between pH 3 and 8. The charge balance for Cl-molality was adjusted from 0.00049 mmol/l to 239.6 mmol/l using the SpecE8 pane. In the closed system, siderite was shown as saturated at pH=6.53 and stayed constant until pH=8.0. In the open system, siderite was saturated at pH=6.110, earlier than in the closed system and stayed constant until pH=8.0. Saturation indexes (SI) of siderite were shown to increase at higher pH, displacing the vivianite from the system.

This task was completed in FIU Performance Year 6. In the month of September, FIU worked on the year-end report to summarize the experimental data on the applicability of this technology for the SRS environmental conditions.

Subtask 2.3: Sorption Properties of Humate Injected into the Subsurface System

FIU started sorption experiments to determine how much Huma-K is sorbed to SRS sediments at pH 4.5 and 6.5. For the sorption experiments, Huma-K concentrations in the range between 10-400 mg L^{-1} were pipetted to the centrifuge tubes, and DI water was added up to a total volume of 19 mL to leave 1 mL of volume for the pH adjustment. The pH was adjusted to 4.5 and 6.5 for all the samples by using either 0.1 M HCL or 0.1 M NaOH. DI water was added to end up with a final volume of 20 mL in each tube. All the samples were vortex mixed and placed on a shaker table at 100 RPM for three days. After the equilibration time, samples were centrifuged at 2700 RPM. The supernatant was analyzed using a Thermo Scientific Genesys 10S UV-Vis spectrophotometer at 254nm.

DOE Fellow, Hansell Gonzalez, continued his 10-week internship at Savannah River Site. The objective of the internship was to study the removal of metals with oxidation state (+1, +2, and

+3) such as silver (Ag^{+}), zinc (Zn^{2+}), and cerium (Ce^{3+}) using sediments that were previously coated with Huma-K. Experiments were initiated with a known concentration of Huma-K sorbed to the sediments at pH 4.5 and 6.5. Then, two desorption steps were performed. Silver (Ag^{+}), zinc (Zn^{2+}), and cerium (Ce^{3+}) were spiked into the centrifuge tubes after the second desorption and allowed to equilibrate for three days. Finally, all samples were centrifuged, and the supernatant was transferred into plastic bottles and sent for ICP-MS analysis. Also, it was studied the sorption of these metals onto SRS sediments without Huma-K coating in order to compare the removal of these metals with SRS sediments that were previously coated with Huma-K. The results are shown below in Figure 2-14.

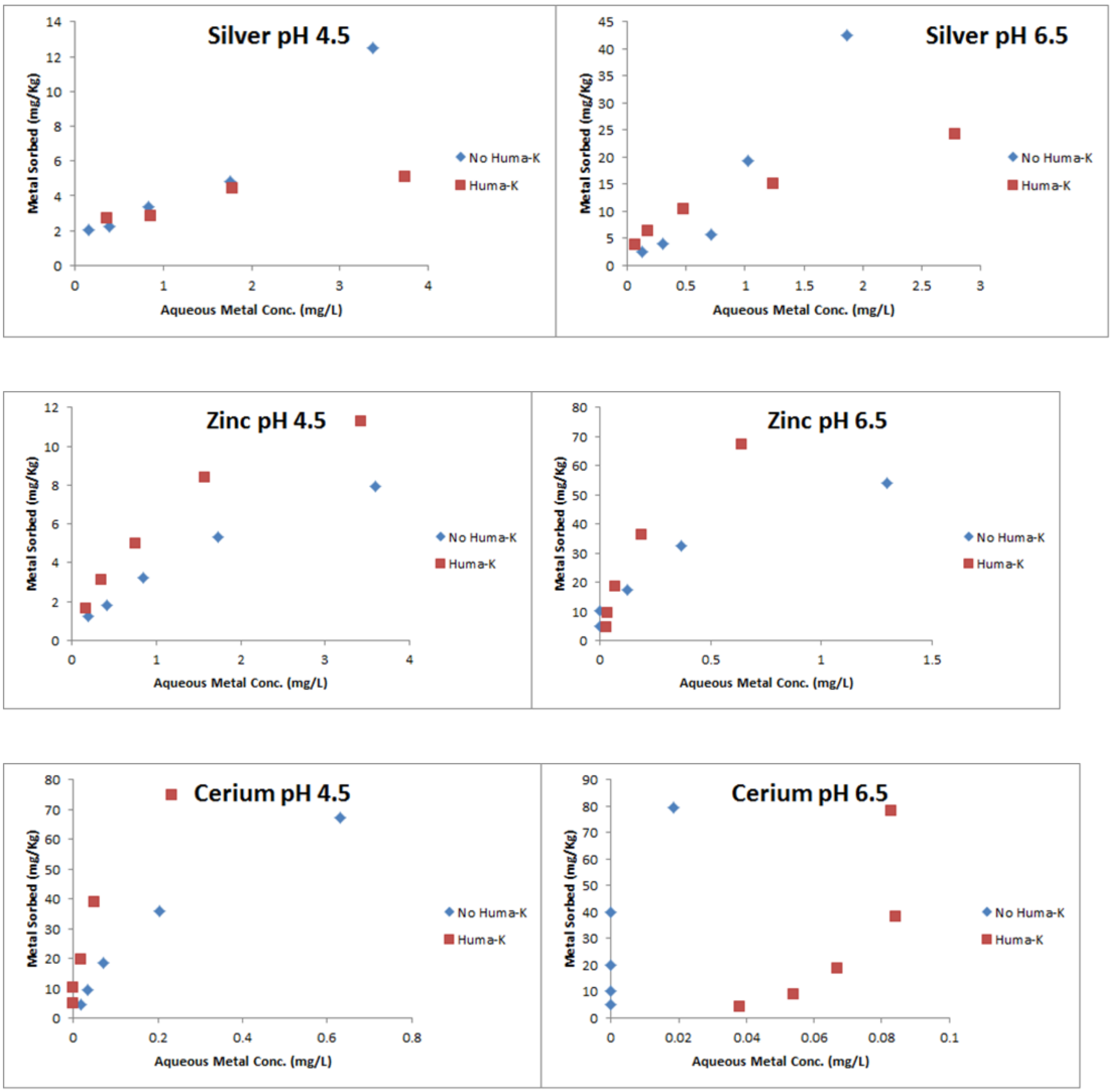


Figure 2-14. Metal sorption with and without Huma-K.

The results show that there was no increase in the removal of silver at both pH values 4.5 and 6.5 when SRS sediments coated with Huma-K were used. However, zinc removal was higher at both pH values when SRS sediments were coated with Huma-K. The removal of cerium was increased at pH 4.5 when SRS sediments were coated with Huma-K, but at pH 6.5, the removal of cerium by SRS coated sediments was slightly less compared to SRS sediments with no Huma-K coating.

In addition, the draft of the manuscript was completed and will be reviewed internally before submission to the journal. Also, a poster for the DOE Fellows Poster Exhibition taking place on November 2nd was prepared and the summer internship technical report was completed. The title of the poster is "Study of an Unrefined Humate Solution as a Possible Remediation Method for Groundwater Contamination." This poster contains a summary of the history of groundwater contamination at Savannah River Site, project objectives, experimental approach, and results obtained during the summer internship.

The research focus for this task during FIU Performance Year 7 will be on batch experiments to evaluate the removal of uranium by SRS sediments coated with Huma-K. The experimentation will start with the kinetics of adsorption of uranium onto SRS sediments with and without Huma-K coating at two different pH values (4 and 7). The study will also investigate the effect of various parameters such as pH, contact time, and concentration of uranium on the process. To accomplish this research, FIU initiated preparation of a Huma-K stock solution and several standards solutions of Huma-K to continue with sorption experiments focusing on uranium removal.

Subtask 2.4. The Synergistic Effect of HA and Si on the Removal of U(VI)

During the reporting period, FIU continued the synergy experiments with sets of triplicate batch samples with pH 7 and 8, prepared with 30 ppm of humic acid (HA), 3.5 mM of silica (Si), 400 mg of sediment and 0.5 ppm uranium. Uranium was added prior to the pH adjustment and care was taken when adding deionized water to allow for addition of acid/base so the final volume was approximately 20 ml. The pH of the samples was adjusted with a stock solution of 0.01M HCl and 0.1M NaOH to desired pH, measured and readjusted daily if there was as a change in pH, and placed on a platform shaker at the end of each daily pH adjustment. Tables 2-4 through 2-7 display the total volume of constituents, acid and base and final pH values at the end of each day for the samples. The samples will be centrifuged at 2700 rpm for 30 minutes to allow the separation of the solids from the solution and diluted with and without filtration for final analysis.

Table 2-4. Sample Matrix for pH 7 Batch Samples

pH 7 Adjusted Set		Constituents							
		SiO2	Humic Acid (HA)	Sediments	Uranium, U (VI)	Volume of acid/ base	DIW, H2O	pH	
		ml	ml	mg	ml	ml	ml	Initial	Final
Batch No. 2	2.1	2.1	6	0	0.01	0.34	11.25	5.27	7.02
	2.2					0.045	11.25	5.19	7.00
	2.3					0.05	11.25	5.15	7.01
Batch No. 3	3.1	0	6	0	0.01	0.085	13.25	5.04	7.00
	3.2					0.085	13.25	4.95	7.03
	3.3					0.045	13.25	4.60	7.01
Batch No. 5	5.1	2.1	6	400	0.01	0.055	11.25	5.77	7.01
	5.2					0.125	11.25	4.98	7.01
	5.3					0.065	11.25	5.56	6.99
Batch No. 6	6.1	0	6	400	0.01	0.07	13.25	4.55	6.98
	6.2					0.145	13.25	5.01	7.02
	6.3					0.06	13.25	5.15	7.03

Table 2-5. Daily pH Adjustments of Samples

Sample #		pH						
		Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Batch No. 2	2.1	6.95	7.04	7.01	7.04	7.02	7.02	7.02
	2.2	7.01	6.99	7.03	7.00	6.98	6.99	7.00
	2.3	7.00	6.99	7.05	7.01	7.00	6.97	7.01
Batch No. 3	3.1	7.05	7.00	6.97	6.96	6.98	7.01	7.00
	3.2	7.03	7.02	6.99	6.97	6.98	6.99	7.03
	3.3	6.99	7.00	7.00	6.99	6.96	6.95	7.01
Batch No. 5	5.1	7.05	6.99	7.01	6.99	6.98	6.98	7.01
	5.2	7.05	6.98	7.00	6.98	7.02	7.00	7.01
	5.3	7.04	6.98	7.03	7.01	6.99	7.00	6.99
Batch No. 6	6.1	7.03	6.96	6.96	6.99	7.01	7.03	6.98
	6.2	7.02	7.01	7.01	7.00	6.99	6.98	7.02
	6.3	7.04	6.98	7.02	6.97	6.98	6.97	7.03

Table 2-6. Sample Matrix for pH 8 Batch Samples

pH 8 Adjusted Set		Constituents							
		SiO2	Humic Acid (HA)	Sediments	Uranium, U (VI)	Volume of acid/ base	DIW, H2O	pH	
		ml	ml	mg	ml	ml	ml	Initial	Final
Batch No. 2	2.1	2.1	6	0	0.01	0.1505	11.25	6.69	8.05
	2.2					0.372	11.25	5.37	7.99
	2.3					0.13	11.25	6.37	8.05
Batch No. 3	3.1	0	6	0	0.01	0.13	13.25	6.1	8.01
	3.2					0.15	13.25	5.54	8.03
	3.3					0.1352	13.25	5.72	8.01
Batch No. 5	5.1	2.1	6	400	0.01	0.247	11.25	5.29	8.03
	5.2					0.175	11.25	5.22	8.03
	5.3					0.156	11.25	5.34	8.01
Batch No. 6	6.1	0	6	400	0.01	0.086	13.25	5.37	8.02
	6.2					0.072	13.25	5.36	8.02
	6.3					0.075	13.25	5.42	8.03

Table 2-7. Daily pH Adjustments of pH 8 Samples

Sample #		pH						
		Day 1	**Day 2**	**Day 3**	**Day 4**	**Day 5**	**Day 6**	**Day 7**
Batch No. 2	2.1	8.060	7.990	8.040	7.970	7.950	8.000	8.050
	2.2	7.990	8.020	7.980	8.040	7.980	8.000	7.990
	2.3	8.050	8.040	8.020	8.020	8.040	8.020	8.050
Batch No. 3	3.1	8.000	8.020	7.970	8.050	8.050	7.980	8.010
	3.2	7.970	7.970	7.960	8.000	8.010	8.010	8.030
	3.3	8.030	7.970	8.040	7.980	8.030	8.050	8.010
Batch No. 5	5.1	8.020	7.980	8.020	8.020	8.040	8.020	8.030
	5.2	8.000	8.000	8.020	8.030	8.050	8.050	8.030
	5.3	7.960	8.010	7.970	8.040	7.960	8.010	8.010
Batch No. 6	6.1	8.040	7.980	8.050	8.060	8.030	8.040	8.020
	6.2	7.970	7.960	7.970	8.000	8.010	8.010	8.020
	6.3	8.030	7.980	7.960	8.010	8.040	8.010	8.030

FIU completed analyzing unfiltered and filtered samples for batches 2, 3, 5 and 6 for pHs between 5 and 8 via KPA to measure uranium concentrations in the sample supernatant solutions. Data from pH 3 to 8 for unfiltered and filtered samples are presented in Figure 2-15 and Figure 2-16 respectively. Similar to previous results, uranium removal decreased with an increase in pH with maximum removal observed at pH 4 for both filtered and unfiltered samples. Addition of sediment was shown to increase the uranium removal efficiency. Filtration of samples appeared to increase the removal of uranium. This can be attributed to the removal of uranium that is bound to colloidal silica particles removed by filtration.

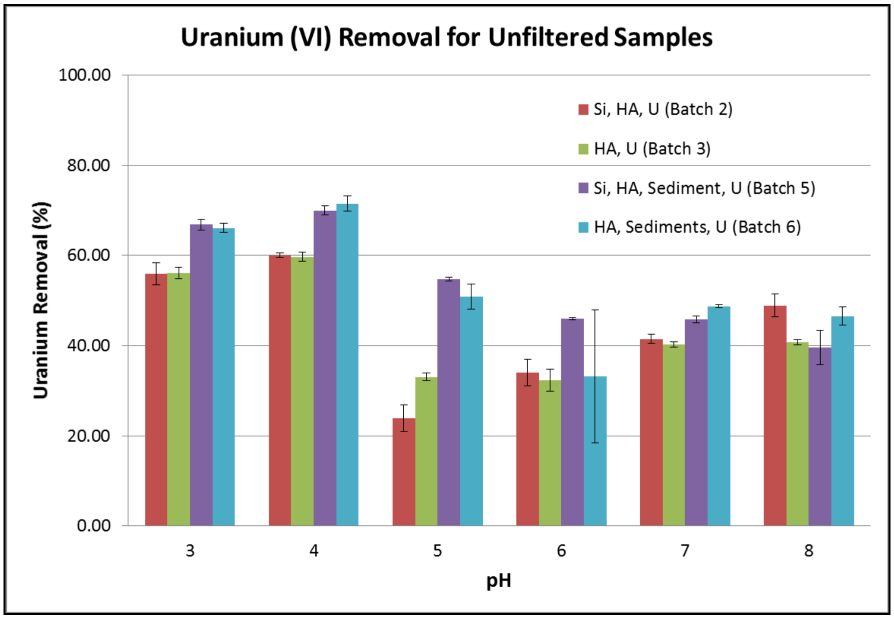


Figure 2-15. Uranium removal for unfiltered samples.

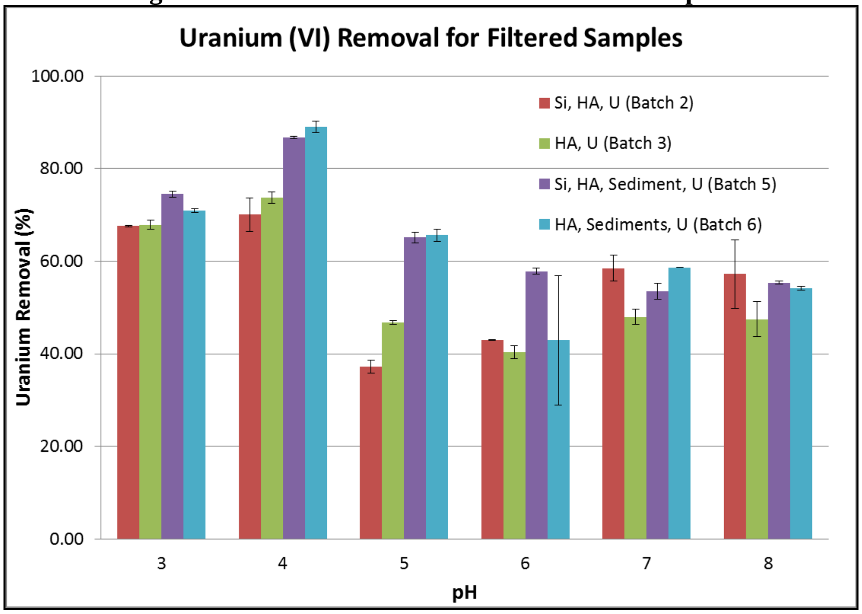


Figure 2-16. Uranium removal for filtered samples.

In previous experiments, FIU has studied the influence of varying humic acid (HA) concentrations on uranium removal at constant U(VI) concentration. However, it is important to study the effect of varying uranium concentrations in the presence of HA and colloidal silica at variable pH. In FIU Performance Year 7, FIU will explore the effect of synergetic interactions between HA and colloidal silica on uranium removal by varying uranium concentrations in the solution. Batch synthetic groundwater samples will be prepared to mimic the contaminated groundwater at SRS, with pH adjusted in the range from 3 to 8. The following binary, ternary and quaternary systems will be evaluated at each pH condition in the presence of HA at different uranium concentrations ranging between 10 - 50 ppm for the removal of U(VI) from the aqueous solutions:

- U(VI) + HA (30 ppm)
- Si (3.5 mM) + U(VI) + HA (30 ppm)
- Sediments + U(VI) + HA (30 ppm)
- Sediments + Si (3.5 mM) + U(VI) + HA (30 ppm)

Subtask 2.5. Investigation of the Migration and Distribution of Natural Organic Matter Injected into Subsurface Systems

The work completed for this task will assemble, integrate, and develop a practical and implementable approach to quantify and simulate potential natural organic matter (NOM, such as humic and fulvic acids, humate, etc.) deployment scenarios over the range of conditions at DOE sites. Initial laboratory experiments and an initial set of simplified models have been developed at SRNL. Under this task, additional batch and column studies and testing will be conducted at FIU to provide the transport parameters for an extension of the current model scenarios. The following was accomplished during the month of July:

- Completed column experiment with pH 3.5 AGW column. Column was filled with oven-dried SRS soil and a bromide tracer test was performed.
- Tracer test data indicated that the column has a pore volume of approximately 88 ml and has high dispersion.
- Following the tracer test, humate sorption and desorption was studied by injecting 1 PV 10,000 ppm of Huma-K followed by AGW at pH 3.5 until the Huma-K concentration in the effluent reached 200 ppm.
- Approximately 23% of Huma-K was retained in the column compared to 21% of retention observed in the experiment with 5,000 ppm Huma-K performed in previous studies. Overall, 740 mg/kg of Huma-K was retained in the current column compared to 460 mg/kg observed previously. By increasing the Huma-K concentration from 5,000 to 10,000 ppm, approximately 60% increase in the retention was observed.
- After the sorption/desorption of Huma-K, 2 PV 100 ppb of uranium (approximately 16.4 μg of uranium) solution at pH 3.5 was injected followed by 2 PV of 3.5, 4.5 and 5.5 pH-adjusted AGW solution.
- As the freshly added solution was interacting with the sorbed Huma-K, more release of Huma-K from the column was observed during uranium injection, and the overall retention of Huma-K decreased from 740 mg/kg to 670 mg/kg.
- Samples collected after the uranium injections were processed to measure the uranium concentration in the effluent samples in order to estimate the uranium recovery.

Approximately 3 μg of uranium was recovered. Overall, 52 μg of uranium was sorbed per kg of soil.

- Discussed the results presented in the progress report with Miles and made plans to run a control column to study the sorption of uranium on the SRS sediment without Huma-K for comparison.
- The experimental column was drained and dried, 0.5 pv of AGW solution at pH 3.5 was injected into to the column to see if there will be any further desorption of uranium as well as Huma-K from the sediment to simulate the effect of water table fluctuations on the sorption process.

Task 3: Surface Water Modeling of Tims Branch

Task 3 Overview

This task will perform modeling of surface water, and solute/sediment transport specifically for mercury and tin in Tims Branch at the Savannah River Site (SRS). This site has been impacted by 60 years of anthropogenic events associated with discharges from process and laboratory facilities. Tims Branch provides a unique opportunity to study complex systems science in a full-scale ecosystem that has experienced controlled step changes in boundary conditions. The task effort includes developing and testing a full ecosystem model for a relatively well defined system in which all of the local mercury inputs were effectively eliminated via two remediation actions (2000 and 2007). Further, discharge of inorganic tin (as small micro-particles and nanoparticles) was initiated in 2007 as a step function with high quality records on the quantity and timing of the release. The principal objectives are to apply geographical information systems and stream/ecosystem modeling tools to the Tims Branch system to examine the response of the system to historical discharges and environmental management remediation actions.

Task 3 Quarterly Progress

Subtask 3.1. Modeling of Surface Water and Sediment Transport in the Tims Branch Ecosystem

This quarter, FIU completed milestone 2015-P2-M5, which involved completing the input of the MIKE SHE model configuration parameters for the simulation of flow in Saturated Zone (SZ) in Tims Branch watershed. The SZ module was developed in two ways: one as a simplified configuration of a two-layer aquifer (shallow aquifer and aquifer), and another using an actual geologic layer configuration within the SRS A/M Area. The two-layer model was developed to help determining if a simplified groundwater flow representation would be adequate to capture the watershed hydrologic response. For each layer, hydrogeological parameters, such as hydraulic conductivities, specific yield, and specific storage, were determined through extensive literature review, and were used as initial model values. Two computation layers were also set up: Shallow Aquifer and Aquifer. Details of the model set up and associated parameters can be found in the related milestone document.

A GIS shapefile of groundwater head contour lines (2003) was prepared and used as the initial potential head for each computational layer in SZ module setup. This file was internally interpolated in MIKE SHE to generate a model-specific DFS2 grid file which was then used to replace the original groundwater contour shapefile used in the SZ module. Figure 2-17 shows the 2003 groundwater head elevation that was used as the initial condition in the SZ flow module.

Two preliminary simulations were set to estimate surface flow depth with and without the SZ module included. Both simulations were performed for the period of January 1, 2014 through September 29, 2014. Figures 2-18 and 2-19 illustrate the simulated depth of water for two different rainfall events on February 14, 2014 and June 1, 2014. The daily rainfall was 50 mm and 70 mm, respectively. Although the model is still under development and no calibration has been made, visual comparison shows the higher depth of water on June 1, 2014, when the area received 70 mm of rain, and the lower depth of water on February 14, 2014, with 50 mm of reported rainfall.

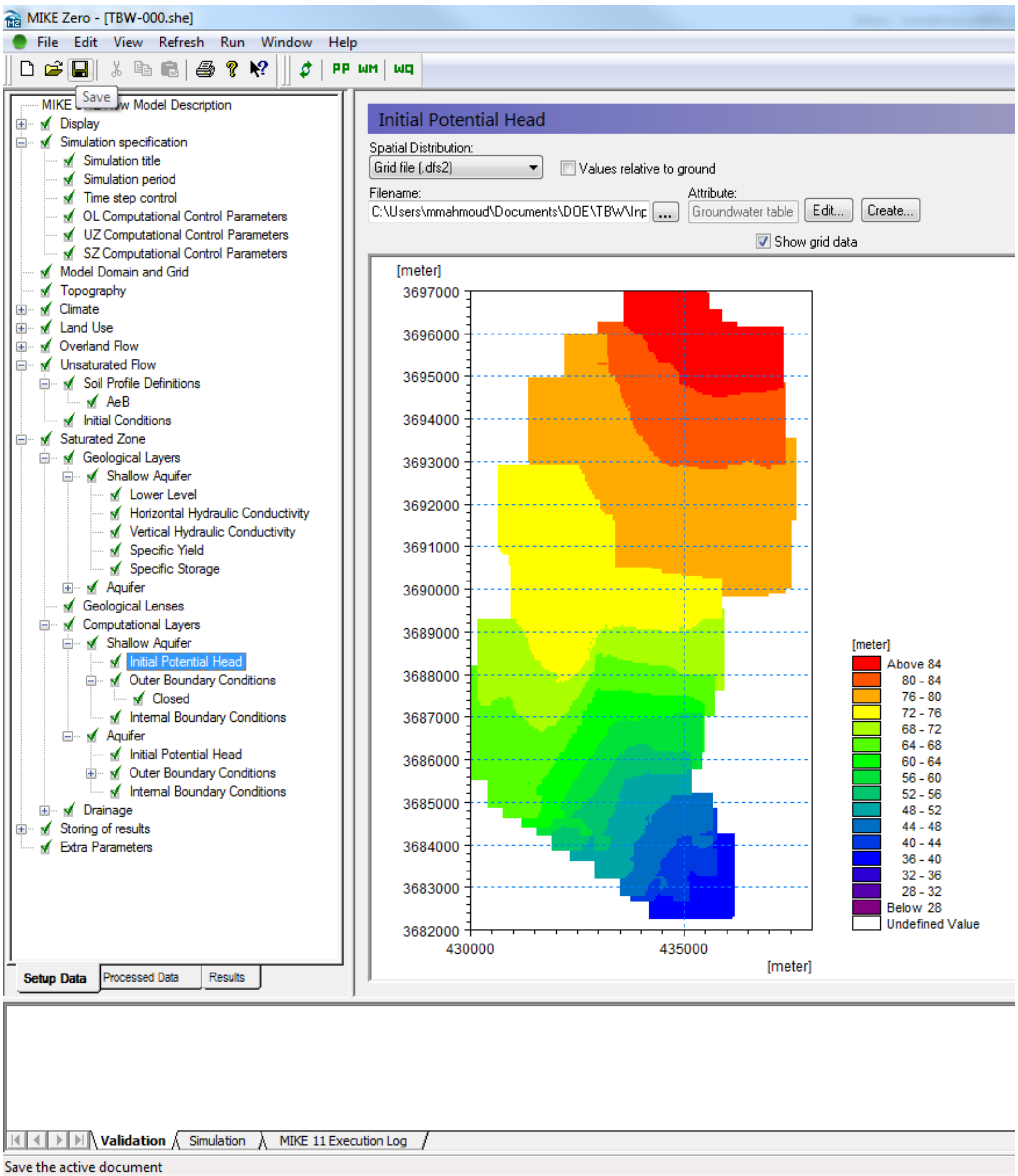


Figure 2-17. DFS file of groundwater head that was used as the initial condition in computation layers within MIKE SHE model.

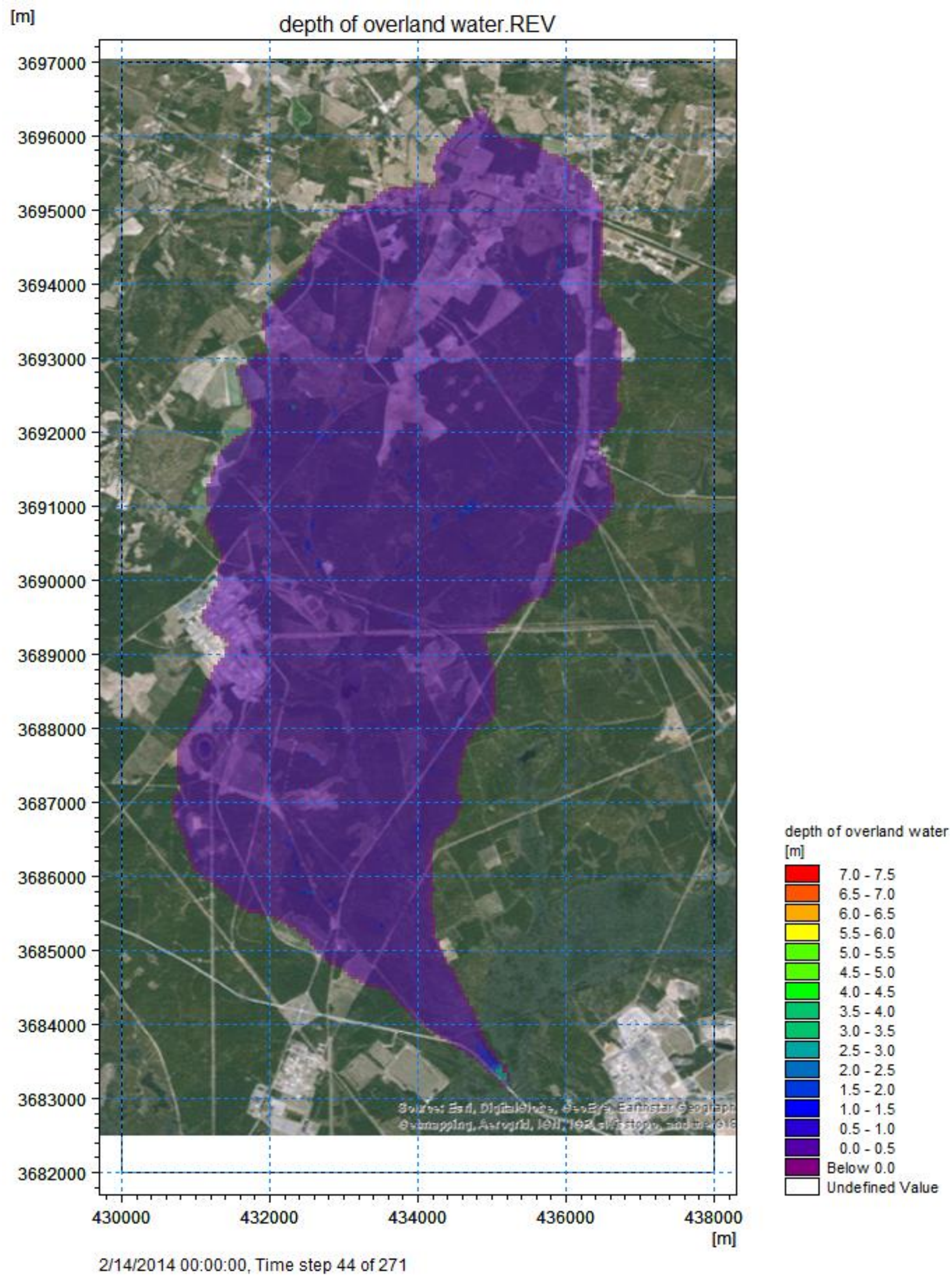


Figure 2-18. Simulation of Depth of Water for 2/14/14 rainfall.

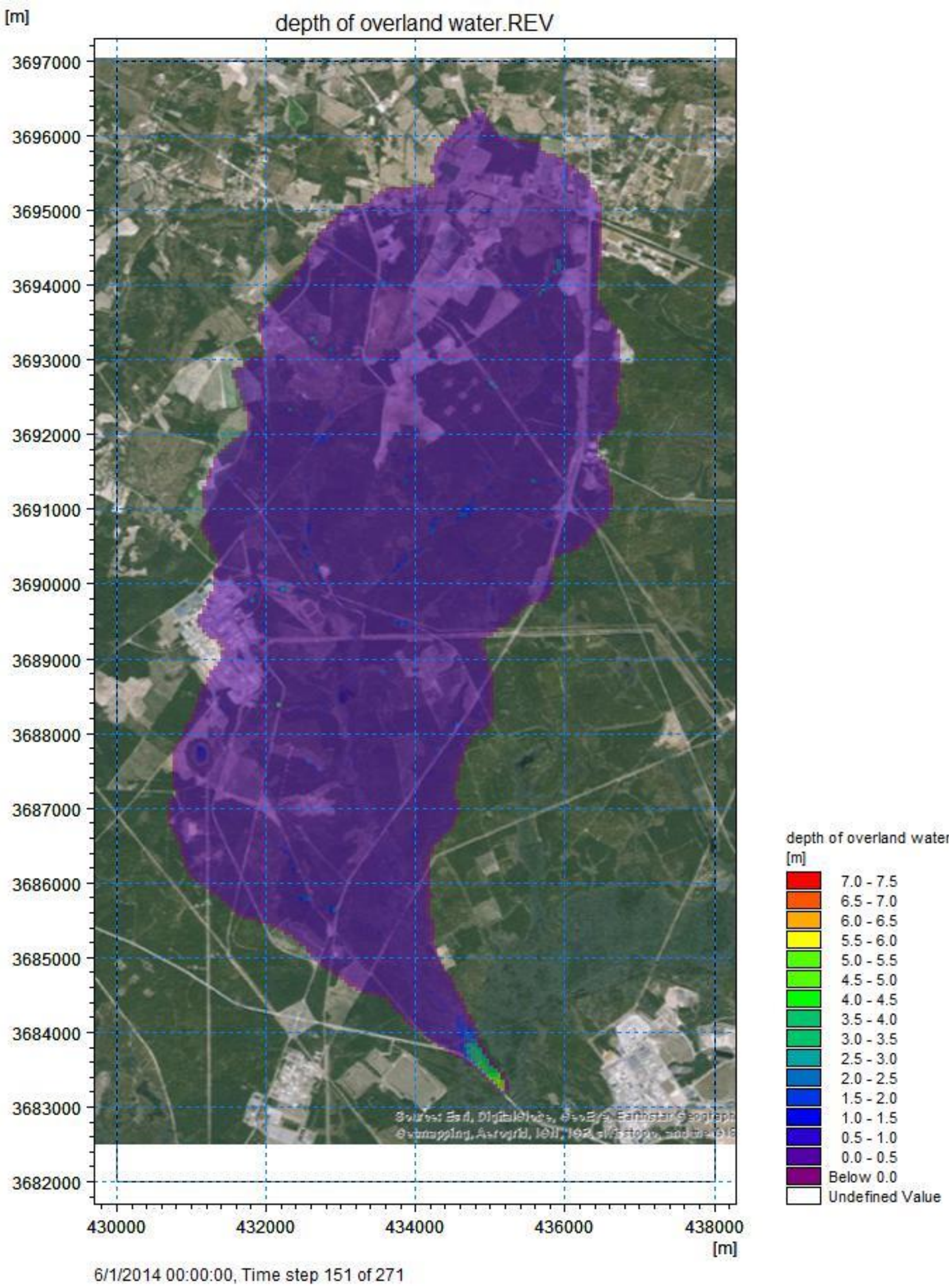


Figure 2-19. Simulation of Depth of Water for 6/1/14 rainfall.

The technical progress report for this task that was submitted on June 30, 2016 is being updated with work completed in the last quarter, which includes completion of the saturated zone module of the MIKE SHE model. This task is in progress and is still in the preliminary stages of development. As such, no specific conclusions can be made at this point. In the coming months, the model grid element size will be refined with a smaller grid size in order to capture more detail of the surface topography and manmade structures such as roads or dams. Optimum grid element size will be established by performing simulations with various element sizes while observing the model runtime.

An alternative hydrological unstructured mesh high resolution flow and transport model using SMS/RiverFlow2D was implemented in Tims Branch Watershed (Figure 2-20). Having a high resolution model will allow comparison of results with the MIKE SHE model and provide higher reliability of the simulation results. In addition, the SMS/RiverFlow2D model will allow FIU researchers and students to develop new model capabilities to better represent some of the pollutant transport characteristics of SRS.

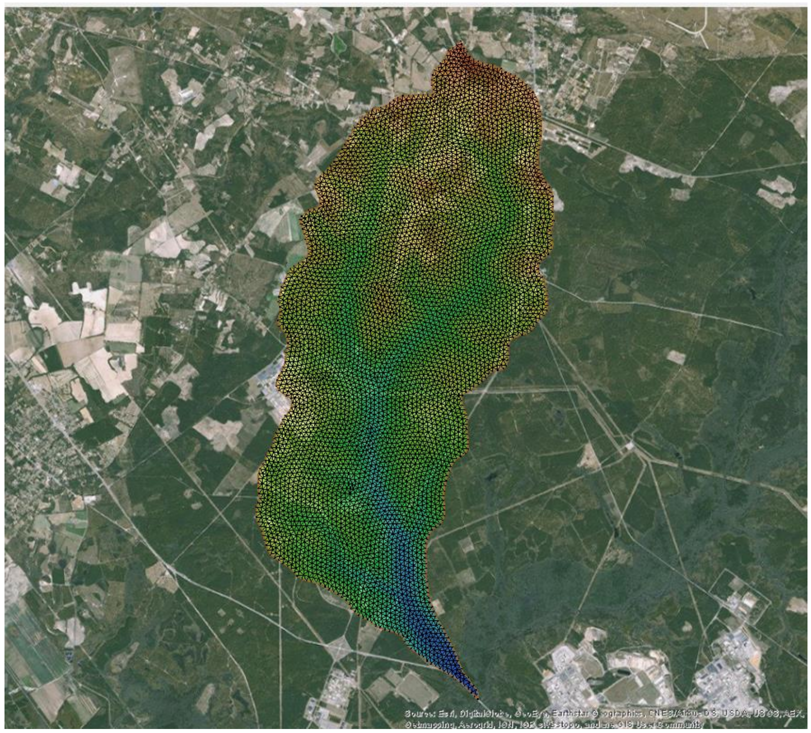


Figure 2-20. Unstructured mesh developed on Tims Branch Watershed as part of the implementation of the alternative hydrologic flow and transport model.

Subtask 3.2. Application of GIS Technologies for Hydrological Modeling Support

FIU ARC continued to work on creating spatially distributed evapotranspiration timeseries grids to refine the evapotranspiration module of the MIKE SHE model. Several monitoring stations located within SRS were mapped from an MS Excel spreadsheet containing their location coordinates using ArcGIS. Each of the monitoring stations also had associated time series rainfall data for the period 1961-2016. The point shapefile generated was added to MIKE SHE and used to run simulations for various time periods during which there were records or periods of heavy rainfall.

In September, the development of a 1-D stream flow model using MIKE 11 was initiated. A combination of ArcGIS and MIKE 11 geoprocessing tools is being used for development of the stream network and cross-sections. This model is being developed to simulate stream flow along the A-014 Outfall tributary. In addition, the ArcHydro model was used to delineate a GIS shapefile of the A-014 Outfall tributary sub-basin for input into both the MIKE SHE and MIKE 11 models. The *in situ* field data collected at SRS in August 2016 was also used to create georeferenced GIS shapefiles of the sample locations which will enable the visualization of the spatial distribution of measured water quality and environmental parameters in Tims Branch and the A-014 Outfall tributary.

Subtask 3.3. Biota, Biofilm, Water and Sediment Sampling in Tims Branch

The month of July was spent developing field and laboratory standard operating procedures and training on the use of various field measurement devices in preparation for a visit to Savannah River Site by FIU ARC researchers and students (DOE Fellows) during the first week of August 2016. The trip involved measuring stream cross-sections, flow velocity, suspended sediment concentration, and water quality parameters. This effort was supported by SREL researchers who assisted in acquiring the necessary security clearances for FIU staff and students to gain on-site access, and who provided field and laboratory equipment and escort by authorized SREL personnel to the sample locations. The main focus of this data collection was to profile cross-sections, measure flow velocity at each cross-section, and collect water samples along A-014, A-011 and Tims Branch. The water samples were processed by FIU DOE fellows and analyzed by Dr. John Seaman at SREL, with the support of his students from the University of Georgia. Results of the chemical analyses were forwarded to FIU in September and provided the concentrations of several chemical and radiological elements (e.g., Mg, Al, Ca, Mn, Fe, Ni, Cu, Zn, Sn, As, Se, Pb, U) which FIU intends to incorporate into the model under development. Analysis results may also be used for conducting further geospatial analyses.

This exercise provided FIU undergraduate and graduate STEM students with an opportunity to receive technical training on various field and laboratory procedures for collecting water samples, measuring flow velocity, quantifying water quality parameters (pH, turbidity, temperature, etc.), and generating multiple stream cross section profiles. The data derived from their fieldwork will be implemented into the hydrology/hydraulic model as initial and boundary conditions. A presentation was delivered on SRS fieldwork during an ARC Brown Bag lunch.

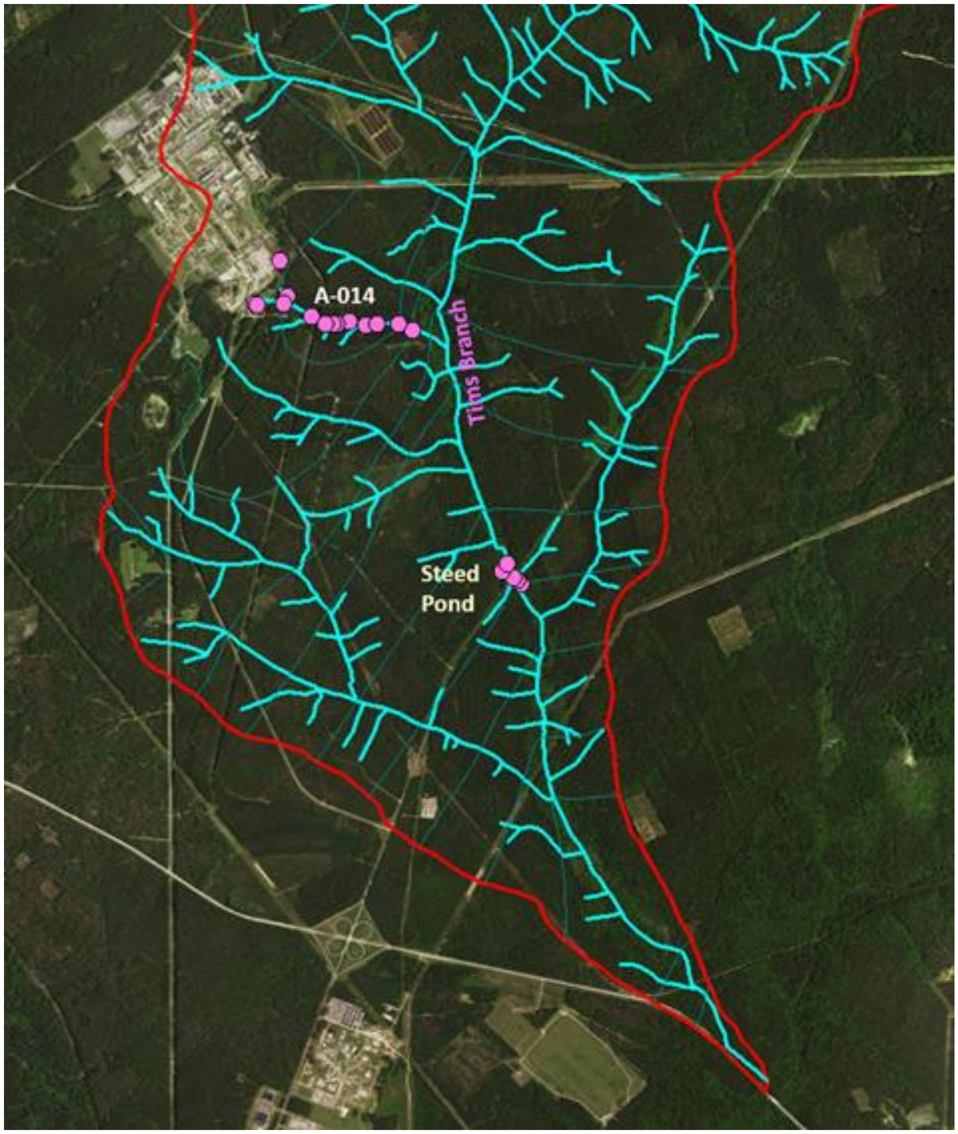


Figure 2-21. Location of sampling points along A-014 and in Steed Pond downstream of Tims Branch, SRS, SC. The pink dots indicate locations where the cross section was measured and water samples were collected.

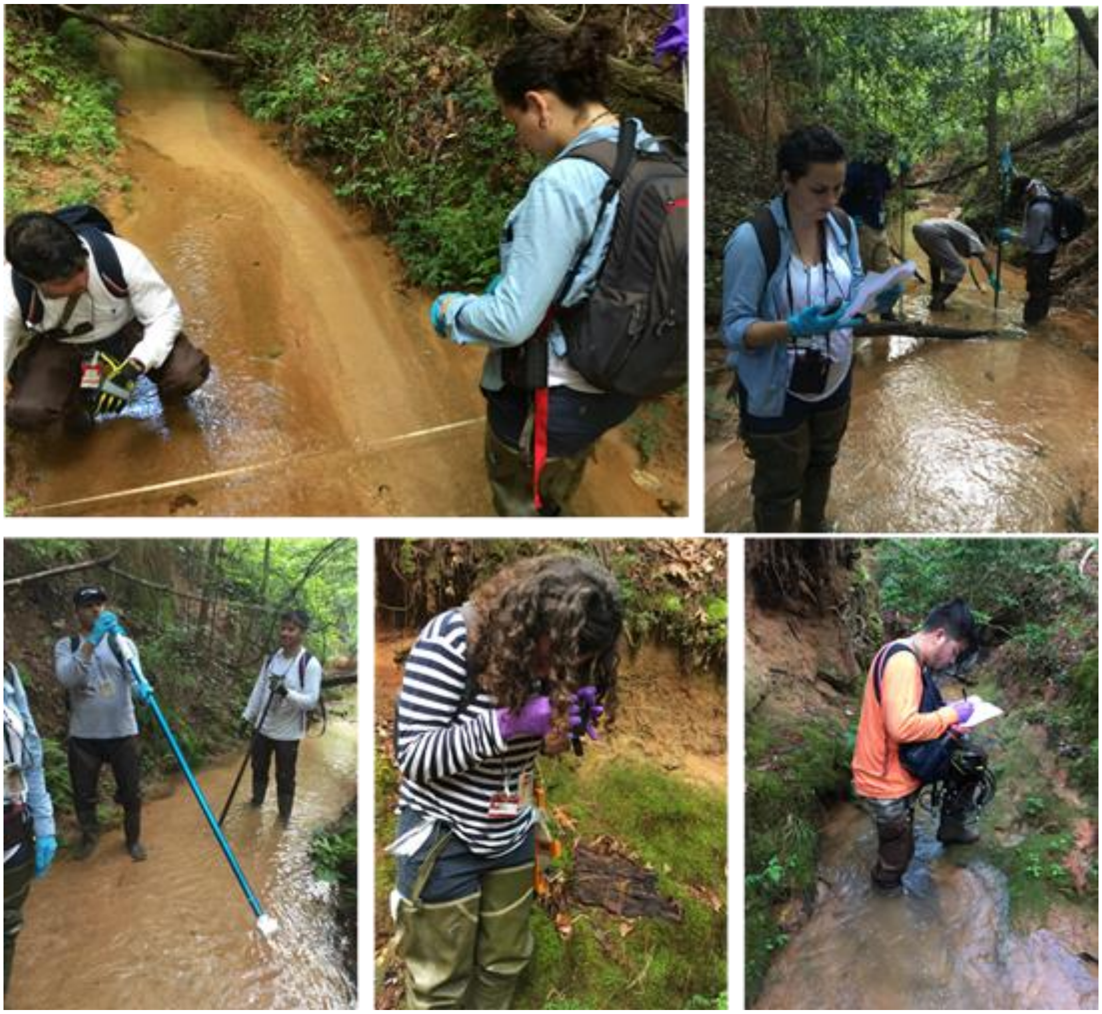


Figure 2-22. DOE Fellow students recording field measurements along A-014, SRS, SC.

Figure 2-23. From left to right: Water samples being vacuum filtered, then weighed, and finally prepared for drying in the oven at Savannah River Ecology Lab (SREL), SRS, SC.

Task 4: Sustainability Plan for the A/M Area Groundwater Remediation System

Task 4 Overview

The research and analysis performed under this task was being performed to support DOE EM-13 (Office of D&D and Facilities Engineering) under the direction of Mr. Albes Gaona, program lead for DOE's Sustainable Remediation Program. This task and associated research was completed and a technical report was submitted to SRNL and DOE on December 18, 2015. This task will not continue into FIU Performance Year 7.

Task 5: Remediation Research and Technical Support for WIPP

Task 5 Overview

This new task is in collaboration with research scientists Donald Reed and Timothy Dittrich in support of Los Alamos National Laboratory's field office in Carlsbad, New Mexico. This research center has been tasked with conducting experiments in the laboratory to better understand the science behind deep geologic repositories for the disposal of nuclear waste. The majority of their work is conducted in high ionic strength systems relevant to the Waste Isolation Pilot Plant (WIPP) located nearby. WIPP is currently the only licensed repository for the disposal of transuranic (TRU) defense waste in the world. However, the facility is not currently operating following an airborne release from a waste drum which failed to contain waste following an exothermic reaction of the waste. This was due to incompatibility of mixed waste received from LANL (organic adsorbent mixed with nitrate salt waste). The off-site releases of $^{239/240}Pu$ and ^{241}Am detected were only slightly above background and were still below public exposure limits. However, FIU-ARC is now initiating a new task to support the basic research efforts requested to update risk assessments for the WIPP site as it moves towards restarting operations.

The objective of this task is to support LANL researchers in the basic science research required to address concerns in risk assessment models for the re-opening of the WIPP site for acceptance of defense waste.

Task 5 Quarterly Progress

The collection of data from the column and batch kinetic experiments was continued during the months of July through September. During the month of August, a trip report was submitted based on the work that began during Dr. Hilary Emerson's appointment at LANL-CEMRC during the spring of 2016 entitled "Research and Technical Support for WIPP: Trivalent Actinide and Lanthanide Partitioning in Culebra Dolomite." Furthermore, abstracts were submitted for presentation at the American Geophysical Union Fall Meeting in December and the FIU McNair Scholars Research Conference in October.

Batch experiments were conducted with different variable concentrations of dolomite (12.5 and 125 g/L dolomite) along with two background electrolytes that consisted of 2 and 5M total ionic strength [3 mM $NaHCO_3$ + NaCl]. At each time interval for batch experiments, the tubes were allowed to settle for 15 minutes to ensure that the dolomite mineral was not present in the aqueous phase prior to sampling. While the six mixtures (5.0g-dol-1,2,3; 0.5g-dol-2-1,2-2,2-3) were left to sit: the pH was measured and the time was recorded after sampling. The pH values for the 5.0 g dolomite samples were measured to be much higher than the pH of the 0.5 g dolomite samples due to the dissolution of carbonate from the minerals. Once the seventh batch kinetics data was collected, the final mass of each tube was taken to ensure that total volume losses throughout the experiment were minimal.

The mini-column experiments with a mixed 5 M or 0.1 M electrolyte background [3 mM bicarbonate + NaCl] + 20ppb Nd were continued. The effluent is collected every 4 hours into 13x100 mm polystyrene tubes in an Eldex fraction collector with a 1.52±0.05 mL/hr flow rate. The significance of the flow rate values showed that the mini-column kept a constant flow rate of 1.5mL/hr with a relative standard deviation being below 5%. The tubes collected from the mini-column were weighed then placed into 2 mL vials to prepare for the ICP-MS. 1.6mL of 2% nitric acid was added into the vials along with the 400 microliters of the sample.

Since the experiments contain solutions with very high ionic strength, the pH measurement is not straightforward as opposed to how it is in dilute solutions. Instead, the pCH (hydrogen ion concentration) must be found, thus, the ionic strength and the ΔpH was calculated. The total ionic strength for the 2 and 5 M stock solutions were calculated and then applied into the equation developed for the NaCl solutions from the Borkowski's 2009 paper:

$\Delta pH = -0.1868(I) + 0.073$.

$\Delta pH = pCH - pH$

I= Total ionic strength

Once the ΔpH was calculated, the pCH could be found via $pCH = \Delta pH + pH_{obs}$. The pCH values were used because it normalizes the ionic strengths in the present solution in terms of the hydrogen ion concentration providing a representative measurement of pCH. This adjustment is necessary because of the effects of the high ionic strength on the activity and the subsequent impact to the general pH measurement.

Since the ICP-MS is currently not operational, the 2 M batch sorption and 5 M column samples have not yet been analyzed for Nd. However, UV-vis measurements were completed to estimate the settling rate of potential colloids generated during mixing of batch samples. The batch samples with the highest dolomite concentrations were selected for UV-vis measurements as they are expected to have the greatest potential concentration of colloids. The 2 M ionic strength samples were analyzed this month and the 5 M ionic strength samples will be analyzed in October. Samples were analyzed with respect to time up to about thirty minutes to estimate settling of particulates. Scans were collected from 400-700 nm wavelengths.

Data are summarized in Figures 2-24 and 2-25 below for 508 and 546 nm as these have been used previously for measurements of total suspended solids. Based on Figure 2-25, there is negligible removal of particulates after approximately 15 minutes (900 seconds). This confirms that suitability of our 15 minute settling time prior to sampling during batch kinetics experiments. The linear fit in Figure 2-25 shows that there is a strong linear correlation with particulate settling with respect to time.

The 0.1 and 5 M ionic strength mini column experiment will continue until break through with continuous collection of samples. Following completion current columns, a 2 M ionic strength column will also be conducted. Furthermore, analysis of samples for aqueous Nd will be completed via ICP-MS as soon as the instrument is repaired. Samples will continue to be prepared and stored until the ICP-MS is functioning.

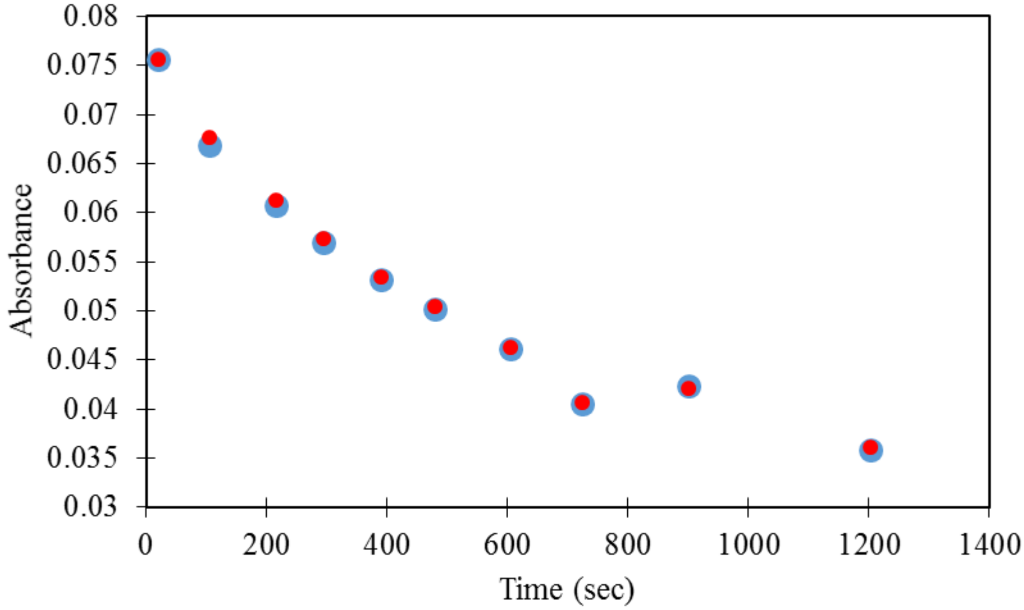


Figure 2-24. UV-vis measurements of 2 M ionic strength batch samples following 48-hour kinetics experiments at 508 (blue) and 546 nm (red) wavelengths.

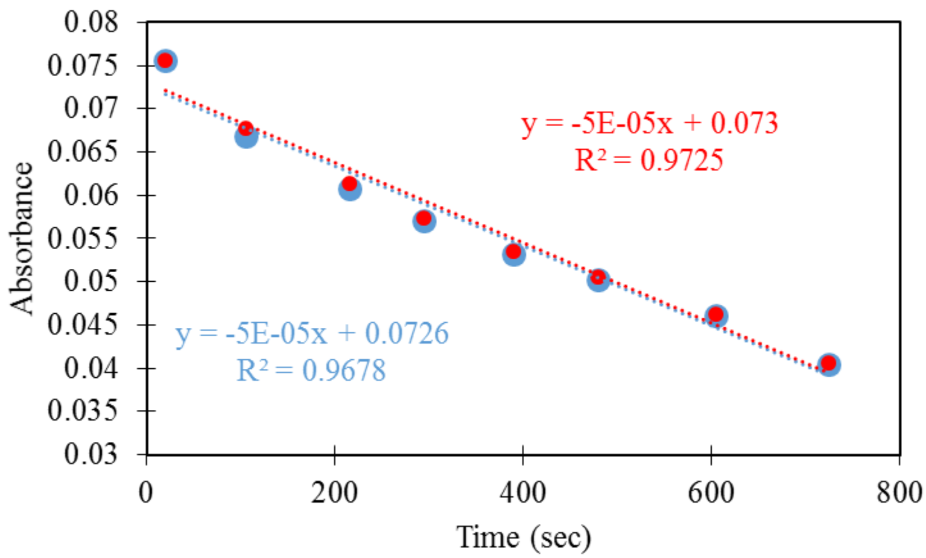


Figure 2-25. UV-vis measurements of 2 M ionic strength batch samples following 48-hour kinetics experiments at 508 (blue) and 546 nm (red) wavelengths with respect to time with a linear fit to estimate the settling rate of particulates.

Milestones and Deliverables

The milestones and deliverables for Project 2 for FIU Performance Year 6 are shown on the following table. Milestone 2015-P2-M5 for Task 3, complete input of the MIKE SHE model configuration parameters for the simulation of saturated zone (SZ) flow, was completed on July 27, 2016 and a memo was sent to relevant SRNL/SRS and DOE-HQ contacts. The project task plan was completed and submitted to DOE HQ on September 30, 2016.

FIU Performance Year 6 Milestones and Deliverables for Project 2

Task	Milestone/ Deliverable	Description	Due Date	Status	OSTI
Project	2015-P2-M1	Submit draft papers to Waste Management 2016 Symposium	11/6/2015	Complete	
Task 1: Hanford Site	Deliverable	Progress report on the experimental results on autunite mineral biodissolution (Subtask 1.2)	2/15/2016	Complete	OSTI
	Deliverable	Progress report on batch experiments for ammonia injection task (Subtask 1.3.1)	6/22/2016	Complete	OSTI
	Deliverable	Literature Review of Geophysical Resistivity Measurements and Microbial Communities (Subtask 1.3.3)	3/18/2016	Complete	
Task 2: SRS	Deliverable	Progress report on batch experiments on sodium silicate application in multi-contaminant systems (Subtask 2.1)	4/11/2016	Complete	OSTI
	Deliverable	Progress report on the synergy between colloidal Si and HA on the removal of U(VI) (Subtask 2.4)	4/21/2016	Complete	OSTI
	Deliverable	Progress report on column experiments to investigate uranium mobility in the presence of HA (Subtask 2.5)	5/20/2016 Reforecast to 7/1/2016	Complete	OSTI
Task 3: Tims Branch	2015-P2-M2	Complete refinement of MIKE SHE model configuration parameters for the simulation of overland flow using revised model domain (Subtask 3.1)	12/30/2015	Complete	
	2015-P2-M3	Complete input of MIKE SHE model configuration parameters for simulation of evapotranspiration (Subtask 3.1)	2/29/2016 Reforecast to 3/31/16	Complete	
	2015-P2-M4	Complete input of MIKE SHE model configuration parameters for simulation of unsaturated flow (Subtask 3.1)	3/31/2016 Reforecast to 4/29/2016	Complete	

	Deliverable	Progress Report for Subtask 3.1: Modeling of surface water and sediment transport in the Tims Branch ecosystem	4/29/2016 Reforecast to 6/30/16	Complete	OSTI
	Deliverable	Progress Report for Subtask 3.2: Application of GIS technologies for hydrological modeling support	4/29/2016 Reforecast to 5/31/16	Complete	OSTI
	2015-P2-M5	Complete input of MIKE SHE model configuration parameters for simulation of flow in the saturated zone (Subtask 3.1)	6/30/2016 Reforecast to 7/29/16	Complete	
Task 4: Sustainability Plan	Deliverable	Draft sustainable remediation report for the M1 air stripper	12/18/2015	Complete	OSTI

Work Plan for Next Quarter

Project-wide:

- Complete the Year End Report (YER) for FIU Performance Year 6 (August 2015 to August 2016).
- Revise the Project Technical Plan (PTP) for FIU Performance Year 7 (August 2016 to August 2017) based on comments received from DOE's review.

Task 1: Remediation Research and Technical Support for the Hanford Site

Subtask 1.1 – Remediation Research with Ammonia Gas for Uranium

- Continue with sequential extraction experiments with uranium-bearing solids with various compositions on new samples composed of Si, Al, HCO_3, U and Ca.
- Conduct EMRA analysis at FIU to characterize the uranium-bearing solid phases produced by the application of the ammonia gas injection method.
- Initiate sample preparation for the continuous flow reactors (CFR) to measure the release of U(VI) from U(VI)-bearing multicomponent precipitates created in conditions mimicking ammonia gas applications for the Hanford Site vadose zone.
- Analysis of samples from DOE Fellow Di Pietro's summer internship will continue to quantify the rate of mineral dissolution following base treatment.
- Experiments will begin with ammonia gas to compare with NaOH and NH_4OH treatment with a focus on the changes in redox conditions with gas versus liquid treatment.

Subtask 1.2. Investigation on Microbial-Meta-Autunite Interactions - Effect of Bicarbonate and Calcium Ions

- Completion of SEM/EDS analysis for microbial samples prepared in the mineral-free experiments.

- Initiate preparation of Na-autunite solids to be used for biodissolution experiments by anaerobic bacteria.

Subtask 1.3. Investigation of Electrical Geophysical Response to Microbial Activity in the Saturated and Unsaturated Environments

- Continue SIP measurements as well as weekly sampling of columns.
- Begin measuring oxidation reduction potential (ORP) of porewater samples.
- Inject microbe culture.
- Complete data analysis python code.
- Initiate data analysis.

Subtask 1.4: Contaminant Fate and Transport Under Reducing Conditions

- Conduct literature review in Tc fate under reducing conditions with emphasis given to bicarbonate rich systems.
- Complete liquid scintillation training.
- Establish SOP for Tc(IV)/(VII) separation.
- Identify ferrous/ferric iron SOP.

Task 2: Remediation Research and Technical Support for Savannah River Site

Subtask 2.1. FIU's Support for Groundwater Remediation at SRS F/H –Area

- Initiate acidification of soil and determination of Al and Fe in the leachates.
- Initiate surface characterization of acidic profile soils

Subtask 2.2 – The Synergistic Effect of Humic Acid and Colloidal Silica on the Removal of Uranium (VI)

- Initiate experiments by preparing batch samples containing 10 ppm of uranium, 30 ppm humic acid with colloidal silica and study the synergetic effect of humic acid and silica on uranium removal in the range of pH 3-8.

Subtask 2.3. Humic Acid Batch Sorption and Column Experiments with SRS Soil

- Perform kinetics of Huma-K sorption on SRS sediments at different times (less than 30 min) to complete the experiment.
- Study the effect of sample matrix quenching on the measurement of uranium concentrations by kinetic phosphorescence analyzer.
- Initiate experiments on uranium adsorption kinetics onto SRS sediments.
- Initiate control column experiment to study the sorption of uranium onto a sediment with specific pH to able to compare the data with previous column data to study the effect of Huma-K.
- Start experiments with modified humic acid obtained from SRNL.

Task 3: Surface Water Modeling of Tims Branch

- FIU will begin refinement of the existing model grid to a smaller grid element size in order to capture more detail of the surface topography and man-made structures such as roads or dam. Optimum grid element size will be established by performing simulations with various element sizes while observing the model runtime.

- Simulations will also be performed to understand the calibration parameters and the relative effect of the hydrological modules on the simulation results, and then make adjustments to the input parameters as necessary.

- FIU will also continue the development of the MIKE 11 models and implement the *in situ* data collected from Tims Branch during their visit to SRS in August 2016 for calibration and validation of the hydrological model being developed.

Task 4: Sustainability Plan for the A/M Area Groundwater Remediation System

- This task is not continuing into FIU Performance Year 7.

Task 5: Remediation Research and Technical Support for WIPP

- Work in collaboration with LANL to continue parallel experiments including mini-columns and batch experiments with Nd(III) for 0.01 – 5 M NaCl.
- Begin model development for mini column experiments in PHREEQC.
- Investigate and apply kinetic models to fit batch sorption data.
- Analyze samples via ICP-MS for Nd (a joint effort with help from LANL collaborators due to hardware issues with the FIU ICP-MS).

Project 3
Waste and D&D Engineering & Technology Development

Project Manager: Dr. Leonel E. Lagos

Project Description

This project focuses on delivering solutions under the decontamination and decommissioning (D&D) and waste areas in support of DOE HQ (EM-13). This work is also relevant to D&D activities being carried out at other DOE sites such as Oak Ridge, Savannah River, Hanford, Idaho and Portsmouth. The following tasks are included in FIU Performance Year 6:

Task No	Task
Task 1: Waste Information Management System (WIMS)	
Subtask 1.1	Maintain WIMS – database management, application maintenance, and performance tuning
Subtask 1. 2	Incorporate new data files with existing sites into WIMS
Task 2: D&D Support to DOE EM for Technology Innovation, Development, Evaluation and Deployment	
Subtask 2.1	D&D Technology Demonstration & Development and Technical Support to SRS's 235-F Facility Decommissioning
Subtask 2.2	Technology Demonstration and Evaluation
Subtask 2.3	Support to DOE EM-13 and the D&D Community
Task 3: D&D Knowledge Management Information Tool	
Subtask 3.1	Web and Mobile Application for D&D Decision Model
Subtask 3.2	Mobile Applications/Platforms for DOE Sites
Subtask 3.3	Development & Integration of International KM-IT Pilot for UK Collaboration
Subtask 3.4	Outreach and Training (D&D Community Support)
Subtask 3.5	Data Mining and Content Management
Subtask 3.6	D&D KM-IT Administration and Support

Task 1: Waste Information Management System (WIMS)

Task 1 Overview

This task provides direct support to DOE EM for the management, development, and maintenance of a Waste Information Management System (WIMS). WIMS was developed to receive and organize the DOE waste forecast data from across the DOE complex and to automatically generate waste forecast data tables, disposition maps, GIS maps, transportation details, and other custom reports. WIMS is successfully deployed and can be accessed from the web address http://www.emwims.org. The waste forecast information is updated at least annually. WIMS has been designed to be extremely flexible for future additions and is being enhanced on a regular basis.

Task 1 Quarterly Progress

The Waste Information Management System (WIMS) was developed to receive and organize the DOE waste forecast data from across the DOE complex and to automatically generate waste forecast data tables, disposition maps, GIS maps, transportation details, and other custom reports. WIMS is successfully deployed and can be accessed from the web address http://www.emwims.org. During this reporting period, FIU performed database management, application maintenance, and performance tuning to the online WIMS in order to ensure a consistent high level of database and website performance.

The WIMS abstract submitted to the Waste Management 2017 Symposia has been accepted for an oral presentation at the conference:

> **Abstract**: 17246 Waste Information Management System with 2016-17 Waste Streams
> **Session**: Decisionmaking Tools and Frameworks that Enhance Communication for ER Cleanup Programs
> **Date/Time**: Tuesday March 07, 2017, 3:20 PM - 5:00 PM

Task 2: D&D Support to DOE EM for Technology Innovation, Development, Evaluation and Deployment

Task 2 Overview

This task provides direct support to DOE EM for D&D technology innovation, development, evaluation and deployment. For FIU Performance Year 6, FIU will assist DOE EM-13 in meeting the D&D needs and technical challenges around the DOE complex. FIU will expand the research in technology demonstration and evaluation by developing a phased approach for the demonstration, evaluation, and deployment of D&D technologies. One area of focus will be working with the Savannah River Site to identify and demonstrate innovative technologies in support of the SRS 235-F project. FIU will further support the EM-1 International Program and the EM-13 D&D program by participating in D&D workshops, conferences, and serving as subject matter experts.

Task 2 Quarterly Progress

Task 2.1.1: Incombustible Fixatives

An abstract related to this research task was submitted to the Waste Management 2017 Symposia by SRNL in collaboration with FIU:

> **Abstract**: 17107 Environmental and Radiological Response of Fixatives and Intumescent Coatings for D&D Applications
> **Session**: D&D of US DOE Facilities
> **Date/Time**: Tuesday March 07, 2017, 1:30 PM - 3:15 PM

The objective of this research task is to improve the operational performance of fixatives by enhancing their fire resiliency. Most fixatives begin to see degradation between 200-400 degrees, at which time radioisotopes could potentially be released into the environment. The layering or combining of an intumescent coating with the fixative is being investigated as a way to mitigate the release of radioisotopes during fire and/or extreme heat conditions.

FIU completed coupon preparation using FIREX intumescent coating (IC) on both stainless steel and wood substrates, applying the product to the requisite thickness. For these coupons, FIU did not use a primer in order to replicate the field site application methods preferred by SRS 235-F site personnel. For the 1/8" stainless steel coupon, FIU applied FIREX to one side of the coupon and Fixative A to the other side. For the wood coupon, FIU layered the FIREX over Fixative A.

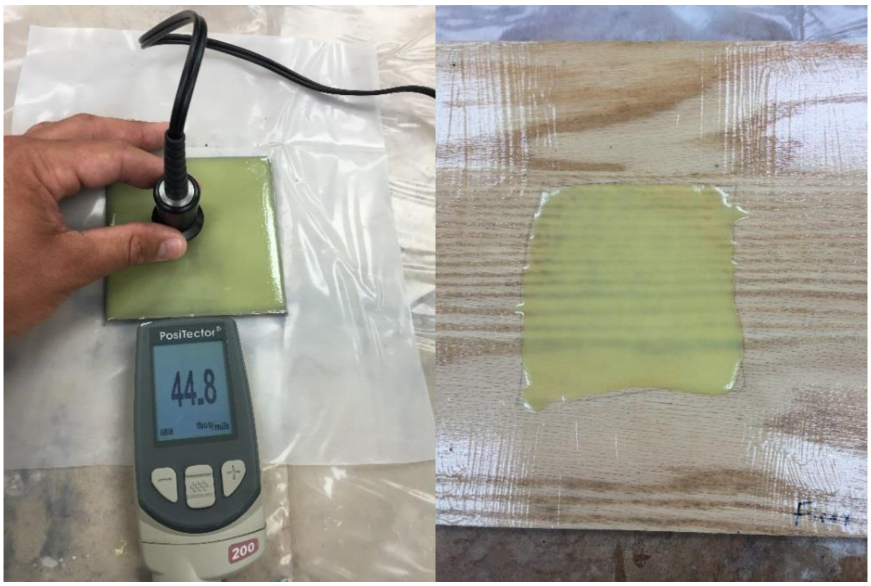


Figure 3-1. Stainless steel (left) and wood (right) test coupon substrates with FIREX intumescent coating.

FIU subjected the 1/8" stainless steel coupon (FIREX on one side and Fixative A on the other side) to a direct flame source (i.e., propane torch) at distances from 3" to 6" for 5 minutes. As can be seen in the figure below, the FIREX intumescent coating began to char in a similar manner to FireDam, creating a leather-like protective layer. Based on the infrared (IR) sensor measurements, temperatures on the surface ranged between 500º-700º F.

Figure 3-2. Stainless steel test coupon with FIREX intumescent coating after exposure to direct flame.

On the back of the stainless steel coupon, coated with Fixative A, no damage was noted and the fixative appeared intact (no discoloration, no melting, no off-gassing, etc.) and the temperature never rose above 120º F (see figure below). The fixative remained tacky to the touch and appeared to maintain its primary functions as a permanent fixative. The FIREX provided the same level of protection to Fixative A when layered over it on the wood coupon and subjected to the same flame source. The only deficiency noted in the layering configuration was a loss of adhesion between FIREX and the fixative.

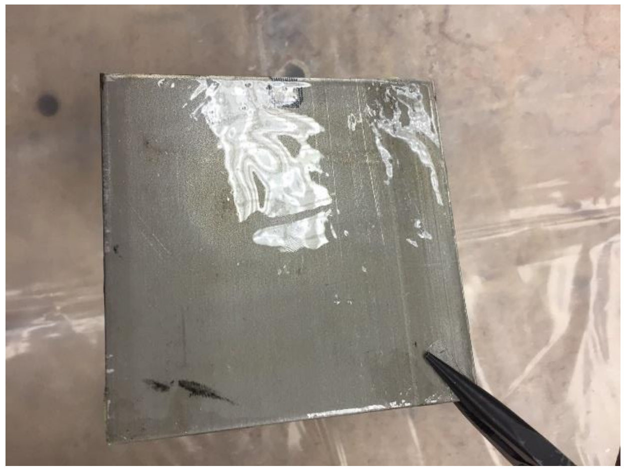


Figure 3-3. Back of stainless steel test coupon with Fixative A coating after front side (with FIREX IC) was exposed to direct flame.

FIU prepared 4 additional IC test coupons and shipped to SRNL researchers for use in conducting parallel research in environmental and radioactive exposure testing. FIU also received overall dimensions associated with the SRS 235-F hot cell which FIU will begin to incorporate into the planning and design for an FIU Performance Year 7 cold test demonstration at the Applied Research Center outdoor testing and demonstration facility hot cell test bed.

FIU visited SRNL on August 8-9, 2016, and provided a joint presentation with SRNL research scientists to SRS 235-F facility personnel, including project managers as well as safety and fire division representatives, on the potential of adapting intumescent coatings as standalone fixatives to assist with the overall safety basis of the site. The brief was exceptionally well received, and there was general concurrence to further the research through a scaled demonstration in a radioactive environment.

FIU began adhesion testing of selected intumescent coatings being considered as potential standalone fixatives in support of SRS 235-F D&D requirements. Utilizing the testing protocols outlined in ASTM D3359, Standard Test Methods for Measuring Adhesion by Tape Test, FIU conducted a series of adhesion tests on 4"x4" stainless steel coupons prepared under environmentally controlled conditions at 72ºF and 43% humidity. Adhesion tests were conducted before and after subjecting the test coupons to extreme heat conditions in a muffle furnace at temperatures between 600-800ºF for 15 minute periods.

The intumescent coating (FX) exhibited superior initial results both before and after exposure to extreme heat. FX demonstrated exceptional adhesion properties to the stainless steel coupons, yielding little to no adhesion loss from the substrate (0-5%) both before and after exposure.

FIU is planning to conduct the same series of ASTM D3359 tests on a second intumescent coating (FD) during October. In addition, the same tests will be performed on stainless steel coupons (both FD and FX) that have been prepared and cured under adverse environmental conditions, including ambient temperatures greater than 90º F and humidity ranging from 60 to 90%. In addition, the time periods for heat exposure will be extended to two hours and the temperatures will be increased up to 1000ºF.

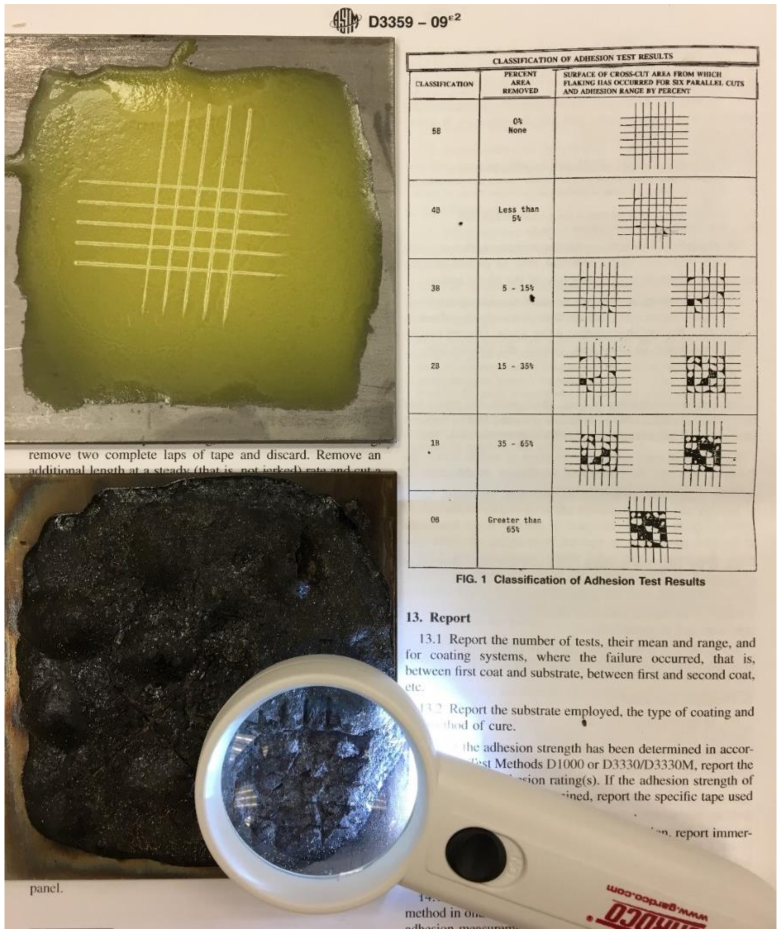


Figure 3-4. FIU is using ASTM standard testing protocols to measure the adhesion of an intumescent coating on test coupons before (top) and after (bottom) extreme heat conditions.

Task 2.1.3: Robotic Technologies for SRS 235-F

As part of this subtask during FIU Performance Year 6, FIU performed research to identify robotic technology systems applicable to the challenges and needs of the SRS 235-F Facility. Research utilized the Robotic Database in D&D KM-IT to search and identify potential robotic technologies and compiled a spreadsheet of all of the available robotic technologies in the database. During FIU Performance Year 7, FIU will leverage the research already completed to begin identifying cross-cutting applications of robotic technologies being developed at FIU in the high-level waste research area that could potentially be used in support of D&D activities.

Task 2.2: Technology Demonstration and Evaluation

The primary objective of this task is to standardize and implement proven processes to refine and better synchronize DOE-EM technology needs, requirements, testing, evaluation, and acquisition by implementing a three-phased technology test and evaluation model. The development of uniformly accepted testing protocols and performance metrics is an essential component for testing and evaluating D&D technologies.

During July, FIU followed up with the participants of the ASTM International E10.03 Subcommittee meeting to develop standardized testing protocols and performance metrics for D&D technologies. Participating members of this subcommittee meeting included Joe Sinicrope (FIU ARC), Rick Demmer (INL), Steve Reese (INL), Aaron Washington (SRNL), Connor Nicholson (SRNL), Andy Jung (Areva), Edward Walter (consultant), Steve Halliwell (VJT Technologies), and Bob Walcheski (UESI).

The two (2) new draft standard specifications on fixative technologies (strippable/removal coatings and permanent coatings and fixatives) were forwarded to Ed Walker and Joe Sinicrope for refinement before distribution to the entire working group for one final review/edit. The standard specifications outline the performance, mechanical, chemical, and physical requirements expected of the technology with the associated performance criteria. The Staff Manager (Steve Mawn) was contacted and official working document numbers for the 2 drafts were assigned so they can be formally tracked. The specifications were finalized in August and completed the Working Group review process before being submitted for a full E10.03 Subcommittee vote.

FIU will continue to lead and work with the Subcommittee membership to develop uniformly accepted testing protocols and performance metrics as an essential component for testing and evaluating D&D technologies. These efforts will help to ensure that the FIU three-phased Technology Test and Evaluation Model is uniform in its application and defensible in its findings and results.

Task 3: D&D Knowledge Management Information Tool (KM-IT)

Task 3 Overview

The D&D Knowledge Management Information Tool (KM-IT) is a web-based system developed to maintain and preserve the D&D knowledge base. The system was developed by Florida International University's Applied Research Center (FIU-ARC) with the support of the D&D community, including DOE-EM (EM-13 & EM-72), the former ALARA centers at Hanford and Savannah River, and with the active collaboration and support of the DOE's Energy Facility Contractors Group (EFCOG). The D&D KM-IT is a D&D community driven system tailored to serve the technical issues faced by the D&D workforce across the DOE Complex. D&D KM-IT can be accessed from web address http://www.dndkm.org.

Task 3 Quarterly Progress

The D&D KM-IT abstract submitted to the Waste Management 2017 Symposia has been accepted for an oral presentation at the conference:

Abstract: 17249 Application of Robotics Technology to D&D
Session: Robotics and Remote Systems – Nuclear Environments: International Applied D&D Operations Cleanup Programs
Date/Time: Thursday March 09, 2017, 1:30 PM - 5:00 PM

FIU held regular bi-weekly teleconferences with DOE on the status and progress of the activities on this task. FIU presented the highlights to DOE from the web analytics report on the usage of the D&D KM-IT website during the first quarter of calendar year 2016. Future web analytics reports will also incorporate information on the use of mobile devices to access D&D KM-IT.

FIU developed text on the D&D KM-IT for DOE to use on their Powerpedia website and sent it to DOE on July 6, 2016. The Powerpedia had an existing article on D&D KM-IT but needed additional information.

FIU completed an initial draft of a new infographic on the topic of knowledge management (KM), including the importance of KM and highlighting examples from KM-IT. The draft infographic was sent to DOE for review and input on August 8, 2016. An image of the draft infographic on KM is included below. FIU also provided technical assistance to a DOE intern for the development of an infographic focused on Facility Engineering. FIU provided feedback and design assistance and shared lessons learned from previous infographics developed for DOE.

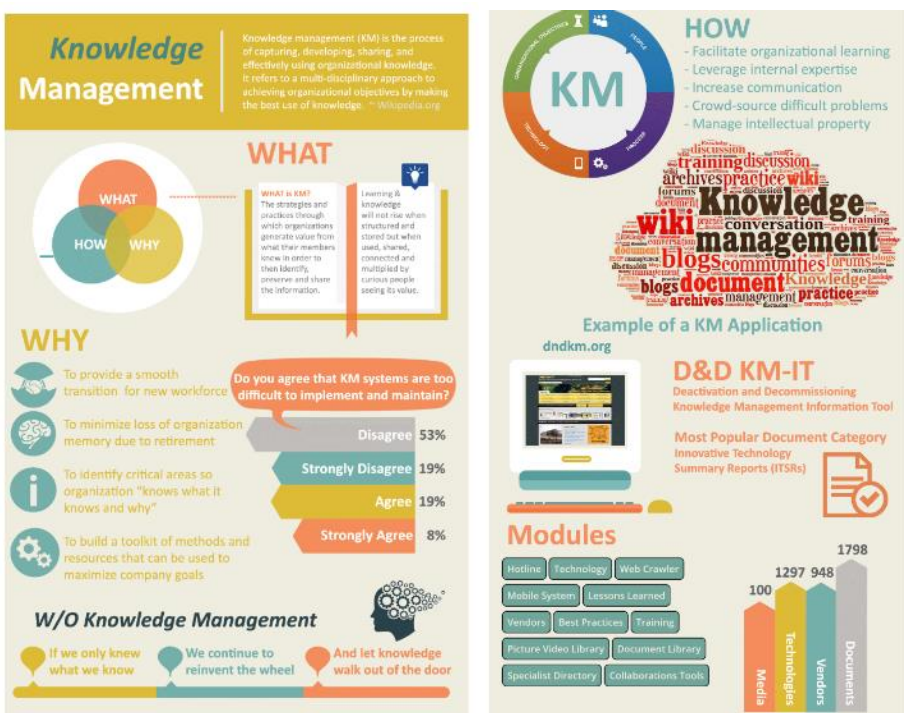
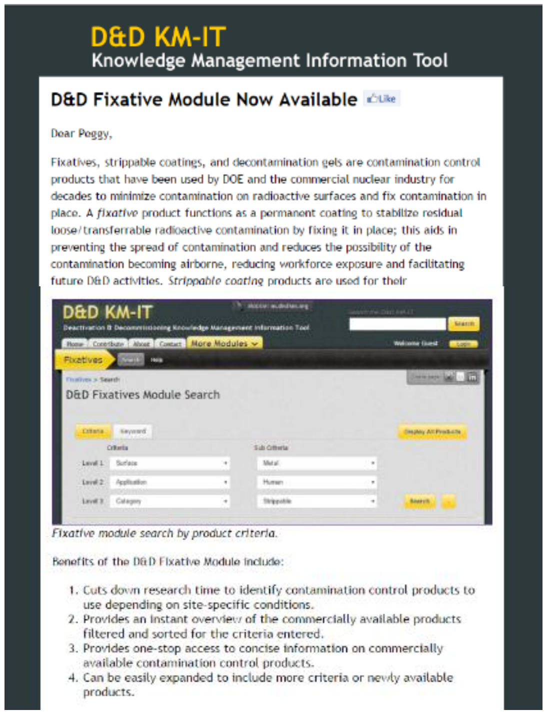


Figure 3-5. Draft infographic on knowledge management.

FIU revised and finalized a newsletter to announce the launch of a D&D Fixative Module on D&D KM-IT to assist in the selection of commercially available fixatives, strippable coatings, and decontamination gels for application during D&D activities. The newsletter was distributed from D&D KM-IT to all the registered users on August 15, 2016. FIU also revised a draft newsletters based on an analysis performed to better understand the seasonal variations of photovoltaic (PV) power generation. This research work to better understand solar energy generation patterns and seasonal variations was performed during the summer of 2015 by DOE Fellow Natalia Duque during a summer internship at SRNL under the supervision and guidance of Mr. Ralph L. Nichols, Fellow Engineer at the Environmental Sciences & Biotechnology Directorate.


D&D KM-IT
Knowledge Management Information Tool

D&D Fixative Module Now Available

Dear Peggy,

Fixatives, strippable coatings, and decontamination gels are contamination control products that have been used by DOE and the commercial nuclear industry for decades to minimize contamination on radioactive surfaces and fix contamination in place. A *fixative* product functions as a permanent coating to stabilize residual loose/transferrable radioactive contamination by fixing it in place; this aids in preventing the spread of contamination and reduces the possibility of the contamination becoming airborne, reducing workforce exposure and facilitating future D&D activities. *Strippable coating* products are used for their

Fixative module search by product criteria.

Benefits of the D&D Fixative Module include:

1. Cuts down research time to identify contamination control products to use depending on site-specific conditions.
2. Provides an instant overview of the commercially available products filtered and sorted for the criteria entered.
3. Provides one-stop access to concise information on commercially available contamination control products.
4. Can be easily expanded to include more criteria or newly available products.

Figure 3-6. D&D KM-IT Newsletter announcing availability of the D&D Fixative Module.

FIU completed the development of an annual Google Web Analytic report for D&D KM-IT for calendar year 2015 (January to December) and submitted it to DOE on September 8, 2016. During 2015, D&D KM-IT was visited from 113 countries with the top five being the United States, United Kingdom, Canada, India and France, with a combined 6,798 visits. The top five states that visited D&D KM-IT were Florida, California, District of Columbia, Washington and Texas.

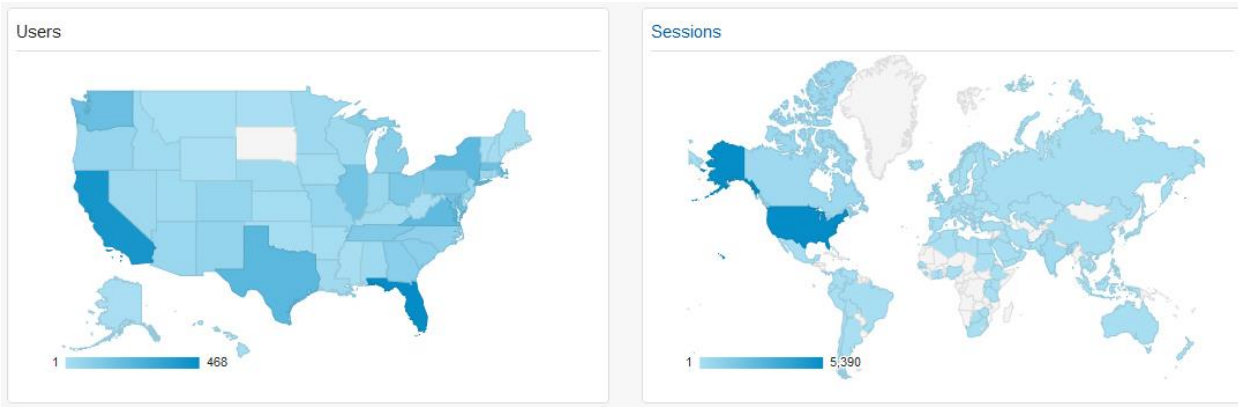


Figure 3- 7. Users by state in the U.S. and by country.

The data for this report comes from Google Analytics and Google Webmaster Tools (GWT) and makes significant use of graphics, designed to be consumed quickly to gain a high-level understanding of the web activity on the site during 2015. The dndkm.org website hosted 9,090 visitors during 2015 (an increase of 21.3% over 2014), of which 7,054 were unique visitors (an increase of 19.48% over 2014). Those visitors produced 46,023 page views during this period (an increase of 51.14% over 2014) and also viewed an average of 5 pages per visit. On average, these visitors spent 3 minutes and 47 seconds on the site. An infographic was developed to provide a visual representation of key information in the report.

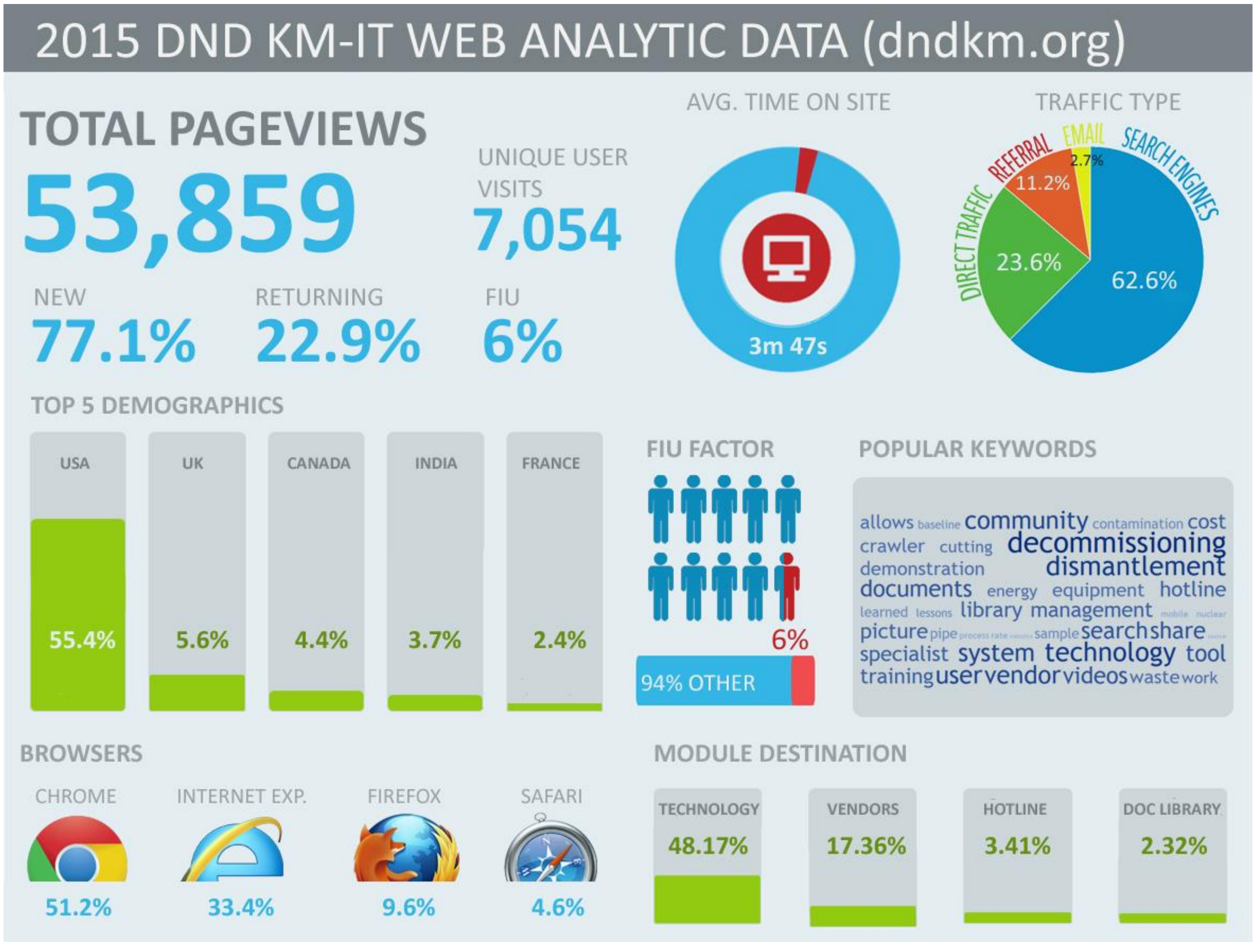


Figure 3-8. Web analytics infographic for calendar year 2015.

A strategic plan document for D&D KM-IT titled, *D&D Knowledge Management Information Tool – A Strategic Approach for the Long-Term Sustainability of Knowledge*, offers a strategic vision for the long-term sustainability of knowledge through the D&D KM-IT by applying the system's assets together with good web practices; thereby, promoting and enhancing the collaborative sharing of knowledge and work experiences across the D&D community. FIU developed a quarterly update document for this document during September and submitted it to DOE on October 5, 2016. The strategic plan for D&D KM-IT is a living document and the projected schedule and status evolve over time as the recommended strategic approaches are implemented. The update document, developed on a quarterly basis, provides an update to the table of recommended actions contained in the original document.

FIU has engaged in several discussions with DOE related to social media integration on D&D KM-IT for the purpose of outreach and marketing. Social media has been identified as a platform that should be targeted to increase visibility of D&D KM-IT among the community and other EM related areas. FIU reviewed the social media guidelines forwarded from DOE to determine the impact, if any, on the planned social media integration. FIU is approaching this integration using DOE's *social media policy and best practices* as a guideline for the following two tasks: 1) Provide social integration on KM-IT to allow Like/Share/Pin to Facebook, Twitter, LinkedIn, and Pinterest; and 2) Create pilot to utilize YouTube as platform for D&D KM-IT Videos. FIU developed a white paper to describe the planned social media integration activities for D&D KM-IT in FIU Performance Year 7 in comparison with the guidelines provided in DOE's *social media policy and best practices.*

DOE Fellows and other FIU students are supporting D&D KM-IT by reviewing the information in the vendor and technology modules and updating contact information. As of September 21, the system included a total of 1297 technologies and 948 vendors.

Milestones and Deliverables

The milestones and deliverables for Project 3 for FIU Performance Year 6 are shown on the following table. For one deliverable due in July, FIU provided a decision brief to Andrew Szilagyi and John De Gregory with DOE EM-13 on recommended technologies to test for FIU Performance Year 7 on May 11, 2016, as part of a larger briefing on FIU's current and future D&D research activities. FIU completed a deliverable on a review of potential robotic technologies for application at the SRS 235-F Facility and sent it to DOE and the site on 8/12/16. FIU also completed a draft infographic on knowledge management (highlighting D&D KM-IT as an example) and sent it to DOE for review on 8/8/2016. A metrics progress report on the outreach and training activities for D&D KM-IT was also completed and sent to DOE on 8/15/16. The project task plan was completed and submitted to DOE HQ on September 30, 2016.

FIU Performance Year 6 Milestones and Deliverables for Project 3

Task	Milestone/ Deliverable	Description	Due Date	Status	OSTI
Task 1: WIMS	2015-P3-M1.1	Import 2016 data set for waste forecast and transportation data	Within 60 days of data receipt	Complete	
	2015-P3-M1.2	WM 2016 Paper for WIMS	11/6/2015	Complete	
Task 2: D&D	2015-P3-M2.1	Completion of Phase 1 testing of incombustible fixatives	12/31/2015	Complete	
	2015-P3-M2.2	Participate in ASTM E10 Committee Meeting to introduce a requirement for standardized D&D testing protocols & performance metrics	01/31/2016	Complete	
	Deliverable	Summary Report on Robotic Technologies for SRS 235-F Facility	Reforecast to 8/12/2016	Complete	OSTI
	Deliverable	Draft Progress Report for incombustible fixatives testing and evaluation	06/30/2016	Complete	OSTI
	2015-P3-M2.3	Participate in ASTM International's Executive Steering Committee Meeting to solicit final approval for development of standardized testing protocols and performance metrics for D&D technologies.	06/30/2016	Complete	
	Deliverable	Decision brief to DOE-EM 13 on recommended technologies to test for FY'17 using FIU's 3-Phased Technology Test and Evaluation Model.	07/29/2016	Complete	
	Deliverable	Draft technical reports for demonstrated technologies	30-days after demo	Complete	OSTI
	Deliverable	Draft Tech Fact Sheet for technology evaluations/ demonstrations	30-days after demo	Complete	

Task 3: D&D KM-IT	2015-P3-M3.1	Waste Management Symposium Paper for D&D KM-IT	11/06/2015	Complete	
	Deliverable	First D&D KM-IT Workshop to DOE EM staff at HQ	TBD**	Reforecast	
	2015-P3-M3.2	Deployment of pilot web-based D&D Decision Model application	01/16/2016	Complete	
	2015-P3-M3.3	Completion of development & integration of International KM-IT pilot for UK collaboration	03/04/2016	Complete	
	Deliverable	Preliminary Metrics Progress Report on Outreach and Training Activities	02/29/2016	Complete	
	Deliverable	First D&D KM-IT Workshop to D&D community	03/31/2016	Complete	
	2015-P3-M3.4	Four Wikipedia integration edits/articles	03/31/2016 Reforecasted to 04/15/16	Complete	
	2015-P3-M3.5	Deployment of pilot mobile application for D&D Fixative Module	05/20/2016	Complete	
	Deliverable	Second D&D KM-IT Workshop to DOE EM staff at HQ	TBD**	Reforecast	
	Deliverable	First infographic to DOE for review	07/25/2016	Complete	
	Deliverable	Second infographic to DOE for review	08/08/2016	Complete	
	Deliverable	Metrics Progress Report on Outreach and Training Activities	08/15/2016	Complete	
	Deliverable	Second D&D KM-IT Workshop to D&D community	TBD**	Reforecast	
	Deliverable	D&D KM-IT Web Analysis Report	Quarterly	Complete	
	Deliverable	Draft Tech Fact Sheet for new modules or capabilities of D&D KM-IT	30-days after deployment of new module	Complete	

***Completion of this deliverable depends on scheduling and availability of DOE EM staff*

Work Plan for Next Quarter

Project-wide:

- Complete the Year End Report (YER) for FIU Performance Year 6 (August 2015 to August 2016).
- Revise the Project Technical Plan (PTP) for FIU Performance Year 7 (August 2016 to August 2017) based on comments received from DOE's review.

Task 1: Waste Information Management System

- Perform database management, application maintenance, and performance tuning to WIMS.
- Submit draft paper to Waste Management 2017 Symposia.

Task 2: D&D Support

- Continue testing for evaluating intumescent coatings.
- Complete design of the SRS 235-F hot cell mock-up and draft the test plan for the cold demonstration / test & evaluation of intumescent coatings at FIU and send to SRNL collaborators for review. Begin purchasing of equipment and materials needed to execute the test plan and begin construction.
- Continue leading the working group in for ASTM International's E10 Committee on Nuclear Technologies and Applications and Subcommittee E10.03 - Radiological Protection for Decontamination and Decommissioning of Nuclear Facilities and Components to support the initiative of developing and promulgating uniform testing protocols and performance metrics for D&D technologies across the stakeholder community.

Task 3: D&D Knowledge Management Information Tool

- Submit draft paper to Waste Management 2017 Symposia.
- Develop quarterly website analytics report and submit to DOE for review.
- Perform outreach and training, community support, data mining and content management, and administration and support for the D&D KM-IT system, database, and network.

Project 4
DOE-FIU Science & Technology Workforce Development Initiative

Project Manager: Dr. Leonel E. Lagos

Project Description

The DOE-FIU Science and Technology Workforce Development Initiative has been designed to build upon the existing DOE/FIU relationship by creating a "pipeline" of minority engineers specifically trained and mentored to enter the Department of Energy workforce in technical areas of need. This innovative program was designed to help address DOE's future workforce needs by partnering with academic, government and DOE contractor organizations to mentor future minority scientists and engineers in the research, development, and deployment of new technologies, addressing DOE's environmental cleanup challenges.

Project Overview

The main objective of the program is to provide interested students with a unique opportunity to integrate course work, Department of Energy (DOE) field work, and applied research work at ARC into a well-structured academic program. Students completing this research program would complete the M.S. or Ph.D. degree and immediately be available for transitioning into the DOE EM's workforce via federal programs such as the Pathways Program or by getting directly hired by DOE contractors, other federal agencies, and/or STEM private industry.

Project Quarterly Progress

FIU STEM (Science, Technology, Engineering, and Math) students are actively supporting the research efforts under the DOE-FIU Cooperative Agreement during FIU Performance Year 6. The following DOE Fellows are supporting the research under Projects 1 – 3:

Project 1: Anthony Fernandez (undergraduate, mechanical engineering), Erim Gokce (undergraduate, mechanical engineering), Gene Yllanes (undergraduate, electrical engineering), John Conley (undergraduate, mechanical engineering), Max Edrei (graduate, M.S., mechanical engineering), Sebastian Zanlongo (graduate, Ph.D., computer science), Clarice Davila (undergraduate, mechanical engineering), Ryan Sheffield (undergraduate, mechanical engineering), and Michael DiBono (undergraduate, mechanical engineering).

Project 2: Alejandro Garcia (graduate, M.S. geoscience), Alejandro Hernandez (undergraduate, chemistry), Alexis Smoot (undergraduate, environmental engineering), Awmna Kalsoom Rana (undergraduate, chemistry), Christine Wipfli (undergraduate, environmental engineering), Christopher Strand (undergraduate, civil & environmental engineering), Claudia Cardona (graduate, PH.D., environmental engineering), Hansell Gonzalez (graduate, Ph.D., chemistry), Natalia Duque (graduate, M.S., environmental engineering), Robert Lapierre (graduate, M.S., chemistry), Sarah Bird (undergraduate, environmental engineering), Silvina Di Pierto (graduate, Ph.D., chemistry), Sarah Solomon (undergraduate, environmental engineering), Mohammed Albassam (graduate, M.S., environmental engineering), Frances Zengotita (undergraduate, chemistry and health), and Juan Morales (graduate, M.S., public health).

Project 3: Jesse Viera (undergraduate, mechanical engineering) and Alexander Piedra (undergraduate, mechanical engineering).

Fellows continue their support to the DOE-FIU Cooperative Agreement by actively engaging in EM applied research and supporting ARC staff in the development and completion of the various tasks. The program director continues to work with DOE sites and HQ to fully engage DOE Fellows with research outside ARC where Fellows provide direct support to mentors at DOE sites, DOE-HQ, and DOE contractors. All Fellows also participated in a weekly meeting conducted by the program director, a conference line has been established to enable DOE Fellows conducting internship to join to weekly meeting and update the program director on their internship activities. During each of these meetings, DOE Fellows presents the work they perform during their summer internship and/or EM research work they are performing at ARC.

The DOE Fellows completed their summer 2016 internships with DOE sites, DOE national laboratories, DOE contractors, and DOE-HQ. A total of 10 DOE Fellows interned this summer as detailed in the following table. During August, these DOE Fellows returned to ARC and drafted the summer internship technical reports based on the work they performed during their internships. The reports will be made available on the DOE Fellows website once site review and approval is complete.

Table 4-1. Summer 2016 Internships

DOE Fellow	Location	Internship Mentor	Comments
Erim Gokce	WRPS	Ruben Mendoza/ Dennis Washenfelder	High Level Waste
Max Edrei	NETL	Chris Gunter	Investigating parameters affecting mixing times for a multiphase PJM process through CFD analysis
Sebastian Zanlongo	LANL	David Mascarenas	LANL Robotics Group
Alejandro Hernandez	SRNL	Miles Denham	Column experiments to study *in situ* precipitation of AgCl to treat I-129 contamination in groundwater
Alexis Smoot	DOE HQ	Skip Chamberlain	Sustainability analysis of the SRS F-Area treatment system, evaluating aspects of the pump and treat system relative to the funnel and gate base passive treatment system
Awmna Rana	REU/SREL	John Seaman (SREL)	SREL
Christopher Strand	LANL	Bill Foley	Soil & Groundwater
Hansel Gonzalez	SRNL	Miles Denham	Study of the sorption of silver (Ag^+) and zinc (Zn^{2+}) on Huma-K coated sediments
Sarah Bird	DOE HQ	Skip Chamberlain	Sustainability analysis of the SRS F-Area treatment system, evaluating aspects of the pump and treat system relative to the funnel and gate

DOE Fellow	Location	Internship Mentor	Comments
			base passive treatment system
Silvina Di Pietro	PNNL	Jim Szecosdy/ Nik Qafoku	Evaluation of the rate of pure minerals and Hanford sediments dissolving in synthetic porewater under anaerobic (oxygen free) conditions

Highlights from the internship assignments include:

DOE FELLOW: Sebastian Zanlongo
LOCATION: Los Alamos National Laboratory
MENTOR: David Mascarenas

Mr. Sebastian Zanlongo's summer project, under the direction of Dr. Mascarenas at Los Alamos National Laboratory, drew inspiration from Jungian psychology to design an artificial personality that can demonstrate different reactions and behaviors depending on its environment and internal state. These actions and behaviors will be designed so that they select the appropriate set of actions for a given set of inputs. Creating a more dynamic model of personalities than is found in current personality projects will allow for a wider range of actions, possibly resulting in emergent behaviors. One of the goals of the internship was to develop a demonstration of some of the features of this personality model. This work could be applied to human-robot interaction, and allow robots to behave more independently in unknown environments. Robots would be able to interpret their current state, and their surrounding environment, and respond accordingly.

Figure 4-1. DOE Fellow Sebastian Zanlongo at LANL summer internship.

DOE FELLOW: **Alexis Smoot**
LOCATION: **DOE Headquarters**
MENTORS: **Skip Chamberlain**

Ms. Alexis Smoot worked on a high level sustainability analysis of the F-Area treatment system at the Savannah River Site, evaluating aspects of the pump-and-treat system relative to the funnel-and-gate based passive treatment system. The goal of this research at the F-Area site is to provide an example for other DOE sites of a sustainable solution to the very difficult challenge of treating radionuclide contamination in the soil and groundwater. Ms. Smoot also worked on a virtual model of the F-Area with Lawrence Berkeley Lab that will be used to test various monitoring scenarios and determining the controlling variables for the area. This work will help to minimize the number of different parameters that must be monitored while providing sufficient information to the site regulators for assurance that the contaminants are contained. The sustainability analysis will aid in the determination of which parameters to monitor.

Figure 4-2. DOE Fellow Alexis Smoot during summer internship.

DOE FELLOW: **Max Edrei**
LOCATION: **National Energy Technology Laboratory**
MENTOR: **Chris Gunter**

Mr. Maximiliano Edrei supported both experimental and computational fluid dynamics (CFD) based research regarding the pulse jet mixing (PJM) process at the National Energy Technology Laboratory in Morgantown, WV. In particular, his work involved investigating parameters affecting mixing times for a multiphase PJM process through CFD analysis. Also, the availability of a quarter-scale PJM vessel on site allowed for various experiments to be conducted on the same topic in which Mr. Edrei assisted. One crucial question regarding the PJM vessels is the scalability of the process. Mr. Edrei's summer research will help shed some light on this crucial question.

Figure 4-3. DOE Fellow Max Edrei during NETL summer internship.

DOE FELLOW: Alejandro Hernandez
LOCATION: Savannah River National Laboratory
MENTOR: Miles Denham

Mr. Alejandro Hernandez worked alongside Ralph Nichols and Miles Denham at SRNL on column studies, testing *in situ* precipitation of AgCl to treat I-129 contamination in groundwater, which relies on the successful injection of dissolved Ag into an aquifer and reaction with chloride. Laboratory-scale microcosm experiments were conducted to simulate the anticipated field scale process. Additionally, Mr. Hernandez helped to initiate similar tests with iodate as the contaminant and analyze samples to determine iodine, nitrate and silver concentrations.

Figure 4-4. DOE Fellow Alejandro Hernandez during SRNL summer internship.

DOE FELLOW: Sarah Bird
LOCATION: DOE HQ
MENTOR: Skip Chamberlain

Ms. Sarah Bird worked on a high level sustainability analysis of the F-Area treatment system at the Savannah River Site, evaluating aspects of the pump-and-treat system relative to the funnel-and-gate based passive treatment system. The goal of this research at the F-Area site is to provide an example for other DOE sites of a sustainable solution to the very difficult challenge of treating radionuclide contamination in the soil and groundwater. Ms. Smoot also worked on a virtual model of the F-Area with Lawrence Berkeley Lab that will be used to test various monitoring scenarios and determining the controlling variables for the area. This work will help to minimize the number of different parameters that must be monitored while providing sufficient information to the site regulators for assurance that the contaminants are contained. The sustainability analysis will aid in the determination of which parameters to monitor.

Figure 4-5. DOE Fellows Alexis Smoot and Sarah Bird at DOE HQ summer internship.

DOE FELLOW: **Hansel Gonzalez**
LOCATION: **Savannah River National Laboratory**
MENTORS: **Miles Denham**

Mr. Hansell Gonzalez spent his summer researching Huma-K coated sediments for the sorption of silver (Ag+) and zinc (Zn2+). Silver and zinc can serve as homologues for the +1 and +2 oxidation state which could serve as a comparison with current experiments pertaining to U(VI) sorption on Huma-K coated Savannah River Site sediments. Sorption of the heavy metals may be investigated at different pH values. Additional parameters will be explored during the course of experiments such as concentration and competition between Ag+ and Zn2+ for binding sites.

Figure 4-6. DOE Fellow Hansel Gonzalez during his summer internship at SRNL.

DOE FELLOW: **Christopher Strand**
LOCATION: **Los Alamos National Laboratory**
MENTOR: **Bill Foley**

Mr. Christopher Strand supported the Surface Water Program through the Environmental Remediation Division - Environmental Services (ER-ES) at LANL. Specific areas of work included using LIDAR data to evaluate sediment movement and/or retention volumes as requested by ER-ES staff. LIDAR, which stands for light detection and ranging, is a remote sensing method that uses light in the form of a pulsed laser to measure ranges to the Earth. These light pulses combined with other data generate precise three-dimensional information about the shape of the Earth and its surface characteristics. LIDAR systems allow scientists and mapping professionals to examine both natural and manmade environments with accuracy, precision, and flexibility.

Figure 4-7. DOE Fellow Christopher Strand during his LANL summer internship.

In addition, DOE Fellow Christine Wipfli continued a one year internship at the International Atomic Energy Agency (IAEA) in the Waste Technology Section, Division of Nuclear Fuel Cycle & Waste Technology at IAEA's Headquarters in Vienna, Austria.

Drs. Leonel Lagos and Dwayne McDaniel along with DOE Fellows Michael DiBono and Max Edrei participated in the American Nuclear Society joint Decommissioning & Environmental Remediation and Robotics/Remote Systems meeting in Pittsburgh. During the conference, Michael presented the miniature robotic inspection tool to be used at the Hanford Site in tank AY-102, which is being developed in close collaboration with scientist and engineers at WRPS under FIU Project 1.

Figure 4-8. DOE Fellows participating at ANS Conference.

ARC staff and DOE Fellows, including Dr. Noosha Mahmoudi, Mohammed Albassam, Natalia Duque, and Juan Morales, traveled to the Savannah River Site to conduct fieldwork, including the collection of *in situ* data such as flow and water quality parameters from Tims Branch stream and its major tributary, A-014 outfall.

Figure 4-9. DOE Fellows Mohammed AlBassam, Natalia Duque, and Juan Morales during their trip to SRS to perform field work and data collection.

The Applied Research Center at FIU was represented at the 252nd American Chemical Society Meeting in Philadelphia by Dr. Vasileios Anagnostopoulos, Dr. Hilary Emerson, and DOE Fellow Alejandro Hernandez. Mr. Hernandez received the ACS Environmental Chemistry Undergraduate Research Award earlier this year which was formally announced during the conference.

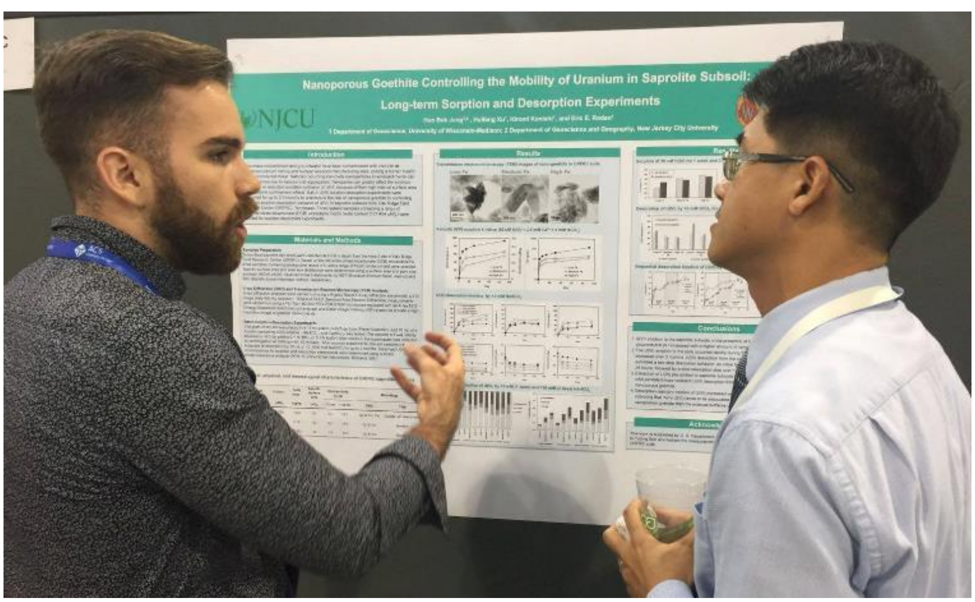


Figure 4-10. DOE Fellow Alejandro Hernandez discussing with a scientist from the University of Wisconsin how soil iron chemistry affects uranium mobility.

DOE Fellows fall recruitment efforts were initiated on August 29 and ran through September 16. Recruitment campaigns were conducted by placing recruitment tables at the College of Engineering and at the main FIU campus in the computer science building. A large group of students showed interest in the program and a signup sheet was used to collect student information. The deadline for FIU students to submit applications for DOE Fellowship was September 16, 2016. Twenty-five (25) applications were received and reviewed by ARC researchers and staff. Ten (10) FIU students were selected for interviews to be conducted in October.

A robotic platform was developed by DOE Fellows Michael Dibono and Gene Yllanes under the supervision of their mentor Anthony Abraho under Project 1; this platform was showcased during the Environmental Lab Day on the Hill Exhibits (National Laboratories - Advancing US Environmental Stewardship through Innovation). DOE Fellow Gene Yllanes and Dr. Lagos (Program Director and PI) attended and showcased the robotic platform and other robotics technologies prototyped at FIU in support of the DOE EM environmental remediation mission. The FIU technologies were also be displayed and showcased at the National Cleanup Workshop held in Alexandria, VA on September 14 and 15, 2016.

Figure 4-11. DOE Fellow, Gene Yllanes with Secretary Moniz and members of Congress (left) and Dr. Monica Regalbuto (DOE-EM), Secretary Moniz, DOE Fellow (Gene Yllanes), and Dr. Leonel Lagos (DOE Fellows Program Director, FIU-ARC) (right).

FIU continued working with DOE Fellows interested in federal jobs. FIU supports our Fellows with identifying federal entry-level career opportunities within DOE and other federal agencies on USA Jobs and forward those vacancy announcements to the DOE Fellows. FIU also continues to identify those DOE Fellows who are preparing to transition from academia to the workforce within the next year for conducting focused mentoring sessions with those Fellows on resume preparation and the USA Jobs application process.

FIU continued working on preparations for the DOE Fellows Induction Ceremony scheduled for November 03, 2016. FIU staff and DOE Fellows (Sarah Salomon and Alexander Piedra) are taking the lead in making all preparations for this event. It is expected that colleagues/collaborators from DOE EM HQ, DOE national labs (SRNL and PNNL), other federal agencies (Army Corps), industry, FIU faculty and staff will participate in this event.

In addition, FIU is developing a DOE Fellows Professional Development seminar series that is aligned with DOE's mentoring program in terms of goals and objectives. The intent of this effort is to round out the technical mentoring the Fellows are already receiving. The initial seminar offerings will include four presentations and discussions centered on challenges entry-level personnel will encounter as they enter the federal workforce. The first seminar, held on September 28, 2016, was on Establishing Your Professional Reputation. The projected timeline and seminar titles still to come are as follows:

- October 2016 - Workforce Communication Techniques
- November 2016 - Successfully Adapting to and Navigating Organizational Cultures
- December 2016 - Emotional Intelligence and the Leadership Spectrum

DOE Fellows began preparation of posters based on their DOE EM research as a part of summer internships as well as the research being conducted at FIU ARC throughout the year for the DOE Fellows Poster Competition scheduled for October. A total of 19 posters were prepared, below is the list of poster titles with presenters name.

1. **Alejandro Garcia:** The influence of biofilm formation on the SIP response of Hanford vadose zone sediment
2. **Alejandro Hernandez:** In-situ Precipitation of AgCl for Treatment of I-129 Contaminated Groundwater
3. **Alexander Piedra:** Baseline Adhesion Testing of Intumescent Coatings
4. **Awmna Rana:** Study of the Fate and Transport of Irrigated Tritium Waste Water in Biological Receptors
5. **Christopher Strand:** Calculating the Retention Storage Volume of Surface Water within a Predetermined Contour Area
6. **Clarice Davila:** Thermal management and modeling of nuclear waste in DST's at Hanford using miniature sensors
7. **Frances Zengotita:** Role of Ionic Strength on Sorption of Neodymium on Dolomite
8. **Gene Yllanes:** Robotic Platform for Inspection of Highly Radioactive Areas
9. **Hansell Gonzalez:** Unrefined humate solution as a potential low-cost remediation method for groundwater contaminated with heavy metals
10. **John Conley:** Nonmetallic Material Testing of Hanford's HLW Transfer System
11. **Juan Morales:** Watershed Toxicology Management approach analyzing point source pollutants in Tims Branch, Savannah River Site, SC
12. **Maximiliano Edrei:** Investigation of Mixing Times of Sparged Bingham plastic type fluids as applied to the Pulse Jet Mixing Process
13. **Michael Dibono:** Miniature Motorized Inspection Tool for DOE Hanford Site Tank Bottoms
14. **Mohammed Albassam:** In-Situ Water Quality Sampling and Flow Measurement to Support Hydrological Model Development for Tims Branch Watershed, Savannah River Site, SC
15. **Ryan Sheffield:** Pneumatic pipe crawler for Hanford DOE site double-shell tanks

16. **Sarah Bird:** Sustainability Index for Comparison of Environmental Remediation Technologies
17. **Sarah Solomon:** Shewanella oneidensis MR1 Interaction with U(VI) in Bicarbonate Media
18. **Sebastian Zanlongo:** Artificial Personality Synthesis
19. **Silvina Di Pietro:** Ammonia Gas Treatment for Uranium Immobilization at DOE Hanford's Site

DOE Fellows Mohammed Albassam, Frances Zengotita, Alexis Smoot and Awmna Rana prepared and submitted abstracts to FIU McNair Scholars Research Conference to be held October 19-21 at FIU's MMC campus.

DOE Fellows Ryan Sheffield and Hansell Gonzalez presented their research accomplishments during FIU Cooperative Agreement End of Year Review presentations held on September 21, 2016. In addition, a team of our DOE Fellows (Natalia Duauqe, Mohammed Albassam and Juan Morales) along with their mentor presented "In-situ Data Collection and Sampling to Support Flow and Contaminant Transport Modeling Effort for Tims Branch, Savannah River Site, SC" based on the visit they made to SRS for collect some data to be incorporated into the model that is being developed under Project 2. DOE Fellows also participated in ARC's lecture series featuring Dr. Aparna Aravelli, the title of the lecture is "Thermal Measurement and Modeling of Nuclear Waste in the Double Shell Tanks at Hanford Nuclear Waste Site Using Miniature Sensors."

The DOE Fellows who participated in a spring/summer 2016 internships are preparing and presenting an oral presentation at the weekly DOE Fellows meetings. The schedule for these presentations is provided below.

Table 4-2. Research Presentation Schedule for DOE Fellow Meetings

DOE Fellow	DOE Site	Date
Alexis Smooth & Sarah Bird	HQ/EM-12 - Washington DC	08/31/16
Erim Gokce	WRPS - Richland, Washington State	09/07/16
Alejandro Hernandez	SRNL - Aiken, South Carolina	09/16/16
Alejandro Garcia	PNNL - Richland, Washington State	09/28/16
Natalia Duque, Mohammed Albassam, & Juan Morales	Savannah River Site, SC	10/12/16*
Maxmiliano Edrei	NETL - Morgantown, West Virginia	10/19/16*
Sebastian Zanlongo	LANL - Los Alamos, New Mexico	10/26/16*
Silvina Di Pietro	PNNL - Richland, Washington State	11/09/16*
Hansell Gonzalez	SRNL - Aiken, South Carolina	11/16/16*
Awmna Rana	REU/SREL - Aiken, South Carolina	11/23/16*
Christopher Strand	LANL - Los Alamos, New Mexico	11/30/16*

* Tentative

During this quarter, the Fellows continued their research in the DOE EM applied research projects under the cooperative agreement and research topics identified as part of their summer internships at DOE sites, national labs, and/or DOE HQ. Each DOE Fellow is assigned to DOE

EM research projects as well as ARC mentors. A list of the current Fellows, their classification, areas of study, ARC mentor, and assigned project task is provided below.

Table 4-3. Project Support by DOE Fellows

Name	Classification	Major	ARC Mentor	Project Support
Alejandro Garcia	Graduate - B.S.	Geoscience	Dr. Yelena Katsenovich	FIU's Support for Groundwater Remediation at PNNL
Alejandro Hernandez	Undergrad - B.S.	Chemistry	Dr. Vasileios Anagnostopoulos	Groundwater Remediation at SRS F/H -Area
Alexander Piedra	Undergrad - B.S.	Mechanical Eng.	Mr. Joseph Sinicrope	Database of Robotic Technologies for D&D Activities
Alexis Smoot	Undergrad - B.S.	Envr. Eng.	Dr. Ravi Gudavalli	Synergistic Effects of Silica and Humic Acid on U(VI) Removal
Anthony Fernandez	Undergrad - B.S	Mechanical Eng.	Mr. Amer Awwad	Evaluation of Nonmetallic Components in the Waste Transfer System
Awmna Kalsoom Rana	Undergrad - B.S.	Chemistry	Ms. Angelique Lawrence	Surface Water Modeling of Tims Branch
Christine Wipfli	Undergrad - B.S.	Envr. Eng.	Dr. Vasileios Anagnostopoulos	Groundwater Remediation at SRS F/H Area
Christopher Strand	Undergrad - B.S.	Civil & Env. Eng.	Dr. Noosha Mahmoudi	Surface Water Modeling of Tims Branch
Clarice Davila	Undergrad - B.S	Mechanical Eng.	Dr. Aparna Aravalli	Investigation Using an Infrared Temperature Sensor to Determine the Inside Wall Temperature of DSTs
Claudia Cardona	Graduate - Ph.D.	Envr. Eng.	Dr. Yelena Katsenovich	Sequestering Uranium at the Hanford 200 Area Vadose Zone
Erim Gokce	Undergrad - B.S.	Mechanical Eng.	Mr. Anthony Abrahao	Development of Inspection Tools for DST Primary Tanks
Frances Zengotita	Undergrad - B.S.	Chemistry & Health	Dr. Hilary Emerson	Absorption of Neodymium into the Dolomite Mineral
Gene Yllanes	Undergrad - B.S.	Electrical Eng.	Dr. David Roelant	Evaluation of FIU's SLIM for Estimating the Onset of Deep Sludge Gas Release Events
Hansell Gonzalez	Graduate - Ph.D.	Chemistry	Dr. Yelena Katsenovich	Sorption Properties of Humate Injected into the Subsurface System
Jesse Viera	Undergrad - B.S.	Mechanical Eng.	Mr. Joseph Sinicrope	Incombustible Fixatives
John Conley	Undergrad - B.S.	Mechanical Eng.	Mr. Amer Awwad	Evaluation of Nonmetallic Components in the Waste Transfer System
Juan Morales	Graduate – M.S.	Public Health	Ms. Angelique Lawrence / Dr. Reinaldo Garcia	Development of Flow and Contaminant Transport Models for SRS

Maximiliano Edrei	Graduate – M.S.	Mechanical Eng.	Dr. Dwayne McDaniel	Computational Fluid Dynamics Modeling of HLW Processes in Waste Tanks
Michael DiBono	Undergrad - B.S.	Mechanical Eng.	Dr. Dwayne McDaniel	Development of Inspection Tools for DST Primary Tanks
Mohammed Albassam	Graduate – M.S.	Envr. Eng.	Dr. Noosha Mahmoudi	Environmental Remediation and Surface Water Modeling of Tims Branch Watershed at SRS
Natalia Duque	Graduate – M.S.	Envr. Eng.	Dr. Noosha Mahmoudi	Surface Water Modeling of Tims Branch
Robert Lapierre	Graduate – M.S.	Chemistry	Dr. Yelena Katsenovich	Sequestering Uranium at the Hanford 200 Area Vadose Zone
Ryan Sheffield	Undergrad - B.S.	Mechanical Engineering	Dr. Dwayne McDaniel	Development of Inspection Tools for DST Primary Tanks
Sarah Bird	Undergrad - B.S.	Envr. Eng.	Dr. Ravi Gudavalli	Modeling of the Migration and Distribution of Natural Organic Matter injected into Subsurface Systems
Sarah Solomon	Undergrad - B.S.	Envr. Eng.	Dr. Vasileios Anagnostopoulos	Modeling of the Migration and Distribution of Natural Organic Matter Injected into Subsurface Systems
Sebastian Zanlongo	Graduate - Ph.D.	Computer Science	Dr. Dwayne McDaniel	Cooperative Controls for Robotic Systems
Silvina Di Pietro	Graduate - Ph.D.	Chemistry	Dr. Hilary Emerson	Evaluation of Ammonia for Uranium Treatment

Milestones and Deliverables

The milestones and deliverables for Project 4 for FIU Performance Year 6 are shown on the following table. The project task plan was completed and submitted to DOE HQ on September 30, 2016.

FIU Performance Year 6 Milestones and Deliverables for Project 4

Milestone/ Deliverable	Description	Due Date	Status	OSTI
2015-P4-M1	Draft Summer Internships Reports	10/16/15	Complete	
Deliverable	Deliver Summer 2015 interns reports to DOE	10/30/15 Reforecast	Complete 11/30/15	OSTI
Deliverable	List of identified/recruited DOE Fellow (Class of 2015)	10/30/15	Complete	
2015-P4-M2	Selection of new DOE Fellows – Fall 2015	10/30/15	Complete	
2015-P4-M3	Conduct Induction Ceremony – Class of 2015	11/05/15	Complete	
2015-P4-M4	Submit student poster abstracts to Waste Management Symposium 2016	01/16/16	Complete	
Deliverable	Update Technical Fact Sheet	30 days after end of project	On Target	

Work Plan for Next Quarter

- Complete the Year End Report (YER) for FIU Performance Year 6 (August 2015 to August 2016).
- Revise the Project Technical Plan (PTP) for FIU Performance Year 7 (August 2016 to August 2017) based on comments received from DOE's review.
- Continue research by DOE Fellows in the four DOE-EM applied research projects under the cooperative agreement and research topics identified as part of their summer internships.
- Finalize and submit DOE Fellow internship reports for summer 2016 at DOE sites, national laboratories, DOE-HQ, and DOE contractors.
- Complete selection of new DOE Fellows for the summer/fall recruitment period and submit list of selected DOE Fellows to DOE.
- Complete preparation and coordination for the DOE Fellows Poster Exhibition & Competition and host event on November 2, 2016.
- Complete preparation and coordination for the DOE Fellows Induction Ceremony for the Class of 2016 and host event on November 3, 2016.