QUARTERLY PROGRESS REPORT

April 1 to June 30, 2014

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

Principal Investigator:

Leonel E. Lagos, Ph.D., PMP®

Prepared for:

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

FIU | Applied Research Center
Florida International University

Introduction

The Applied Research Center (ARC) at Florida International University (FIU) executed work on five 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 April 1 to June 30, 2014.

The period of performance for FIU Year 4 under the Cooperative Agreement was September 17, 2013 to May 17, 2014 and the period of performance for FIU Year 5 will be May 18, 2014 to May 17, 2015. Therefore, the activities and accomplishments described in this summary report are divided between the FIU Year 4 and FIU Year 5 periods of performance: April 1 to May 17 and May 18 to June 30, respectively. Highlights during this reporting period include:

Program-wide:

- During this reporting period, FIU completed development and uploaded a total of five (5) Year End Report (YER) documents covering the technical period of performance for FIU Year 4 (September 2013 – May 2014) on June 30, 2014 (available on FIU's DOE Research website: http://doeresearch.fiu.edu/SitePages/2014.aspx). FIU coordinated with DOE-EM's Technical Monitor (Mr. John De Gregory) and DOE HQ technical leads for all five projects under this cooperative agreement.
- In addition, FIU received consolidated comments from DOE HQ on the FIU Year 5 Continuation Application (CA) on May 13, 2014. FIU incorporated the suggested revisions, developed resolutions to the comments, and sent the CA back to the DOE on June 12, 2014. The Continuation Application documents are submitted to the Department of Energy's Office of Environmental Management (DOE-EM) on an annual basis as part of the DOE-FIU Cooperative Agreement (under Contract # DE-EM0000598). The proposed projects represent FIU-ARC's technical support to DOE EM in the area of environmental remediation and workforce development.
- FIU also developed detailed Project Technical Plans (PTPs) to guide the completion of the work scope during FIU Year 5 and sent these to DOE on June 17, 2014.

Project 1:

- A summary document associated with milestone 2013-P1-M2.1.1 was sent to EM-21 and site contacts on 4/18/14. This document details the engineering scale testing of the asynchronous pulsing system. A summary document associated with milestone 2013-P1-M2.2.1 was also sent to EM-21 on 4/18/14. This document details the modeling of plugs in HLW pipelines and the effects pipeline geometry has on plug formation.
- A summary document associated with Milestone 2013-P1-M19.1.1 was sent to EM-21 on 4/18/14. This document provides a summary of the data analysis for the jumpers in the 242-A Evaporator Pit and the AW-02E Feed Pit.

- A draft experimental test plan for subtask 18.1.2 was sent to EM-21 on 4/25/14. The test plan provided information for the phase 2 testing of FIU's SLIM to detect residual waste during pulse jet mixer (PJM) cycling.
- A draft summary report associated with Subtask 2.2.1 was sent to EM-21 and site contacts on 5/2/14. This document details the computational fluid dynamics modeling of plug formation using the software package Comsol.
- A draft summary report associated with Subtask 19.1.1 was sent to EM-21 on 5/2/14. This document details the analysis of the data analysis for jumpers in the 242-A Evaporator and the 241-AW-02E Pit.
- A draft summary report associated with Subtask 18.2.2 was sent to EM-21 and site contacts on 6/9/14. This document details the development of a dynamic simulation model of the inspection tool for the AY-102 refractory pads.
- A draft summary document associated with milestone 2013-P1-M17.1.2 was sent to EM-21 and site contacts on 6/9/14. This document details the results on the non-Newtonian modeling of mixing multiphase flows.
- Draft topical reports for the asynchronous pulsing system and the peristaltic crawler were sent to EM-21 and site contacts on 6/16/14.
- A draft topical report for task 17.1 was submitted on 6/19/14 to EM-21 and the site contacts.
- A draft summary document associated with milestone 2013-P1-M2.1.2 was sent to EM-21 and site contacts on 6/18/14.
- Finally, FIU participated in the EM-21 program review teleconference on 6/17/14.

Project 2:

- For task 1, two deliverables titled "Progress report on characterization of new samples prepared to minimize nitratine impact" and "Progress report on atomic force microscopy (AFM) assessment of bacterial cells exposed to U(VI)" were completed and sent to DOE contacts on 4/21/2014 and 4/30/2014, respectively.

Project 3:

- Project 3 re-scoping discussions were held during this reporting period with the Savannah River Site and DOE HQ (EM-12 and EM-13). Conference calls were held on April 15 and 16, 2014 and new work scope which focuses on remediation and treatment technology at SRS and utilizes the capabilities developed under Project 3 was developed and submitted for approval.
- A technical report deliverable on "Geodatabase structure, customizations and scripting capabilities" for Task 3.4: Geodatabase Development for Hydrological Modeling Support was submitted to the DOE OR site and HQ contacts on 4/18/2014.
- The final technical report for Task 4: Geodatabase Development for Hydrological Modeling Support, associated with the Project 3 FIU Year 4 Carryover Work Scope, was completed and submitted as an Appendix to the FIU Year 4 Year End Report (available

on FIU's DOE Research website: http://doeresearch.fiu.edu/SitePages/2014.aspx) on 6/30/14.

Project 4:

- FIU completed milestone 2013-P4-M3.5, deployment of popular content displays on D&D KM-IT, and sent the link to DOE for review/testing on 4/24/2014.
- FIU completed milestone 2013-P4-M2.2, draft report on the aging infrastructure across the DOE complex and sent the report to DOE on 5/2/2014.
- FIU also completed milestone 2013-P4-M3.6, D&D management through contributions in Wikipedia and sent a draft summary report to DOE on 5/9/2014.
- Finally, FIU completed milestone 2013-P4-M5.1, the development and deployment of the environmental contamination and remediation model and sent the link to DOE for review/testing on 5/16/2014.

Project 5:

- A total of 9 DOE Fellows started their summer internship assignments in June and will spend their summer of 2014 working at DOE program offices or on environmental research projects under the guidance of their site mentors. Locations for the internships include DOE HQ (EM-12 and EM-13) in Washington, DC; Hanford, WA; Richland, WA; and Savannah River, SC.
- Six new DOE Fellows were hired during the Spring 2014 recruitment process and began their DOE Fellowship on June 9, 2014. The new DOE Fellows, all undergraduates, are majoring in mechanical engineering (2), environmental engineering (2), electrical engineering (1), and biomedical engineering (1).

FIU Year 4 Carryover Work Scope

The activities described in the Continuation Application for FIU Year 4 were planned for a period of performance from September 17, 2013 to May 17, 2014. However, a portion of the funding from Year 4 was provided near the end of the year and scope associated with these carryover funds is being performed in addition to scope associated with FIU Year 5. To differentiate the work scope, the carryover scope activities from FIU Year 4 being performed during FIU Year 5 are highlighted in gray.

The program-wide milestones and deliverables that apply to all projects (Projects 1 through 5) for FIU Year 4 are shown on the following table:

Task	Milestone/ Deliverable	Description	Due Date	Status	OSTI
Program-wide (All Projects)	Deliverable	Draft Project Technical Plan	10/17/13	Complete	
	Deliverable	Quarterly Progress Reports	Quarterly	Complete	
	Deliverable	Draft Year End Report	6/30/14	Complete	OSTI

The program-wide milestones and deliverables that apply to all projects (Projects 1 through 5) for FIU Year 5 are shown on the following table:

Task	Milestone/ Deliverable	Description	Due Date	Status	OSTI
Program-wide (All Projects)	Deliverable	Draft Project Technical Plan	06/18/14	Complete	
	Deliverable	Monthly Progress Reports	Monthly	On Target	
	Deliverable	Quarterly Progress Reports	Quarterly	On Target	
	Deliverable	Draft Year End Report	06/30/15	On Target	OSTI
	Deliverable	Presentation overview to DOE HQ/Site POCs of the project progress and accomplishments (Mid-Year Review)	11/21/14*	On Target	
	Deliverable	Presentation overview to DOE HQ/Site POCs of the project progress and accomplishments (Year End Review)	06/30/15*	On Target	

**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 were included in FIU Year 4:

- Task 2: Pipeline Unplugging and Plug Prevention
  - Subtask 2.1 – Development of Alternative Unplugging Technologies
  - Subtask 2.2 – Computational Simulation and Evolution of HLW Pipeline Plugs
- Task 17: Advanced Topics for Mixing Processes
  - Subtask 17.1 – Multiple-Relaxation-Time, Lattice Boltzmann Model for High-Density Ratio, Multiphase Flows
- Task 18: Technology Development and Instrumentation Evaluation
  - Subtask 18.1 – Evaluation of FIU's Solid-Liquid Interface Monitor for Rapid Measurement of HLW Solids on Tank Bottoms
  - Subtask 18.2 – Development of Inspection Tools for DST Primary Tanks
- Task 19: Pipeline Integrity and Analysis
  - Subtask 19.1 – Pipeline Corrosion and Erosion Evaluation

The following tasks are included in FIU Year 5:

- Task 2: Pipeline Unplugging and Plug Prevention
  - Subtask 2.1.1 – Support for Potential Deployment of the Asynchronous Pulsing System and the Peristaltic Crawler
  - Subtask 2.2.1 – 2D Multi-Physics Model Development
- Task 17: Advanced Topics for Mixing Processes

    - Subtask 17.1.1 – Computational Fluid Dynamics Modeling of Jet Penetration in non-Newtonian Fluids

- Task 18: Technology Development and Instrumentation Evaluation
    - Subtask 18.1.1 – Evaluation of SLIM for Rapid Measurement of HLW Solids on Hanford Mixing Tank Bottoms
    - Subtask 18.1.2 – Testing of SLIM for Deployment in HLW Mixing Tanks at Hanford
    - Subtask 18.2.1 – Development of First Prototype for DST Bottom and Refractory Pad Inspection
    - Subtask 18.2.2 – Investigation of Using Peristaltic Crawler in Air Supply Lines Leading to the Tank Central Plenum

- Task 19: Pipeline Integrity and Analysis
    - Subtask 19.1.1 – Data Analysis of Waste Transfer Components
    - Subtask 19.2.1 – Development of a Test Plan for the Evaluation of Nonmetallic Components
    - Subtask 19.2.2 – Preliminary Experimental Testing of Nonmetallic Components

Task 2: Pipeline Unplugging and Plug Prevention

Task 2 Overview

Over the past few years, FIU has found that commercial technologies do not meet the needs of DOE sites in terms of their ability to unplug blocked HLW pipelines. FIU has since undertaken the task of developing alternative methods/technologies with the guidance from engineers at the national laboratories and site personnel. The new approaches that are being investigated include an asynchronous pulsing system (APS) and a peristaltic crawler system (PCS). Both technologies utilize lessons learned from previous experimental testing and offer advantages that other commercially available technologies lack. The objective of this task is to complete the experimental testing of the two novel pipeline unplugging technologies and position the technologies for future deployment at DOE sites. Another objective of this task is to develop computational models describing the build-up and plugging process of retrieval lines. In particular, the task will address plug formation in a pipeline, with a focus on the multi-physical (chemical, rheological, mechanical) processes that can influence the formation.

Task 2 Quarterly Progress – April 1 – May 17, 2014

Subtask 2.1: Development of Alternative Unplugging Technologies

For the asynchronous pulsing subtask, efforts in April concentrated on completing unplugging tests. After analyzing the parametric testing results, it was decided to perform unplugging experiments using triangle, square, and sine waves at frequencies of 1, 2 and 3 Hz. A total of nine experiments were conducted and unplugging was achieved during each experiment. Table 1-1 shows the results of each test, including the signal type, frequency, the average peak, trough and amplitude of both static and dynamic pressures, as well as the number of cycles and cycle time needed to unplug the pipeline.

Table 1-1. Unplugging Test Results

Signal Type	Frequency (Hz)	Static Pressure Transducer			Dynamic Pressure Transducers			Cycle Count	Cycling Time (sec)
		Average Peak (psi)	Average Trough	Average Amplitud	Average Peak (psi)	Average Trough	Average Amplitud		
Triangle	1	192.5	0	192.5	60.5	-6.75	67.25	1973	1973
Triangle	2	141.5	45	96.5	31.5	-3.4	34.9	2805	1403
Triangle	3	142.5	50	92.5	30	-6.5	36.5	15818	5273
Square	1	192.5	30	162.5	34	-31.5	65.5	2708	2708
Square	2	156	32.5	123.5	17	-35	52	4344	2172
Square	3	142	45	97	31.5	-15	46.5	9892	3297
Sine	1	197.5	17	180.5	58	-6	64	1816	1816
Sine	2	148	42	106	33	-5	38	5113	2557
Sine	3	137.5	55	82.5	9	-29	38	8162	2721

An example of the pressure data obtained during the unplugging trials is provided in Figure 1-1. Prior to the unplugging occurring, the pressure profile on each side of the plug face has a sharp peak, while after unplugging, the profile amplitude is reduced and develops a flat peak. This change in the profile is due to water leaking past the blockage.

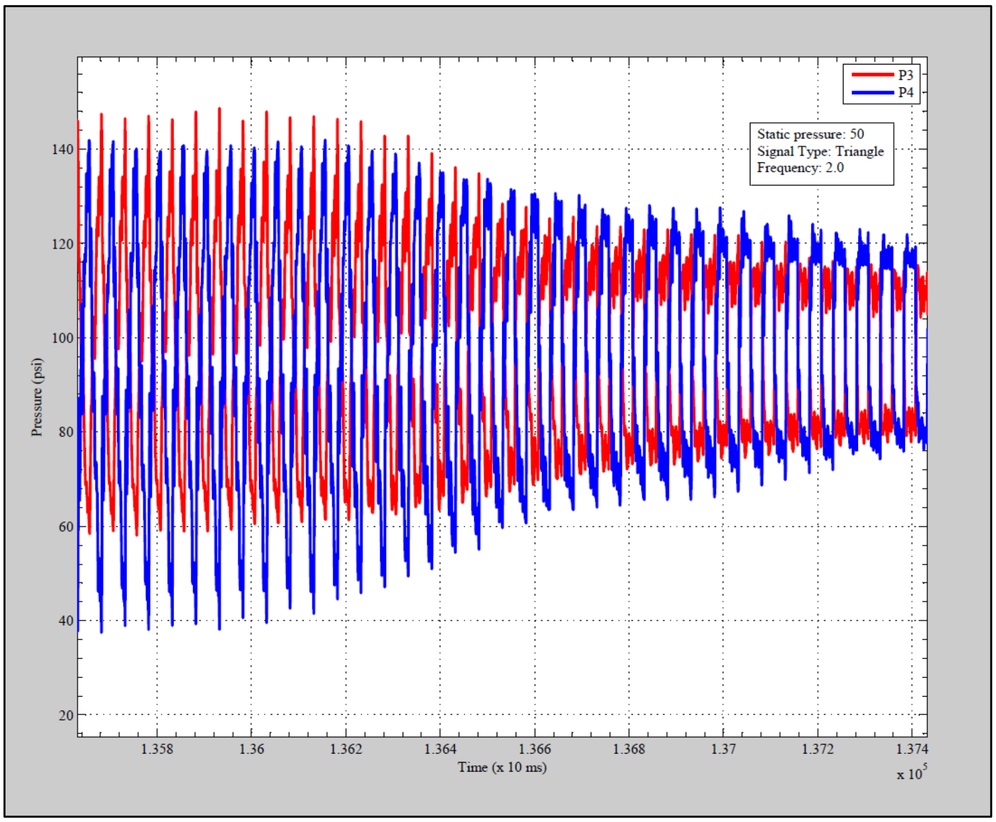


Figure 1-1. Unplugging pressure profile for a triangle wave at 2 Hz.

Additional efforts concentrated on completing the data analysis and reporting results. While analyzing the data, it was discovered that two unplugging trials had significantly shorter unplugging times than a majority of trials. Figure 1-2 shows pressure responses at each face of the plug for one of these trials. Since all plugs were manufactured using the same batch of kaolin and plaster of Paris, it was concluded that the deviation was due to manufacturing variances which has been well documented in simulants made with kaolin clay. A second set of trials were repeated using plugs manufactured with the same material and procedure. Operational parameters for the trials were repeated and the results were similar (in terms of unplugging times) with the general trends. Figure 1-3 shows the results from a repeated trial.

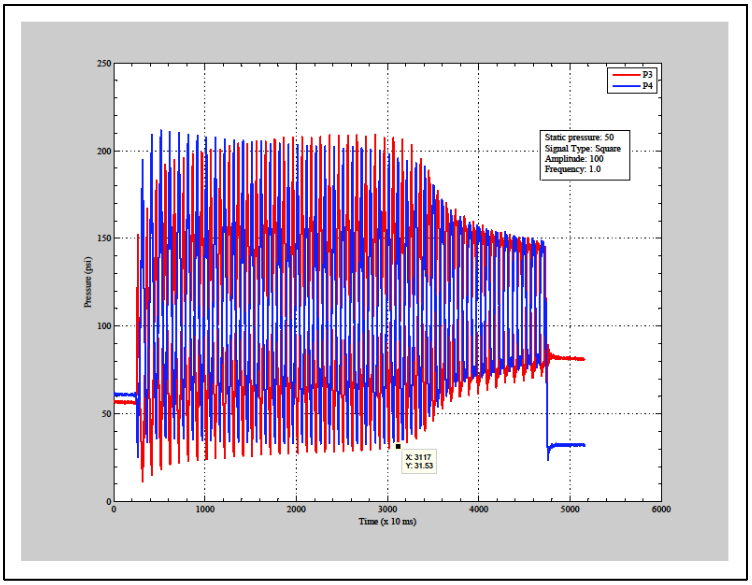


Figure 1-2. Pressure responses of an unplugging trial with significantly shorter unplugging time.

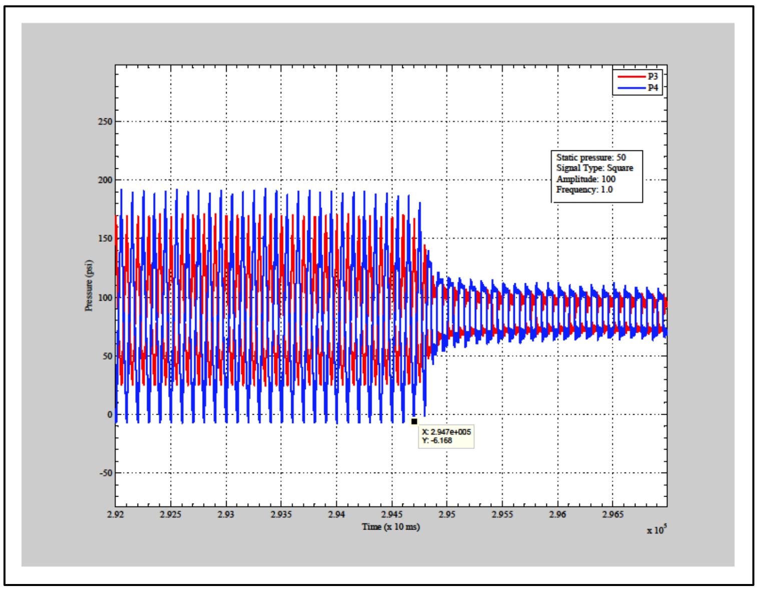


Figure 1-3. Pressure results from a repeated unplugging trial.

For the peristaltic crawler subtask, the experimental testing using the engineering-scale testbed was conducted. The hydraulic, pneumatic and electrical systems of the crawler were connected to the control station using the 500-ft tether. Prior to introducing the crawler at the inlet point, the pipeline was flooded and the ends were elevated to keep the water inside the pipeline. During the testing, the crawler navigated 41 ft before reaching the first elbow in 2 hours, 17 minutes (approximately 24 ft/hr). The time recorded to clear the first elbow was 16 min. After clearing the elbow, the crawler stopped navigating and it was necessary to uncouple the pipeline after the first elbow (Figure 1-4) to address any possible issues. Navigational tests of the crawler were then continued from the crawler's last position in the pipeline. The longest distance recorded was 60 ft with a total time elapsed of approximately 4 hours.

Figure 1-4. Issues encountered after clearing the first elbow.

During additional testing, the crawler navigated 41 ft in 2.25 hours and cleared the 1^{st} elbow in 17 minutes. It was observed that higher pressures were required to continue crawling after the first elbow. Increasing the bellow pressure to 50 psi generated the necessary pulling force but required the sequence cycle to lengthen from 16 to 32 seconds to allow for deflation of the bellow. The longest navigational distance achieved after the 1^{st} elbow was 7 ft.

For the experimental testing conducted to date, issues related to the durability of the crawler components were observed. These include premature damage of the pneumatic lines caused by cyclic pressurization and rupture of the front and back cavities. Although the unit was fatigue tested in prior testing, the unit was not fatigue tested under load (i.e. pulling the tether). The added axial load creates an increase of the stress concentrations on the rubber cavities at the clamp. Additionally, the increase in pressure and pressurization times of the pneumatic lines caused failures of the pneumatic connectors at the valves. Figure 1-5 shows the position achieved by the crawler after the first elbow and failure of the pneumatic lines. FIU determined that pneumatic lines rated to higher pressure were needed to prevent failure.

Figure 1-5. Largest distance achieved after elbow, failure of the pneumatic lines at the valves.

Subtask 2.2: Computational Simulation and Evolution of HLW Pipeline Plugs

For the computational simulation of HLW pipeline plugs subtask, efforts were focused on developing a 2D numerical model that could simulate precipitation kinetics of solids growth in a pipeline. This required solving the three interfaces: 1) flow interface, 2) chemical reaction interface, and 3) mixture interface. The model geometry for the simulations consisted of a two dimensional (2D) horizontal pipe with a diameter of 0.078 meters and a length of 1.84 meters. The model inputs used for the three interfaces are shown in Figure 1-6. The flow output was used as input to the chemical interface to simulate an irreversible chemical reaction involving three species. The chemical reaction resulted in the formation of product species whose units were in terms of molar concentration. Since the mixture interface uses volume fraction as an input, the data output of the chemical interface was exported to a text file where the data was converted from molar concentration to volume fraction. Then, the text file with the conversion factor was imported back and used as an input condition to the mixture interface to simulate solids growth in a pipeline.

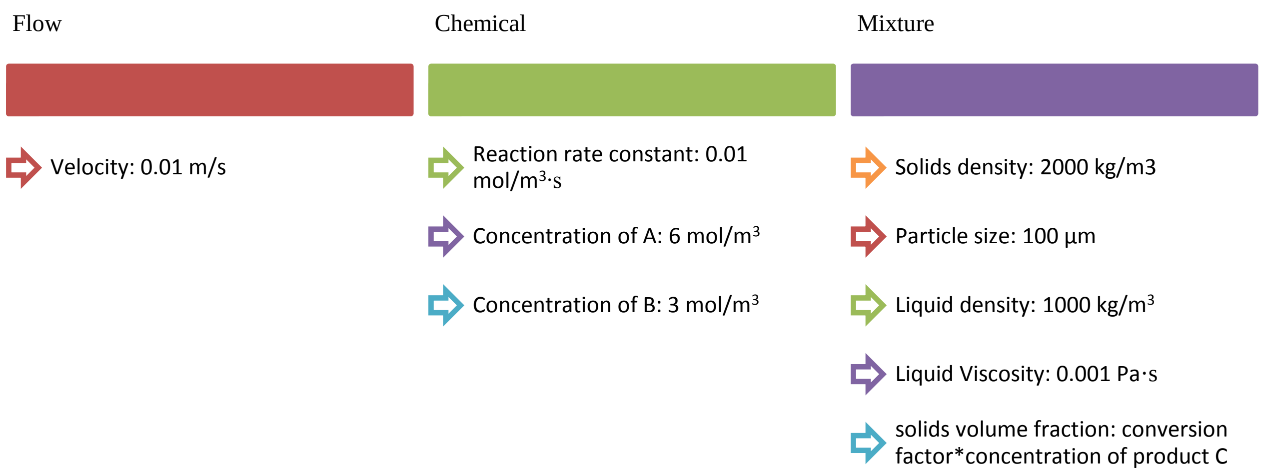


Figure 1-6. Model inputs used for the numerical simulations.

The flow interface was solved first to compute the velocity fields within the model domain. The flow became fully developed once it passed the entrance region. The slice plot of flow velocity along the cross sections of the pipe is shown in Figure 1-7. The maximum velocity is shown by the red color.

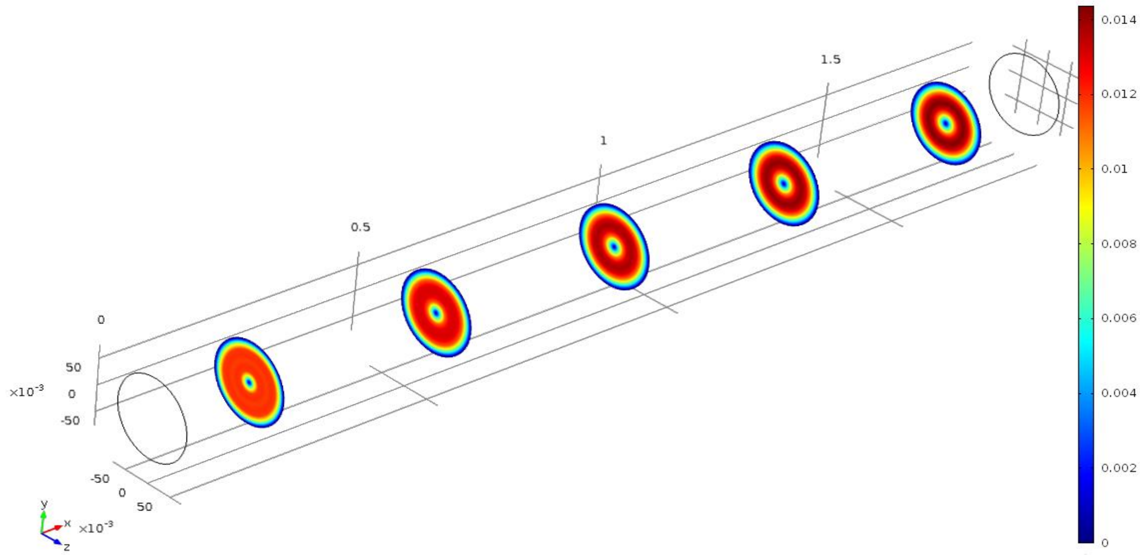


Figure 1-7. Velocity profile along the cross-sections of the pipe.

The calculated velocity field from the flow interface was next used as an input to the chemical reaction interface to study the evolution of chemical species transported by diffusion and convection mechanisms. An irreversible, isothermal chemical reaction with three species (A+B→C) was simulated within the pipe. Here, species A and B were the reactants and species C was the product that was formed. A reaction rate constant was applied that governed the reaction kinetics between the species. The concentration of species A decreased from 6 mol/m^3 to about 4.5 mol/m^3 as it became consumed as shown in Figure 1-8.

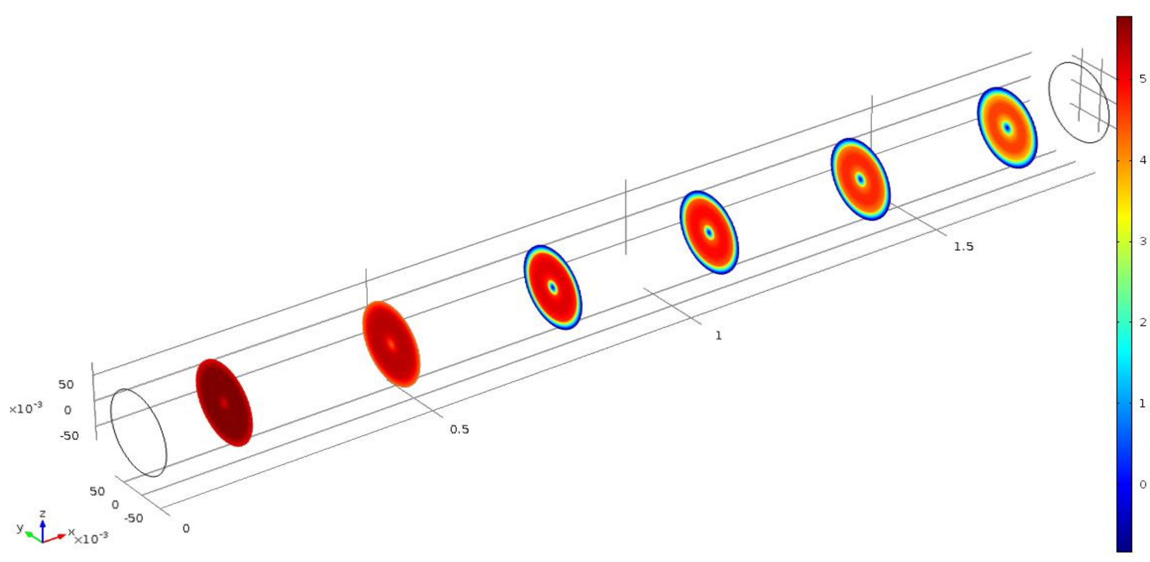


Figure 1-8. Concentration snapshot of species A as it undergoes a chemical reaction.

The concentration of species C at the same time increased from 0 mol/m^3 to about 1.8 mol/m^3 as it was produced in the pipeline as shown in Figure 1-9.

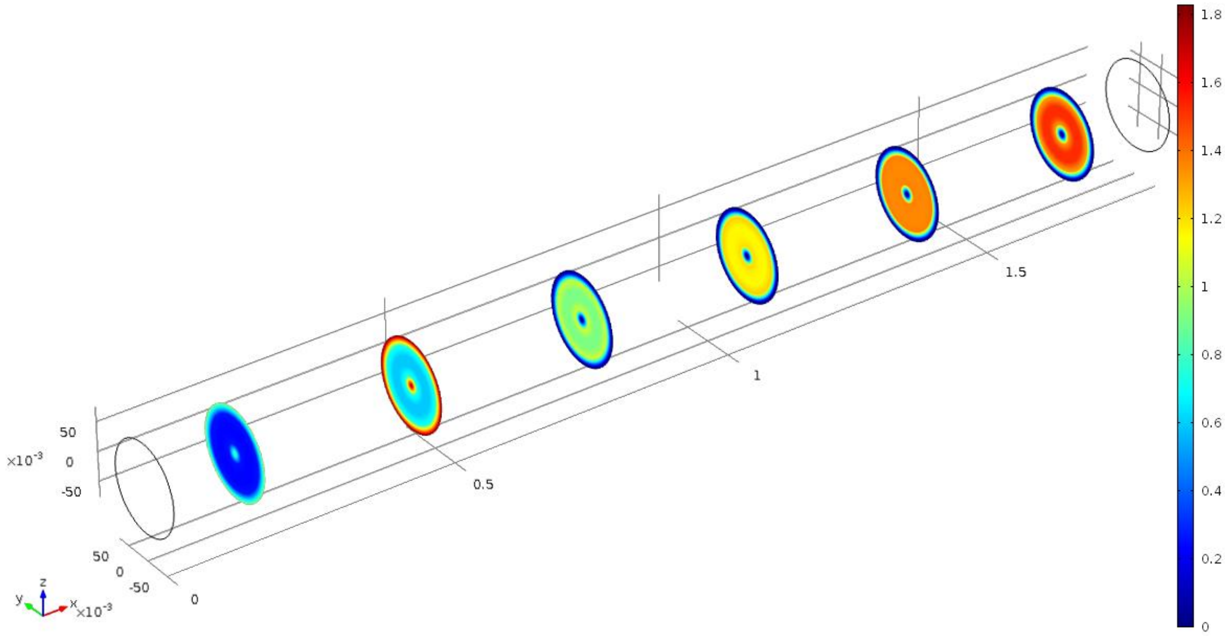


Figure 1-9. Concentration snapshot of species C as it was produced.

The growth profile of product species C was next used to simulate solids growth in a pipeline. The idea was to model the precipitation kinetics which involves a gradual increase in solids concentration as they react. This translates into an increase in the volume fraction of solids in a pipeline. Since the concentration output of the chemical reaction interface is in molar concentration, the data was exported into Excel and converted to the volume fraction units. This required taking into consideration the molarity and solids density values. After the data conversion was completed, the data file was imported back into the model to simulate the growth of solids in a pipeline. The mixture interface consisted of two phases: a continuous phase which was water and a dispersed phase which was solids. The sum of the two phases was equal to 1. Initially the pipe had zero volume fractions of the solids (i.e., it was 100% filled with water). Hence, the volume fraction of the continuous phase was 1 at the start of the simulation. The volume fraction of the continuous phase decreased from 1 to 0.983 as the solids grew in the pipeline as shown in Figure 1-10.

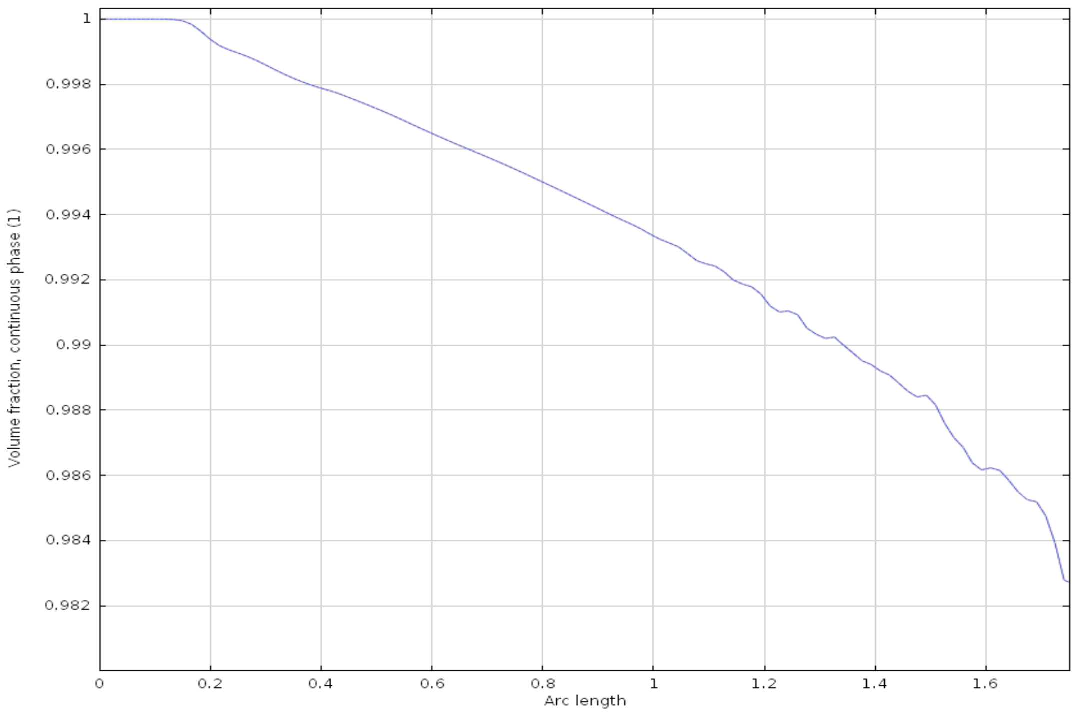


Figure 1-10. Volume fraction of continuous phase along the pipe length.

At the same time, the volume fraction of the solids increased from 0 to 0.017 as they were formed along the pipe length as shown in Figure 1-11.

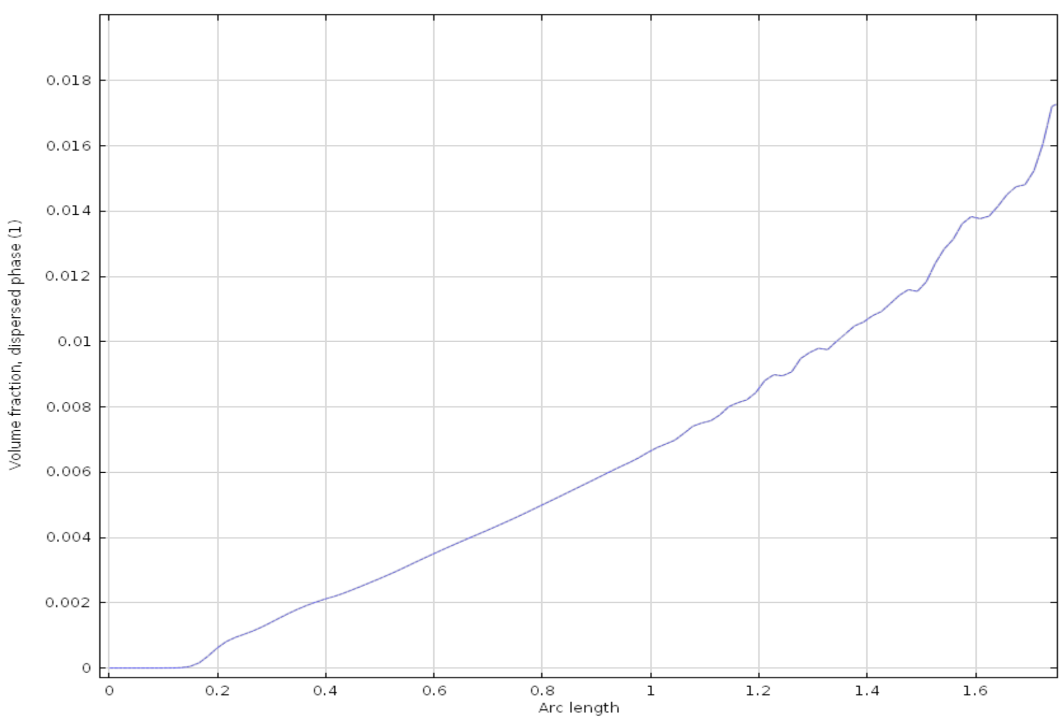


Figure 1-11. Volume fraction of dispersed phase along the pipe length.

In the past, the flow and chemistry modules in COMSOL were one-way coupled. The species modeled were diluted and their density was assumed to be that of water. The mixture interface that models the settling dynamics could not be coupled to the chemistry interface since the species did not have density as an input model parameter. Hence, a new model was created that could simulate two way interactions between flow and chemistry physics and aid in developing the precipitation model. The interfaces that seemed to suffice the model development approach include using the following two interfaces and coupling them:

- Laminar flow with compressible formulation. This formulation allows for changes in density, which is needed because of the volumetric change caused by the dissociation reaction.
- Transport of concentrated species. This handles the species transport in systems with high concentrations, where Fick's law is not valid.

The modeling efforts were focused on simulating coupled flow-gas interactions. The successful implementation of the coupling will next be extended to model flow-solid reactions.

The implementation of two-way coupling required investigating the set-up process needed to couple the interactions. The COMSOL documentation guide and tutorials were reviewed to increase the knowledge base. After finalizing the two interfaces, the model geometry consisting of horizontal pipe was created and the mesh to partition the model domain was researched. It was determined that the use of a mapped mesh, which is structured, to discretize a long and thin geometry, typical for tubular pipes, was the optimal choice.

Task 2 Quarterly Progress – May 18 – June 30, 2014

FIU Year 4 Carryover Work Scope

Subtask 2.1: Development of Alternative Unplugging Technologies

Following the repeating of the unplugging trials for the asynchronous pulsing system, data analysis resumed, comparing pressure differentials, dynamic responses and cycle counts. During the analysis, it was observed that even though the plugs were unplugging, the system was not delivering the optimal pressure pulses to the plug. As can be seen in Figures 1-12 and 1-13, pressure transducer 4 recorded a higher reading than transducer 3. Since both transducers were calibrated before installation, the difference in pressure can be explained by small amounts of residual air trapped within the pipeline on the transducer 3 side.

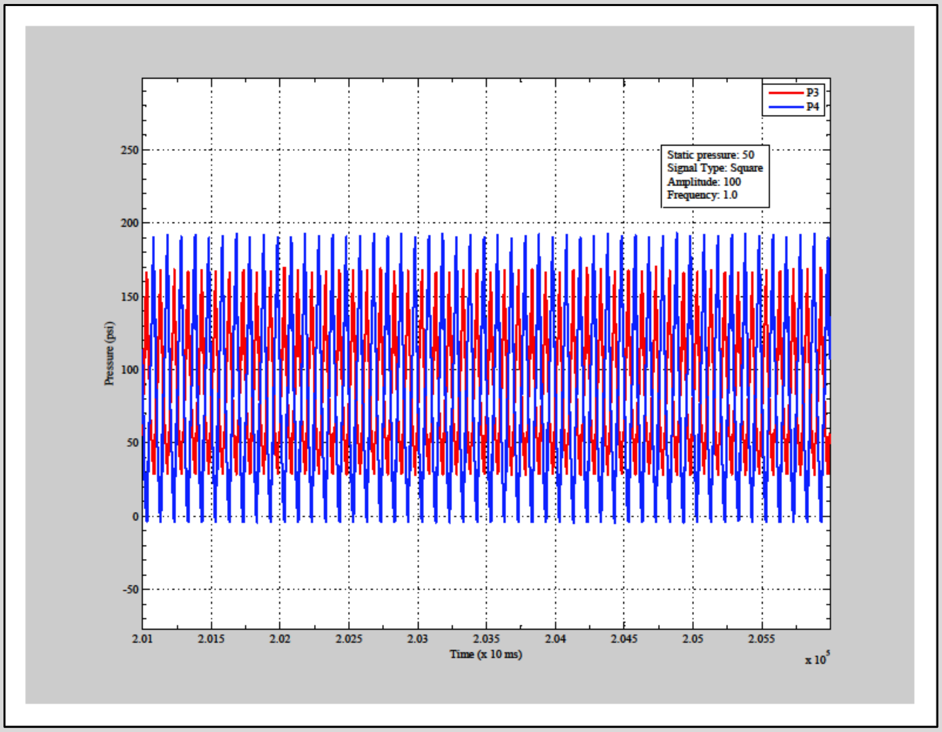


Figure 1-12. Square wave pulse at 1 Hz.

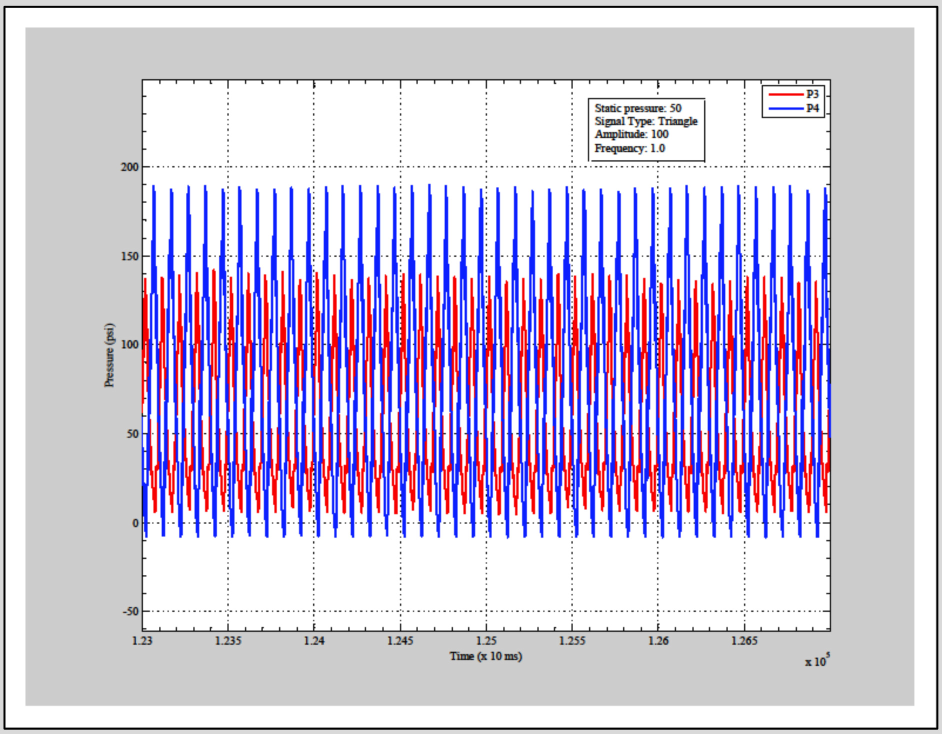


Figure 1-13. Triangle wave pulse at 1 Hz.

Efforts next concentrated on developing several test strategies to systematically determine the system's limitations when air is entrapped in the engineering scale pipeline system. We have performed similar trials in the past with smaller pipe loops and used this data to estimate the effects and mitigation techniques for the larger pipeline. The following tests will serve as a validation and will include a variable that wasn't present previously; namely the inclusion of a sample test plug during the air mitigation process. The main concern is that applying the mitigation techniques would pre-fatigue the test plug before being able to accurately perform the unplugging testing. Currently, our test process includes a resting time to allow the air to agglomerate and travel, followed by applying a minor vacuum combined with several pulses to vibrate the water column. The vacuum serves to expand air pockets that may be trapped in crevices while the column vibration aids the air to travel towards the venting points. This mitigation process was performed in the past without a sample plug since this was conducted as part of performing parametric and baseline testing. We are considering the implementation of these removal processes to allow us to obtain data on the maximum amount of air within the pipeline where the system can still unplug. However, we must first determine if our mitigation techniques will pre-fatigue the sample and yield non-representative results. For this reason, plug fatigue tests are being developed to determine plug performance after exposure to air mitigation techniques within the pipeline.

In addition, a topical report describing the evolution and testing of the asynchronous pulsing system was submitted to EM-21 and site contacts on 6/16/14 for review.

For the peristaltic crawler subtask, the experimental testing using the engineering-scale testbed continued. The pneumatic lines were upgraded to handle higher pressures. During different trials of the navigational tests, failures in the front and back cavity were observed. Previous bench-scale tests showed a life-time for the cavities of over 15,000 cycles. However, due to the deflection of the cavities caused by pulling the tether, stress risers along the circumference of the clamp resulted in a shorter life of the cavities. Figure 1-14 shows a failure of the rear cavity. Tests were continued by replacing the cavities each time they failed and re-starting the navigational from the last point along the pipeline. The largest distance recorded was 60 ft from the inlet point. After several attempts, a loss of vacuum was observed. It was concluded that atmospheric moisture accumulated in the vacuum pump's oil, preventing it from working properly. Figure 1-14 also shows the vacuum pump's oil saturated with moisture.

Figure 1-14. Failure of the rear cavity, moisture accumulated in the vacuum pump.

Efforts on the peristaltic crawler system next focused on repairs for the vacuum pump due to moisture accumulation. After replacing the oil, it was determined that the vanes needed lubrication for proper functioning. Once repaired, the pump was tested and connected to the crawler's vacuum port. Additionally, the design of a testbed to evaluate the PCS in a schedule 40 pipeline was completed and the space requirements were approved. Figure 1-15 shows the layout of the testbed. It includes two 21 ft and one 12 ft straight sections coupled together with two 90° elbows. In order to use the available resources, the two 21-ft threaded-end sections will be coupled to threaded-Victaulic fittings and the 12-ft section will be grooved in-house.

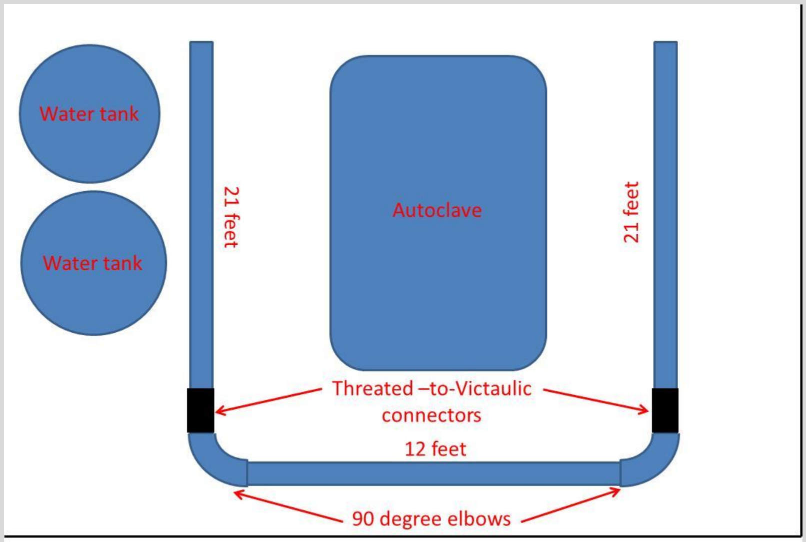


Figure 1-15. Testbed for evaluating schedule 40 pipes.

Additionally, a topical report detailing all the research to date for this task was provided to EM-21 and site contacts on 6/16/14. A Year End Report corresponding to the work conducted in FIU Year 4 (FY13) and a summary document for the milestone corresponding to 2013-P1-M2.1.2 was also submitted.

FIU Year 4 Carryover Work Scope

Subtask 2.2: Computational Simulation and Evolution of HLW Pipeline Plugs

A computational model was created, investigating the two-way coupling of flow and chemical interfaces. In the numerical approach implemented, species A reacts to form B as shown in the Figure 1-16. The conversion and reaction distribution was modeled as an isothermal tubular reactor under steady-state conditions.

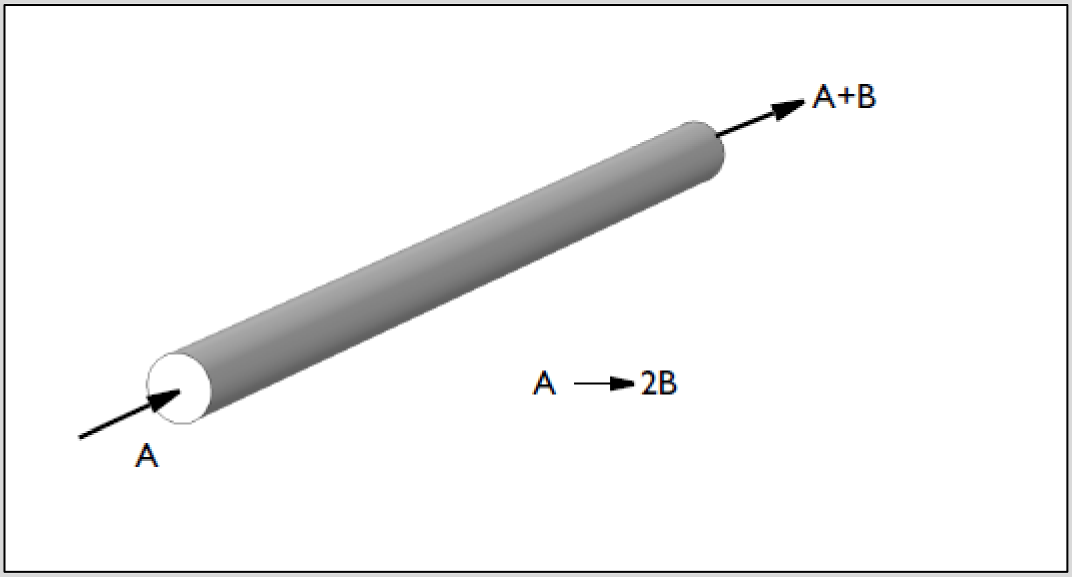


Figure 1-16. Dissociation reaction in a pipe.

Each mole of the reactant, A, reacted to form two moles of the product, B. As the dissociation reaction proceeds, the composition of the mixture changes from pure A at the inlet to a mixture of A and B. The dissociation led to a volumetric expansion of the gas mixture as the reaction proceeded. The fluid's change in density influenced the gas velocity in the reactor, causing acceleration as the reaction proceeded.

Under isothermal conditions, the Laminar Flow and Transport of Concentrated Species user interfaces in COMSOL Multiphysics were applied to solve the coupled model of the compressible Navier-Stokes equations and the Maxwell-Stefan convection and conduction equations. Figure 1-17 shows the velocity magnitude for the isothermal case at different cross-sections of pipe. The velocity increases along the axis direction (z) because of the volume expansion of gas mixture during the proceeding of reaction. The maximum of velocity was found at the center of the tube due to the no-slip on the side surface

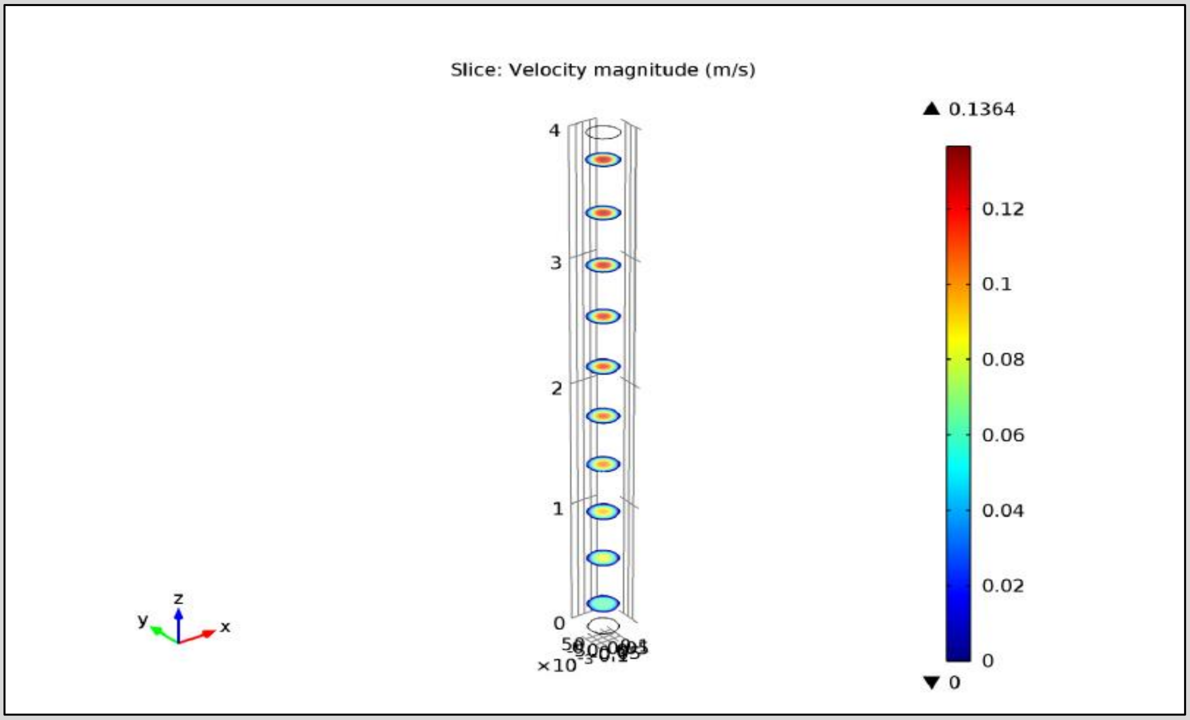


Figure 1-17. Velocity magnitude at different cross sections of pipe.

Figure 1-18 shows the mass fraction of species B for the isothermal case at different cross-sections of pipe. The closer to the side surface, the lower is the convective flow velocity, which gives rise to the higher mass fraction of species B towards the tube surface. The average mass fraction of species B at the outlet is 68.7%.

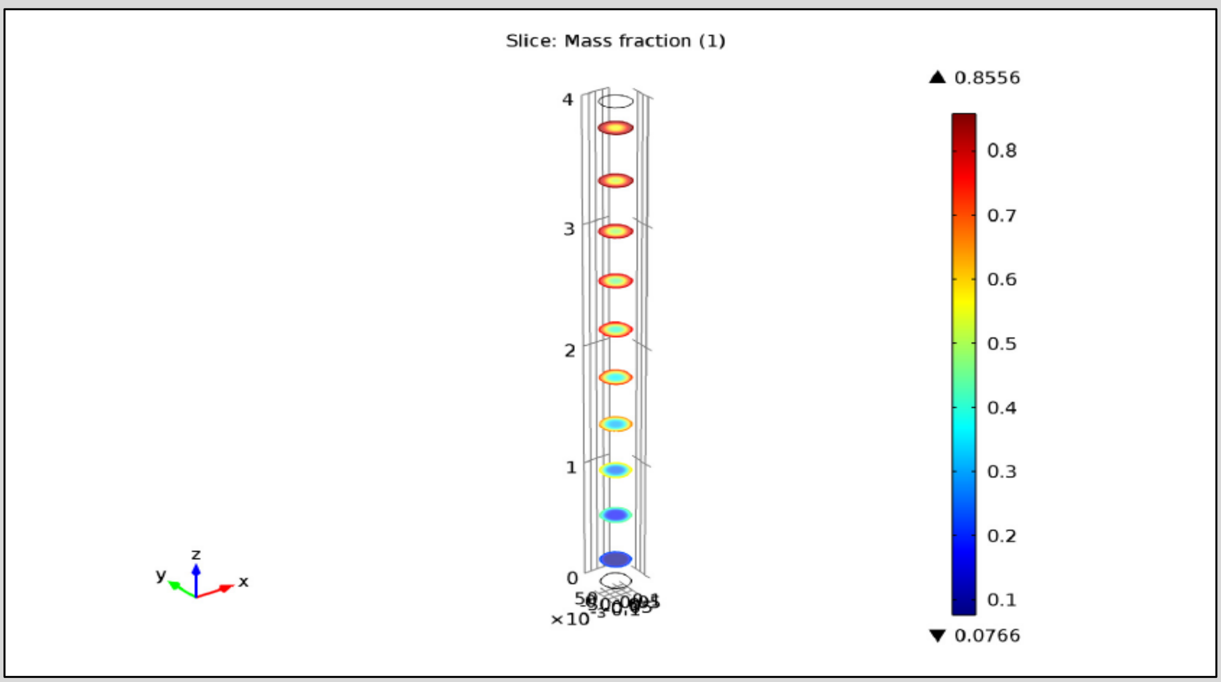


Figure 1-18. Mass fraction of species B at different cross sections of pipe.

During this performance period, a baseline computational model was created that models the flow in a 90° pipe elbow. Successful convergence of the numerical model will then be extended to include two phase mixture flow to simulate settling dynamics in a bended pipe. The model simulated the pipe flow using the k-ω turbulence model. The results will be compared to experimental correlation in order to determine the numerical accuracy. The numerical model will then be extended to include two phase mixture flow to simulate settling dynamics in a bended pipe.

The model geometry is shown in Figure 1-19. It includes a 90° pipe elbow of constant diameter, D, equal to 35.5 mm, and coil radius, R_c, equal to 50 mm. The straight inlet and outlet pipe sections are both 200 mm long. Only half the pipe is modeled because the xy-plane is a symmetry plane. The working fluid is water at temperature T=90°C and the absolute outlet pressure is 20 bar. The density, ρ, is 965.35 kg/m^3 and the dynamic viscosity, μ, is $3.145 \cdot 10^{-4}$ Pa·s. The water was approximated as incompressible. The flow at the inlet is a fully developed turbulent flow with an average inlet velocity of 5 m/s.

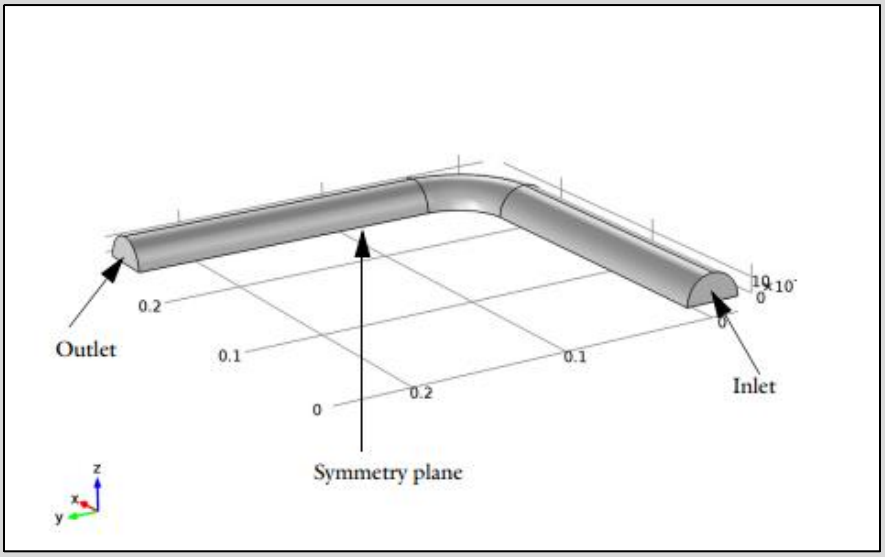


Figure 1-19. Pipe elbow geometry.

The high Reynolds number, $Re_D=5.45 \cdot 10^5$ based on the pipe diameter, calls for a turbulence model with wall functions. Here the k-ω model is selected over the k-ε model. The reason for this is that the k-ε model shows separation after the bend[1] and the k-ε model has a tendency to

[1] G.F. Homicz, "Computational Fluid Dynamic Simulations of Pipe Elbow Flow," SAND REPORT, SAND2004-3467, 2004.

perform poorly for flows involving strong pressure gradients, separation and strong streamline curvature[2].

The mesh used was structured with the exception that the mesh in the bend itself was unstructured as shown in Figure 1-20.

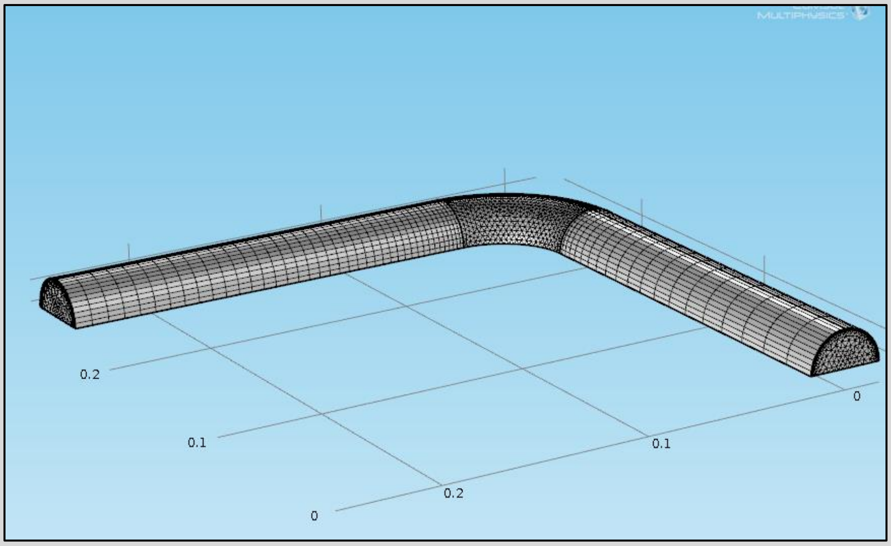


Figure 1-20. Mesh used for the pipe elbow geometry.

The inlet conditions were obtained from a 2D axisymmetry model where the inlet profiles in turn were plug flow profiles. The entrance length for this Reynolds number was approximated to 35 pipe diameters, but to ensure that the flow really became fully developed, the 2D pipe was 100 diameters long. The outlet results from the 2D pipe were mapped onto the inlet boundary of the 3D geometry by using coupling variables.

The resulting streamline pattern is shown in Figure 1-21. There is a separation zone observed after the bend which was consistent with the results observed by Homicz[3]. Further downstream, two counter-rotating vortices were formed, caused by the centripetal force.[4] Only one of the vortices was visible in Figure 1-21 since the other was located on the other side of the symmetry plane.

---

[2] F. Menter, "Zonal Two Equation k-ω Turbulence Models for Aerodynamic Flows," AIAA Paper #93-2906, 24th Fluid Dynamics Conference, July 1993.
[3] G.F. Homicz, "Computational Fluid Dynamic Simulations of Pipe Elbow Flow," SAND REPORT, SAND2004-3467, 2004.
[4] http://www.thermopedia.com/content/1113/?tid=104&sn=1420

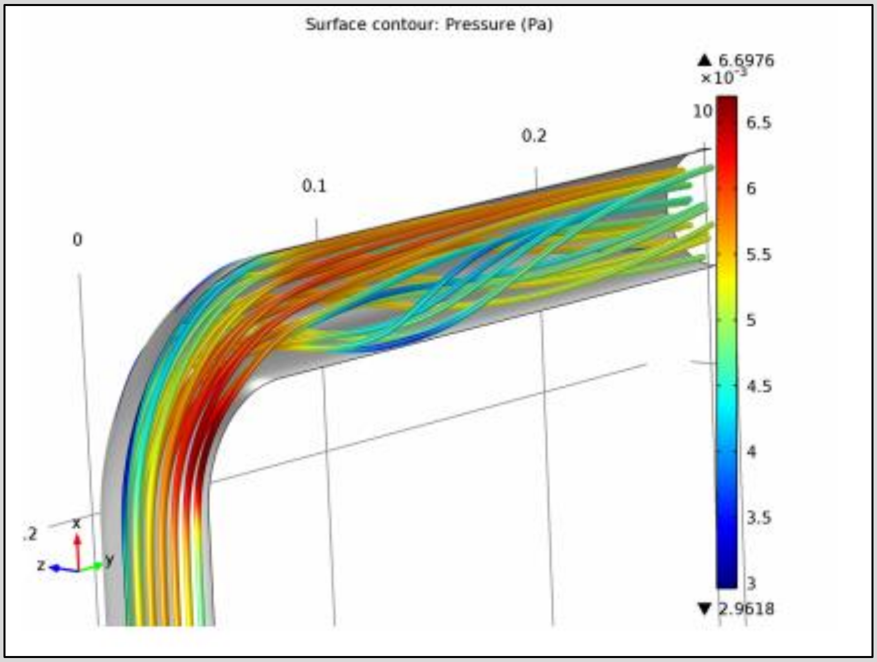


Figure 1-21. Streamlines colored by the velocity magnitude.

A major part of the work efforts were also focused on submitting several project documents such as the Year End Report, Project Technical Plan and presentation material for the EM-21 Program review.

Task 17: Advanced Topics for HLW Mixing and Processing

Task 17 Overview

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.

Task 17 Quarterly Progress – April 1 – May 17, 2014

Subtask 17.1: Multiple-Relaxation-Time, Lattice Boltzmann Model for High-Density Ratio, Multiphase Flows

During April, FIU implemented the velocity boundary conditions in the Lattice Boltzmann Model (LBM) code in order to simulate the fluid injections in Newtonian and non-Newtonian fluids. The flow injection was created by adjusting the values of the *f* and *g* distribution functions before the streaming step according to the inlet velocity and density values. The figure below shows such an example where a portion of the left boundary (40<y<60) has been designated as the inflow boundary where the fluid injection occurs. A velocity value of 0.001 has been assigned. The initial condition for the flow field was set for a stationary circular bubble located at the center of the domain. As a result of the injection process, the bubble is dislocated towards the right at the speed induced by the inflow boundary condition. The right side of the domain has also a portion designated to be the outflow boundary condition where the injected fluids exit the domain.

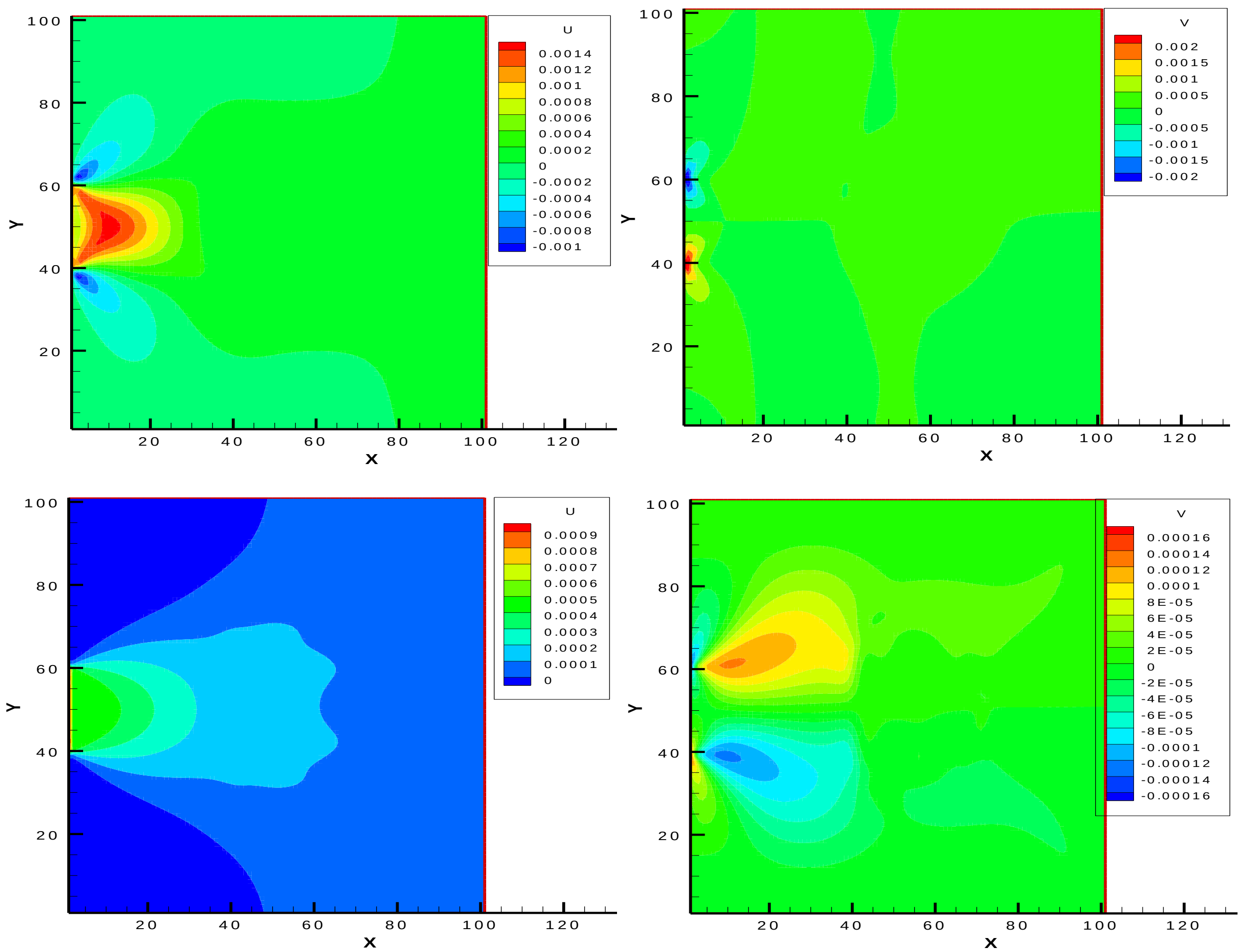


Figure 1-22. Contours of horizontal and vertical velocity components in a square domain caused by injection at the left boundary in a Newtonian fluid (top row) and a Bingham plastic (bottom row).

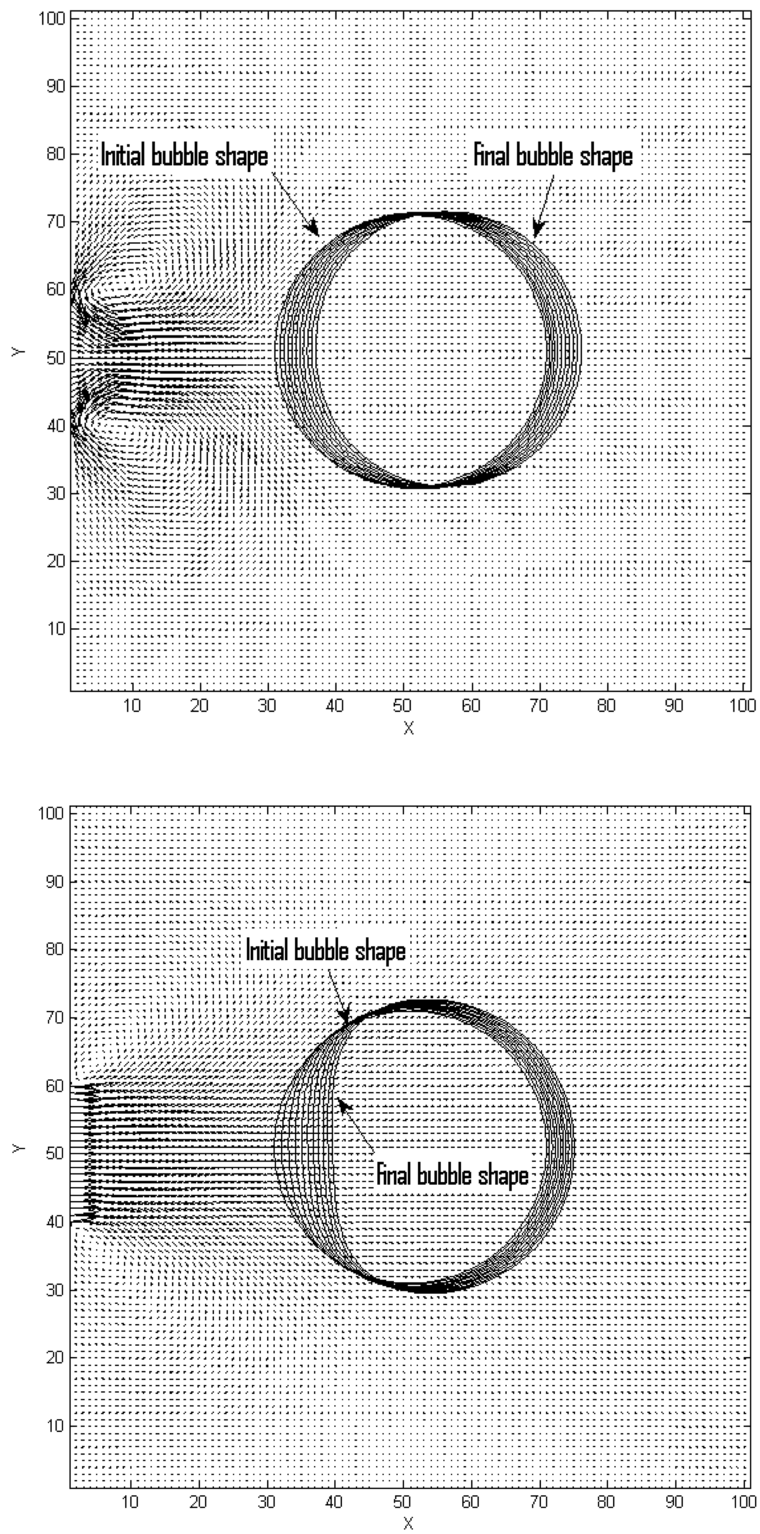


Figure 1-23. Bubble interface displacement from initial to final state caused by the injection at the left boundary in a Newtonian fluid (top figure) and Bingham plastic (bottom figure).

The above figures show that the circular bubble shape is maintained in the Newtonian flow case where the displacement of the interface in the high speed and low speed zones are the same due to constant viscosity; however, in the Bingham plastic case, the deformation of the bubble in the high speed zone is larger as compared to the low speed zone since the viscosity is lower in this area caused by the increase shear stress in the area near the injection due to high velocities. This study exemplifies the challenges in mobilizing bubbles in nuclear waste sludge that exhibit Bingham plastic behavior due to the differences in the fluid characteristics.

During early May, FIU continued the implementation of the velocity boundary conditions in the LBM code in order to examine the effects of the fluid injections in multiphase systems with Newtonian and non-Newtonian fluids. Two separate simulations have been created with the same geometry, flow conditions and solver settings except that the viscosity definition for the main phase was set to Netwonian fluid for case 1 and a non-Newtonian fluid in case 2 in a rectangular domain of size 51 X 101 in lu (lattice units). A portion of the left boundary ($20<y<30$) has been designated as the inflow boundary where the fluid injection occurs at an inlet velocity of $u=3x10^{-3}$ lu/ts, which corresponds to a Reynolds number of 9 for the Newtonian case. The initial condition for the flow field was set for 6 stationary circular bubbles dispersed randomly inside the domain (Figure 1-24). As a result of the injection process, the fluid inside the container starts mixing and the bubbles are dislocated at the local flow speed induced by the inflow boundary condition. The right side of the domain has also a portion designated to be the outflow boundary condition where the injected fluids exit the domain. Figure 1-25 shows the time change of the density distribution of the container in both cases at the same time intervals. It was observed that the flow pattern induced by the incoming laminar jet has created a vastly different mixing scenario in case 2 with the Bingham plastic material. Our simulations are indicative that CFD can be utilized as a predictive tool to identify the changes in the performance of pulsed-jet mixers in nuclear waste tanks when the injections occur in the supernate layer where the fluid characteristics are similar to a Newtonian fluid as compared to the slurry layer where a Bingham plastic type of sludge material is expected to exist.

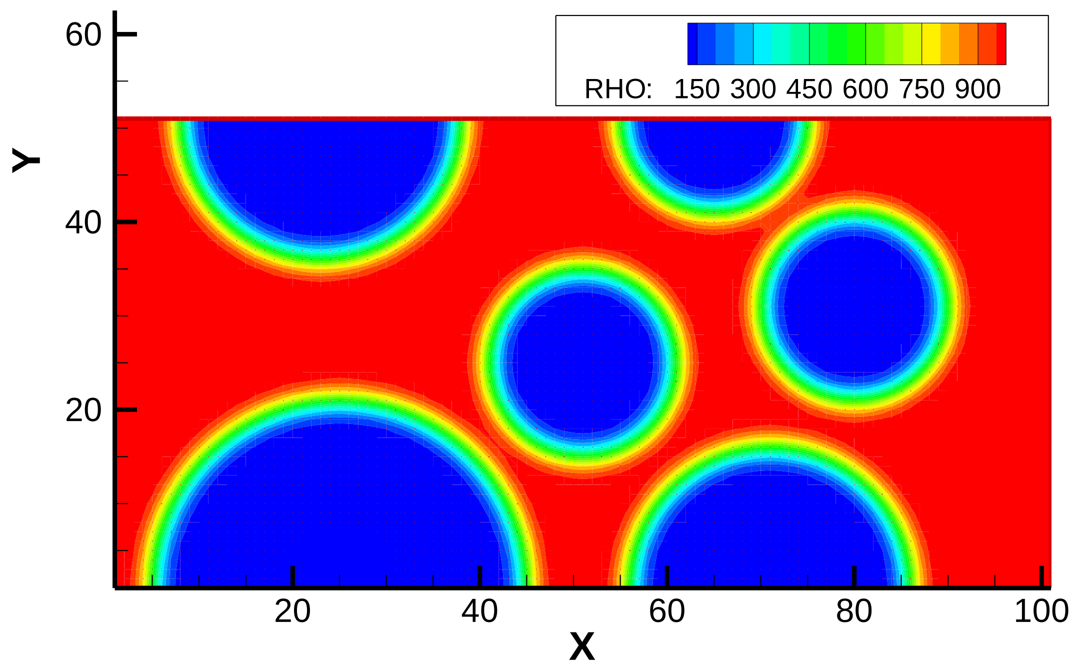


Figure 1-24. Initial condition in the container with a gas phase (represented in blue) dispersed in a liquid phase (represented in red) where the density ratio is 10.

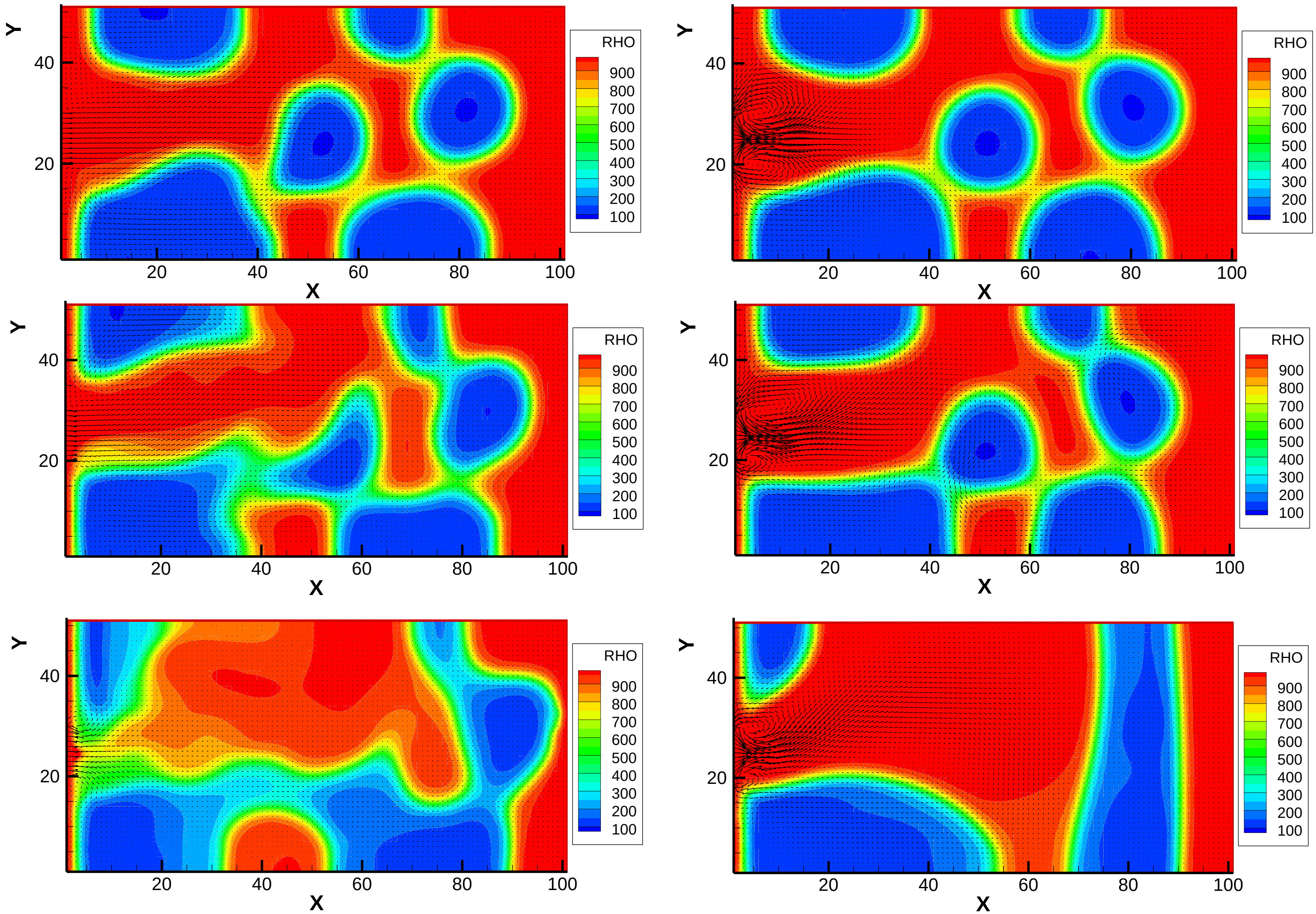


Figure 1-25. Bubble interface displacement at t=5000, 10,000 and 20,000 in a Newtonian fluid (right column) and Bingham plastic (left column).

Task 17 Quarterly Progress – May 18 – June 30, 2014

FIU Year 4 Carryover Work Scope

Subtask 17.1: Multiple-Relaxation-Time, Lattice Boltzmann Model for High-Density Ratio, Multiphase Flows

For the period of May 18-May 31, 2014, FIU communicated with the CFD lead at Bechtel, Joel Peltier, the Software Development Engineer at CD-Adapco company, Nathanael Inkson, and the CD-Adapco representative for software licenses, Kent Garbee, in order to identify the existing capabilities of the Star-CCM+ software for non-Newtonian fluid mixing in turbulent conditions. It was concluded that the capabilities of the Star-CCM+ software was satisfactory to meet the FIU and Bechtel requirements for simulating pulsed-jet mixing of nuclear waste since currently implemented in STAR-CCM+ is the Herschel-Bulkley model which combines a Bingham fluid with a power-law model. This model is available in both single phase and multiphase form: multiphase is either a volume-of-fluid model that resolves liquid interfaces or an Eulerian-Eulerian two-fluid model that has a less clear interface. These models are already in the code although user functions could be used if we require developing our own models. FIU's DOE Fellow Sasha Philius contacted the company and was able to receive a student version of the software for testing purposes for a year. FIU will investigate the licensing options for research licenses to be used in high performance computing environments.

During June, efforts focused on completing documentation associated with milestones and deliverables. This included a milestone summary document for 2013-P1-M17.1.2 which highlighted results from LBM simulations of fluid and gas injections in non-Newtonian fluids. The simulations demonstrated that LBM can be used to provide a means for modeling Bingham plastic fluids similar to waste in Hanford tanks for processes involving mixing. This summary document was sent to EM-21 and site contacts on 6/9/14. A draft topical report was also submitted on 6/19/14 which provided a detailed description of the background and the history of the development of the LBM code. It also provided verification and validation simulations as well.

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 – April 1 – May 17, 2014

Subtask 18.1: Evaluation of SLIM for Rapid Measurement of HLW Solids on Tank Bottoms

During April 2014, a pilot-scale test plan for SLIM was completed and sent to the Hanford Site and to DOE EM headquarters on April 25. A goal for this test plan is to demonstrate that SLIM will meet all of the functional requirements for a technology deployment in a high-level radioactive waste mixing tank. The functional requirements will include data quality objectives for the accuracy, speed and other performance factors needed for the SLIM mechanical deployment and sonar imaging systems. The functional requirements are expected to be met by testing results and also through safety analyses, deployment and operating procedures, and other documentation needed for any technology deployed in high-level radioactive waste (HLW) tanks. During 2014, it is envisioned that an actual Hanford HLW mixing tank will be identified that would benefit from the deployment of the SLIM technology in 2015 or 2016. As the tests progress, it is expected that additional tests might be suggested either to improve the likelihood of deployment or to address engineering safety issues or other concerns in the deployment and operation of the system.

A polyethylene tank has been placed in the FIU ARC High Bay Research Facility. Preparation has begun with setting up the tank with SLIM and a mixing pump. HLW particulate simulant (1 micron diameter kaolin particles) will be ordered.

Software algorithms for filtering the data and data display continued all month. Specific data filters developed, tested and to be applied include:

1. A minimum time filter to remove scatters sometimes seen around the sonar head;
2. A maximum time filter based upon tank dimensions and angles that will eliminate most double scattered sonar pings which show as points beyond a surface;
3. A nearest neighbor analyses that eliminates most sonar pings that scatter from particulates suspended in the water tank (important when mixing up to 30% by volume of solids to the water in the tank); and
4. Smoothing functions for interpolation of 2-D sonar slices into quality 3-D images even in sparse datasets (i.e., less than five 2-D sonar slices contributing to the sonar image due to the short time available for imaging).

Depicted below are the initial testing results of filters 2 and 3 using the processing sonar data collected in March. The image is of a standard brick sitting in the bottom of our laboratory test tank. Ultimately, filtering is needed to allow for automated analysis of the volume of the settled solids in the bottom of the mixing tanks at Hanford.

The figures below were generated from data taken with the following experimental settings: 60° swath arc, rotation motor step size setting of 1, and swath motor step size of 1. Figure 1-26 shows FIU's 3-D sonar imaging software which displays unfiltered data. The two images in this figure are side view and top view of the 3-D display of the sonar data without filtering.

In Figure 1-27, FIU's 3-D sonar imaging software displays side and top views of the 3-D display of the sonar data with filtering that eliminates all data that is below the floor of the tank (due to sonar pings that scatter twice and still return to the sonar head). The initial algorithm currently corrects only the data that is below the tank floor (Z-axis) and could be expanded to eliminate data from beyond the tank walls. Sonar images during mixing with extensive scattering off suspended particles are expected to show significant double scatters beyond the tank walls. Red circles are used to show areas where filtering removed undesired (double scattered) sonar data compared to that shown in Figure 1-26.

Figure 1-28 displays the 3-D sonar data filtered to eliminate spikes that arise from scattering off suspended particles as well as possible noise in the system. This algorithm averages points based on the values of neighboring data. This mildly aggressive filtering algorithm will look at the Z-coordinate of each individual point and compare its neighboring points. If the difference in value between both neighboring points is greater than the specified user value, then the Z-coordinate will be replaced with the average of the two neighboring points. As seen by the red circles, the spikes observed within the original unfiltered data have been reduced. Observe the reduced height of the spikes in comparison with the original image. The spikes can be completely eliminated with a different scale applied to the nearest neighbors filtering. Finally, Figure 1-29 displays the sonar data filtered using both of the filters described above (double scatters and reflections off suspended particles). Both of these filters will be refined and completed during May 2014.

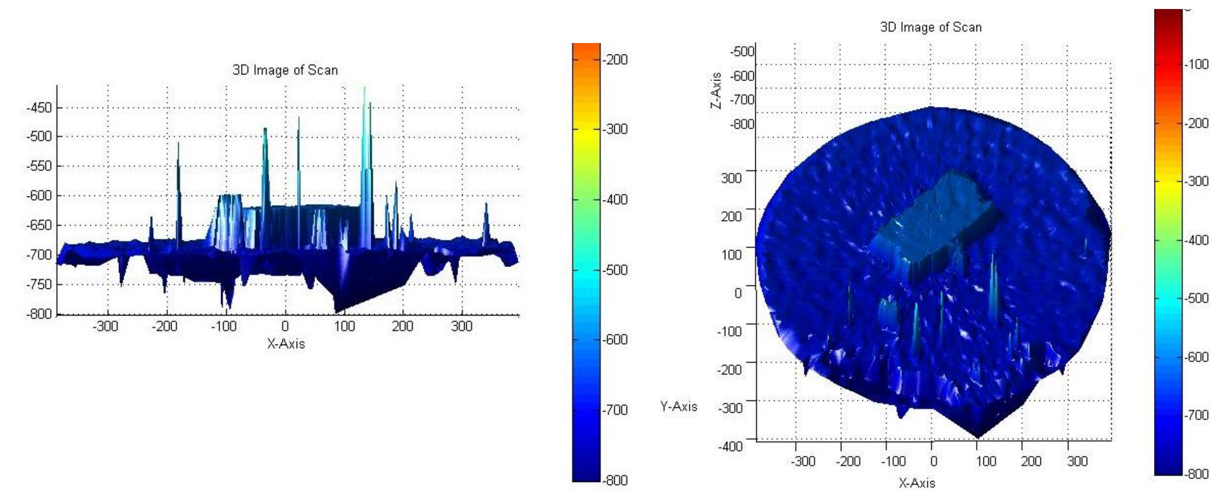


Figure 1-26. 3-D sonar side view and top view displays for unfiltered data.

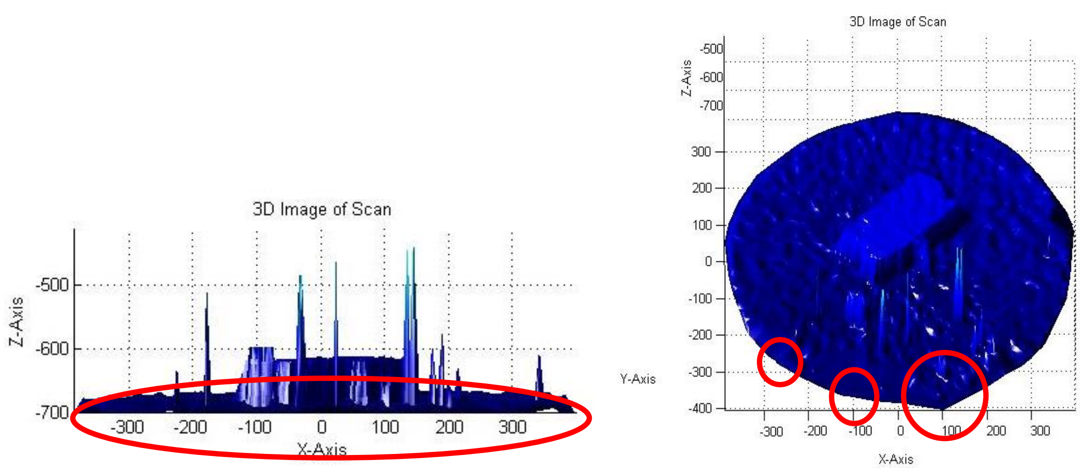


Figure 1-27. 3-D sonar side view and top view displays – filtered to remove data below floor.

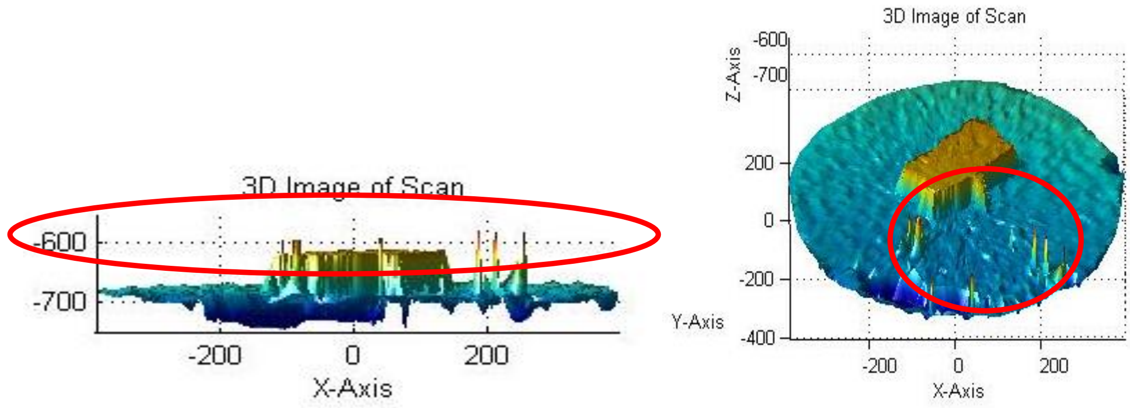


Figure 1-28. 3-D sonar side view and top view displays – filtered to reduce spike size.

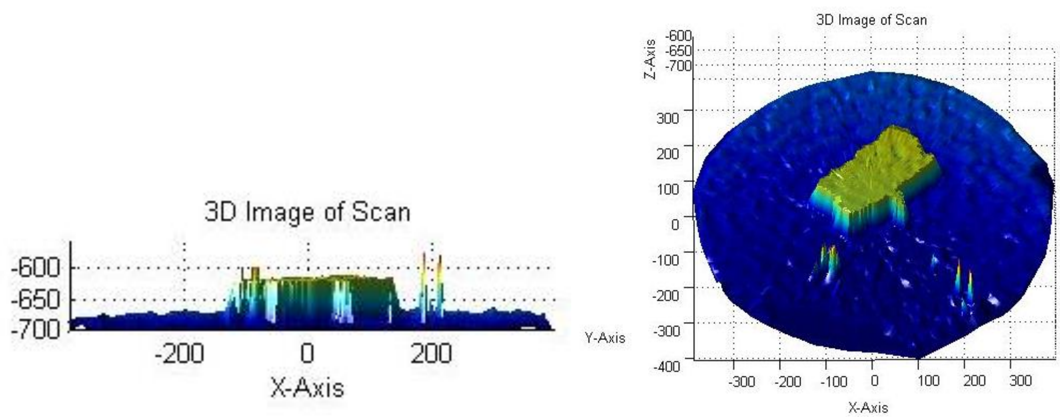


Figure 1-29. 3-D sonar side view and top view displays with filter to remove data below floor and filter to reduce spike size.

Sonar Data Validation, Verification and Completeness

The commercial sonar component of FIU's SLIM provides 3-D sonar images by interpolating between data from multiple 2-D slices. Described below is the process of post-processing the sonar data to ensure data is valid to verify its completeness. This data is then input into an algorithm to measure the volume of all material and objects imaged above a floor area (e.g., the volume of solids on a tank floor area).

Algorithm to Separate 3-D Sonar Data from Sonar ASCII Text File

The sonar data for each 2-D scan (or slice) is stored in a long list of XYZ points using a comma as a delimiter. An example of the format can be seen in Table 1-2 below. This table displays the initial set of points for one of the initial experimental tests (or trials) that was conducted on SLIM in recent months. This test was recorded as Trial 2 and was successfully completed in approximately 24 seconds with the highest possible setting of swath motor step size (setting 1) and a moderately low rotate motor step size setting (setting 7). Table 1-3 shows the results of the 6 trials conducted in the past along with each of their settings. For this description of data preparation and processing, the data from "Trial 2" (outlined in red) was used for portioning and analysis.

Table 1-2. Example of Output ASCII Data from Sonar (in mm)
000000,000168,000614
000000,000158,000616
000000,000147,000614
000000,000137,000613
000000,000127,000615
000000,000118,000617
000000,000108,000617
000000,000098,000616
000000,000088,000617
000000,000078,000617
000000,000068,000617
000000,000058,000617
000000,000049,000617
000000,000039,000618
000000,000029,000617
000000,000019,000618…………etc

Table 1-3. Time Trials Results

Trial	Time	Swath Motor Step	Rotate Motor Step	Swath Arc
1	~45 Seconds	1	3	30
2	~24 Seconds	1	7	30
3	~19 Seconds	1	10	30
4	~32 Seconds	3	3	30
5	~19 Seconds	3	7	30
6	~15 Seconds	3	10	30

The data is retrieved from the sonar output text file with an extension ".txt" (Figure 1-30). This text file is then uploaded into MATLAB using a delimiter function in order to separate the data into its X, Y, and Z partitions. The sonar provides an extensive list of data without any separation identifying where each individual swath began or ended. MATLAB is used to further partition the data into the individual 2-D swaths. Using Trial 2 as an example, 29 individual swaths (Figure 1-31) were identified and registered. There are 34 pings per 2-D swath each with points denoted by x, y and z coordinates (Figure 1-32). The algorithm scans the 3-D coordinate data and identifies when a new swath is recorded when a value along the X coordinate column is far greater than the previous value.

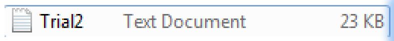


Figure 1-30. Time Trial Used, Trial 2.

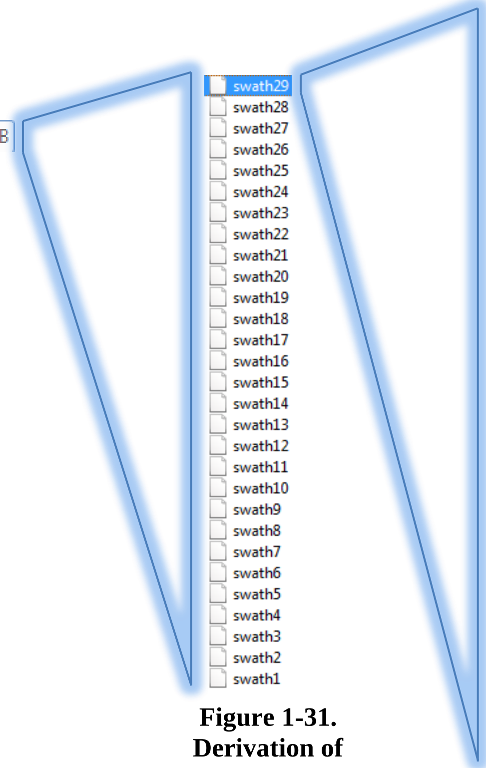


Figure 1-31. Derivation of 29 Swaths from Trial 2.

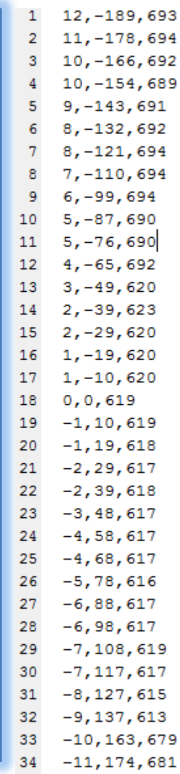


Figure 1-32. Derivation of 34 pings from Swath #29 of time Trial 2.

The correct separation of sonar data into its individual 2-D swaths is required for the post-processing of the volume of material above a floor area.

Subtask 18.2: Development of Inspection Tools for DST Primary Tanks

During April, FIU worked on developing a conceptual model that will provide a virtual environment to vary and optimize configurations for the inspection tool for the double-shell tank (DST) primary tank refractory pads. One of the objectives is to have the inspection tool navigate upside down along the bottom of the tank, avoiding any obstructions in the refractory channel. Figure 1-33 provides a 3D rendering of the proposed inspection tool as it would be oriented with respect to the tank bottom.

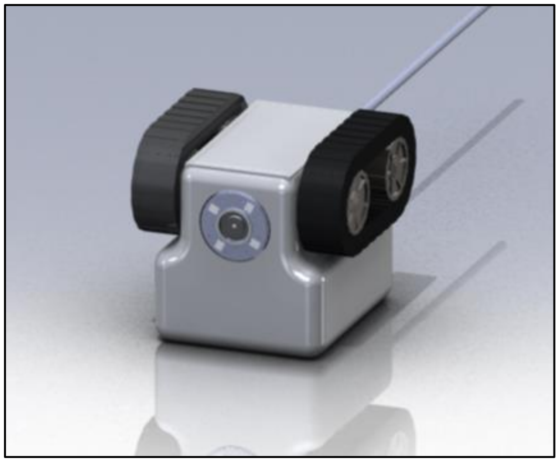


Figure 1-33. 3D CAD drawing of the proposed design.

A 2D dynamic finite element analysis (FEA) model is being developed in ABAQUS to assist in the design development of the inspection tool. The model consists of 1 flexible body and 4 rigid bodies. The flexible body is for the track and the four rigid bodies include two wheels, the body of the inspection tool and the tank. At this point in the model development, the inspection tool and wheels are not assigned a mass. In the future, a mass will be assigned to the tank that includes the mass of the motor, camera, gears, magnets and outer shell. The mass will be located at the center of gravity of the unit, which will also be determined.

One advantage of the model is that a torque motor is used to drive the rear wheel. For this simulation, an off-the-shelf motor with a torque of 2.76×10^{-3} lb-in was utilized. Gears can then be sized to increase the torque if needed. Additionally, coefficients of friction have been included to model the contact between the wheel and the track and the track and the tank shell. Standard values of 0.3 and 0.5, respectively were used. The track is modeled as a hyperelastic material using the Neo-Hookian approximation to account for large deformations and compressibility effects. Coefficients for the volumetric compression and hyperelastic modulus were 1.79×10^{-4} psi and109.21 psi, respectively. A force has also been added between the tank and the inspection tool to emulate the magnetic force from the magnet. The magnets produce the force necessary to keep the tread in contact with the tank and assist in developing the traction force used to propel the tool. The force used in the simulations was based off specifications from off-the-shelf magnets (2 lbs/in^2).

Figure 1-34 shows the simulation of the unit translating along the tank bottom, propelled by the motor. The next step will be to continue the development of the model by assigning masses for the individual components and adding gravity and a force emulating the tether drag force. The motor can then be sized based on various levels of drag.

Figure 1-34. Inspection tool translating under torque load applied at real wheel.

In order to minimize costs by avoiding custom manufacturing, during early May, FIU compiled information on commercially available off-the-shelf components to build the inspection tool prototype. These components meet or come close to meeting the specifications of operating temperature (170°F) and radiation tolerance (85 rad/hr) and thus will be used for the modification of the conceptual 3D model. Information on most components required was obtained. The specifications of these components are listed in the tables below.

Table 1-4. Magnet

K & J Magnetics, Inc						*www.kjmagnetics.com*		
Catalog Number	**Material**	**Max Operating Temp**	**Length**	**Width**	**Thickness**	**Distance from Tank**	**Pull Force**	**Total Price**
BXOX01	Nickel Plated	176°F	1in	1in	0.0625in	0.03in	4.12 lb	$2.57

Table 1-5. Motor

Digi-Key Corporation						*www.digikey.com*		
Catalog Number	**Torque (mNm)**	**Outside Diameter**	**Length**	**Voltage Range**	**Weight**	**Unit Price**	**Quantity**	**Total Price**
P14350-ND	0.1	0.315	0.413in	1 ~ 3.5VDC	0.006lb	$4.07	2	$8.14

Table 1-6. Camera

Advanced Inspection Technologies						*http://aitproducts.com/*			
SKU	**Diameter**	**Tether Length**	**Power**	**Material**	**Output**	**Operating Temperature**	**Bends**	**Lighting**	**Unit Price**
MINCOR D	0.51in	100ft	AC/DC	Stainless Steel Housing / Sapphire Lens	USB Output / Video	69°F-140°F	Yes (90°)	12 White LED	$4,000.00


Table 1-7. Wheel and Tank Tread							
Precision Industrial Components						*http://www.pic-design.com/*	
Catalog Belt Series	**Pitch**	**Reinforcement Cable Diameter**	**Positional Accuracy**	**Wheel Diameter**	**Body Material**	**Reinforcement**	**Operating Temperature**
MINCORD	Single Core	.032	Excellent	.55in	Polyurethane	Stainless Steel or Aramind Fiber	-65°F-180 °F

Table 1-8. Gears							
Stock Drive Products/Sterline Instrument a Designatronics, Inc Company						*www.sdp-si.com*	
Catalog Number	**Teeth**	**Inner Diameter**	**Pitch Diameter**	**Outside Diameter**	**Bore Size**	**Face Width**	**Material**
A 1B 1-Y64014	14	0.1797	0.219	0.25in	0.0393701	0.1	303 SS
S1163Z-064S018	18	0.2397	0.2813	0.3125	0.1248	0.1	303 SS
S1163Z-064S021	21	0.2866	0.3281	0.3593	0.1248	0.1	304 SS

Table 1-9. Bearings							
Catalog Number	**Bore Size**	**Outside Diameter**	**Overall Width**	**Flange**	**Unit Price**	**Quantity Needed**	**Total Price**
S9912Y-UBM-1	0.1248	0.25	0.094	NO	13.05	10	$130.50

FIU Year 4 Carryover Work Scope

Subtask 18.1: Evaluation of SLIM for Rapid Measurement of HLW Solids on Tank Bottoms

Volume Calculation Algorithm for SLIM Sonar

The data from the sonar data is stored in a digital ASCI file. Our algorithm imports the data from the sonar ASCI file to allow analysis such as the calculation of the cumulative volume of the material or objects imaged. Data validation, verification and analysis is done first to ensure that the volume calculation is robust and works with all possible sonar data sets. The data of each 2-D swath is verified and validated. Any 2-D swaths that have missing data require interpolation of neighboring data to complete the data set to allow for the robust volume calculation algorithm.

The volume calculation algorithm scans through each partitioned swath and compares it to the one after it. For example, using Trial 2 as an example, swath 1 (Figure 1-35) and swath 2 (Figure 1-37) are used for this illustration. The 2-D plot of Swath 1 and Swath 2 illustrate the how the algorithm calculates the cumulative volume of the material or objects imaged (Figure 1-36).

```
0,168,614
0,158,616
0,147,614
0,137,613
0,127,615
0,118,617
0,108,617
0,98,616
0,88,617
0,78,617
0,68,617
0,58,617
0,49,617
0,39,618
0,29,617
0,19,618
0,10,618
0,0,620
0,-10,620
0,-19,620
0,-29,622
0,-39,622
0,-49,620
0,-65,692
0,-76,691
0,-87,689
0,-99,693
0,-110,691
0,-121,693
0,-132,693
0,-144,695
0,-155,693
0,-167,696
0,-178,694
```

Figure 1-35: Swath 1 of Trial 2, this data represents the blue line in Figure 1-16

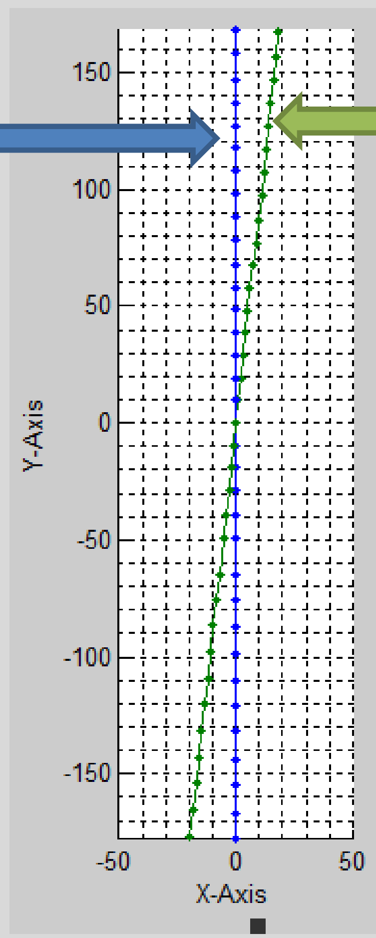


Figure 1-36: 2D Plot of Swath 1 and Swath 2 from time trial 2

```
18,167,612
17,157,615
16,147,615
15,137,617
14,127,619
13,117,617
12,107,615
11,97,615
10,87,616
9,77,617
7,68,616
6,58,619
5,48,617
4,39,618
3,29,617
2,19,618
1,10,618
0,0,619
-1,-10,620
-2,-19,620
-3,-29,622
-4,-39,621
-5,-49,620
-7,-65,692
-8,-76,691
-10,-86,689
-11,-98,693
-12,-109,690
-13,-120,690
-15,-132,695
-16,-143,694
-17,-154,693
-18,-165,691
-20,-177,694
```

Figure 1-37: Swath 2 of Trial 2, this data represents the green line in Figure 1-16

The algorithm examines two points from each swath at a time. With a total of four points, a trapezoidal figure is created, similar to the one seen in Figure 1-38. The surface area (Blue, Red, Green outlines on Figure 1-38) for this figure will be calculated and then multiplied by the average Z component of all four points examined. This process will continue until the algorithm is finished comparing the corresponding points within the two swaths. Next, the algorithm will analyze the following swaths in the exact same manner. As this process continues, it will gradually increase the volume until the algorithm has finished analyzing the final swath within the file.

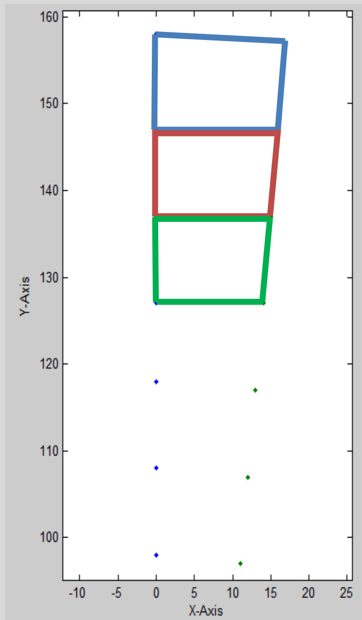


Figure 1-38: Illustration of Volume Algorithm Function (Blue, Red, and Green trapezoid figures represent the individual surface areas calculated by the algorithm)

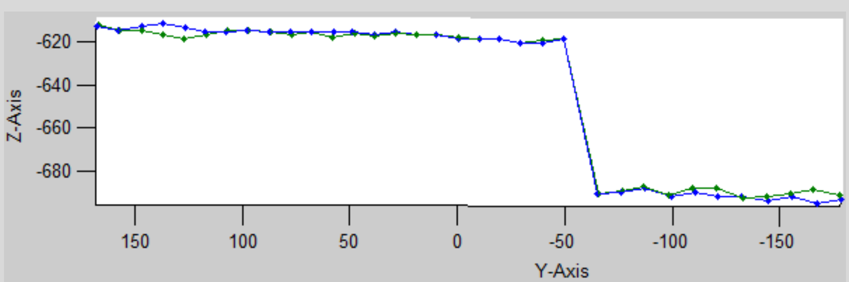


Figure 1-39: Z Component of Swath 1 and Swath 2 of Trial 2 (blue is swath 1, green is swath 2)

The cumulative volume calculated for Trial 2 was 1.39×10^6 mm^3 which compares well with the actual volume of the brick which is 1.51×10^6 mm^3, yielding a percent relative error of 8%. The primary purpose of this application of SLIM and its sonar component is to image solids on the tank floor area quickly while large amounts of solids are entrained in the liquid being mixed. The presence or absence of solids on the tank floor throughout the pulse jet mixing cycle is most important since it will ensure complete mixing or allow engineers the option of changing engineering parameters in order to assure complete mixing.

Sonar Data Verification and Validation

The calculation of the volume of settled solids on the tank floor has typically shown accuracy of approximately 8% but some calculations have shown errors over 100%. A closer look at the sonar data in these large error cases show problems with the data (e.g., missing data) as well as data from swaths that hit high on the tank wall leading to settled solids volumes that are too large. The correction for invalid data points has been addressed. A method to eliminate incorrect height data from wall reflections for the settled solids layer volume calculations is currently under development.

Locating Outliers in Individual Swaths and Replacing with Interpolated Values

During May, the derivation of a volume calculation algorithm for SLIM allowed us to determine the accuracy of the solids imaged by SLIM. The volume of the imaged object was calculated to be within 8% (relative error) of its actual volume.

In order to create a more robust volume calculation that would be accurate despite invalid sonar data points, we continued testing the accuracy of this algorithm while varying the options on SLIM. Analysis of the sonar data showed that the sonar at times produces pings with coordinates (XYZ) of (000000, 000000, 000000) as seen in Table 1-10 below.

Table -1-10. Listing of 17 Sonar Ping Coordinates with Outlier (0, 0, 0) Highlighted

1882	000382,-000085,000686
1883	000352,-000079,000681
1884	000327,-000073,000684
1885	000302,-000067,000684
1886	000000,000000,000000
1887	000254,-000057,000688
1888	000229,-000051,000685
1889	000206,-000046,000686
1890	000183,-000041,000687
1891	000162,-000036,000689
1892	000141,-000031,000695
1893	000117,-000026,000690
1894	000096,-000021,000690
1895	000067,-000015,000621
1896	000048,-000011,000619
1897	000029,-000006,000619
1898	000010,-000002,000620

These pings within the XYZ ASCII data derived from the SLIM sonar produces data outliers that must be addressed. To eliminate the effects of these outliers on the volume calculation algorithm, a separate correction algorithm was created. Within this correction algorithm, there are three different steps. An example of this process is explained below through a miscellaneous trial which consists of the following settings: swath arc=60°; swath motor step size=1; rotate motor step size=1; pings per swath=33.

Step 1: Determine the location of the data outliers within each swath.

Table 1-11 shows a listing of the swath number that the outlier was discovered in. The table also shows the number of accurate pings (#pings) within that swath and the number of pings that need to be corrected (PingsToFill) within each individual swath based on the expected number of pings per swath.

Table 1-11. Location of Data Outliers

Errors in Data =

	Swath	#Pings	PingsToFill
SwathError1	58.00000	32.00000	1.00000
SwathError2	84.00000	32.00000	1.00000
SwathError3	93.00000	32.00000	1.00000
SwathError4	96.00000	32.00000	1.00000

Step 2: Determine the correct value of coordinate for ping errors.

The second step of the algorithm will then cycle through each ping of the swath and compare the X coordinate of one point to the X coordinate of the following ping within the same swath. It will register the location of the largest calculated difference between neighboring points until it has cycled through that particular swath. After cycling through that particular swath, it will return to the registered location of the outlier and find the average X, Y and Z coordinate using the accurate pings found before and after the registered location.

Step 3: Insert the point correctly back into the swath vector of coordinates.

The algorithm will now take the calculated X, Y, and Z coordinates and place them at the registered location within the corresponding swath.

Previously, the volume calculation algorithm was compatible with the low-setting step-size scans from the SLIM sonar and would have huge errors when applied to large-setting step-size scans that took greater than 40 seconds. The errors arose due to the data outliers and pings from walls discovered within random swaths within each scan. The swaths in which these data outliers occur are completely random and there does not seem to be any correlation between the location of the outliers and the settings of each scan. This correction algorithm is used in order to ensure a robust calculation capable of processing every range of settings available on the SLIM sonar. The correction algorithm will automatically identify the number of pings that each swath should have and “fix” or simply correct the data outliers within each data set in order to increase accuracy when calculating the volume of imaged solids on tank floors.

FIU Year 4 Carryover Work Scope

Subtask 18.2: Development of Inspection Tools for DST Primary Tanks

FIU modified the conceptual model for the inspection tool for the double-shell tank (DST) refractory pads using off the shelf components. With the exception of the frame, all components are commercially available as mentioned in the previous reporting period. Figure 1-40 shows these components in the proposed configuration for the modified design

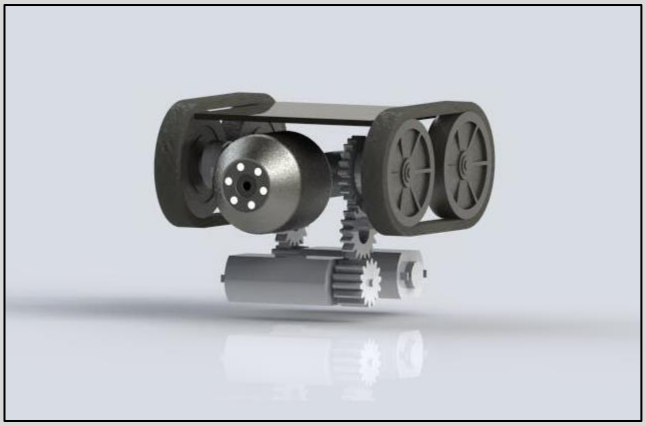


Figure 1-40. 3D rendering of components.

All of the components must be confined within the housing in such a way that the spacing allows for the proper operation of all components. Figure 1-41 shows the orientation and relative positioning of the components in the design. The housing that will be utilized consists of three sections that can be assembled together and will be used to encase the components. Initially, the gears and motors will be set into the bottom of the right and left segments of the housing and then camera will be set into place. The right and left sections will close shut to encase all components and hold them in place to prevent unwanted movement. Finally, the top housing section will be placed over to complete the prototype.

Figure 1-41. 3D assembly of the design.

Figure 1-42 provides a 3D rendering of the proposed inspection tool as it would be oriented with respect to the tank bottom. The overall dimensions are 1.295 in. wide, 1.095 in. high and 1.3 in. long, from wheel to wheel.

Figure 1-42. 3D rendering of completed model.

During June, FIU began the preliminary steps to building a prototype for the inspection tool for the double-shell tank (DST) primary tank refractory pads using off-the-shelf components. All components are commercially available as mentioned in the previous reporting period and have been ordered. Figure 1-43 demonstrates the components that have arrived.

Figure 1-43. Components: gears, bearing, shaft, and motor.

The largest gear required manufacturing to remove the support that connects it to the shaft as well as the motor that required the shaft to be cut to a shorter length to fit within the frame. The motor has been soldered to cables that will allow for power supply. As seen in Figure 1-44, the conceptual model was again modified to include supports and bearings for the shafts and gears.

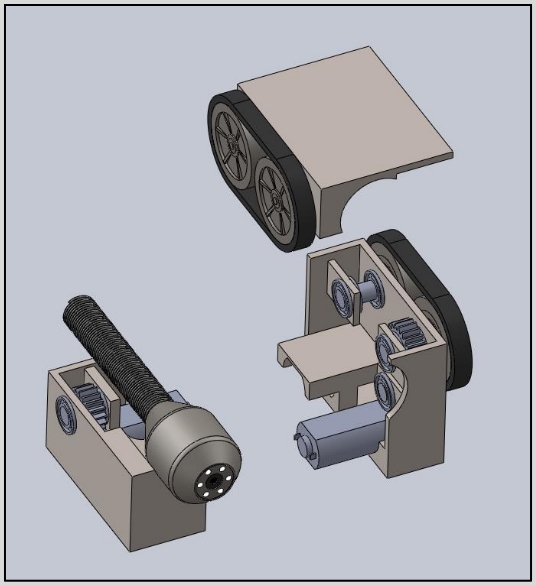


Figure 1-44. Conceptual SolidWorks model.

FIU expects to test the motor and gear configuration to determine the maximum torque and force it is capable of pulling. The testing system will be set on one frame and thus, using the updated conceptual model, the right frame of the housing unit (Figure 1-45) was printed using a 3D rapid prototype printing. The printed frame is shown in Figure 1-46.

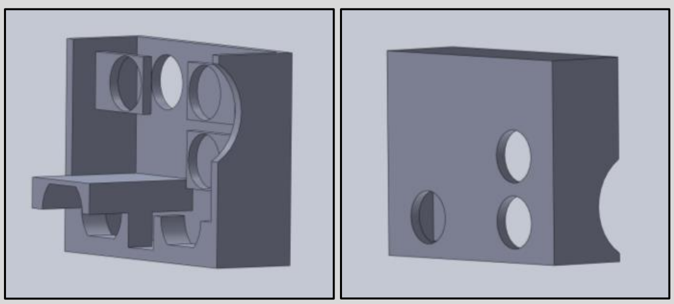


Figure 1-45. Housing unit right frame.

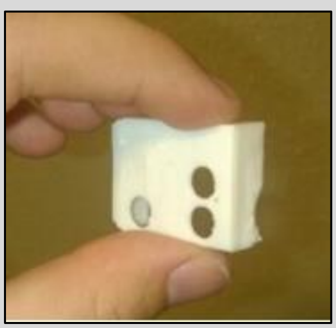


Figure 1-46. Rapid prototype printed frame.

Finally, a draft copy of the summary report documenting the design of the inspection tool was completed and sent to EM-21 and site contacts for review on 6/9/14.

Task 19: Pipeline Integrity and Analysis

Task 19 Overview

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, but the data still needs to be analyzed to determine effective 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– April 1 – May 17, 2014

Subtask 19.1: Pipeline Corrosion and Erosion Evaluation

During April, reports were written that provide descriptions and analysis of the jumpers in the 242-A Evaporator Pit and the 241-AW-02E Feed Pit. The report also provides the details of comparisons between the sections analyzed for each jumper as well as comparisons of jumpers and their flow volumes. When appropriate, an estimated remaining useful life (ERUL) was determined that was based on the volume of fluid transferred. The analysis is based on ultrasonic measurements that were taken at various locations of the jumpers (elbows and straight sections). For this summary, an overall discussion for jumpers in the 242-A Evaporator Pit is presented. The information for each of the 5 jumpers is provided in Table 1-12, which includes the type of material transferred, volume transferred and the diameter of each jumper.

Table 1-12. Summary of Jumper Information for the 242-A Evaporator Jumpers

Jumper	Material Transferred	Volume Transferred (Mgal)	Jumper Diameter (in)
18-4	Slurry	0	2
C-4&5	Slurry	11	2
19-5	Slurry	42	2
J-13A	Supernatant	29	3
13-K	Supernatant	86	3

Jumper 18-4 has not transferred any waste and can be used as a baseline for comparing C-4&5 and 19-5 which transferred approximately 11 and 42 Mgal of slurry, respectively. Average thickness measurements for the sections in Jumper 18-4 (one 5D elbow, one long radius elbow and two straight sections) were slightly above the manufacture’s nominal thickness. Average thicknesses for the sections evaluated in Jumper C-4&5 (one long radius elbow and two straight sections) were very similar with only Straight-5 having an average thickness of 0.001 inch below nominal. This suggests that no erosion has occurred in Jumper C-4&5. Jumper 19-5 has transferred approximately 4 times the volume that Jumper C-4&5 transferred. Average thickness measurements for Jumper 19-5 were also similar to the nominal thickness; however, three sections (one 5D bend elbow and two straight sections) were slightly below nominal. For these three sections, the ERULs were determined and the required transfer volume well exceeds the volume transfer required for the life of the plant. The 5D bend elbows from 18-4 and 19-5 had similar longitudinal averages with expected thinning at the extrados of the elbow due to the manufacturing process. The long radius jumpers from each of the three jumpers also showed the thinning at the extrados, but slight variations in thicknesses at the top and bottom of the elbows suggest that the variances observed are random and due to manufacturing processes. The straight sections from 18-4 had different trends associated with the average longitudinal measures. Straight-1 thickness averages were consistent around the circumference while Straight-2 had an increase towards the bottom. This demonstrates the potential variance that should be expected in terms of the manufacturing process, since 18-4 has not transferred any waste. Straight-5 and Straight-6 from Jumper C4&5 also had consistent averages around the radius with averages very similar to nominal. The straight sections in Jumper 19-5 showed very different longitude average trends, with Straight-3 slightly increasing as the position rotated clockwise and Straight-4 having an oscillatory trend as the position rotated clockwise. These variances are small and the trends do not suggest that erosion has occurred.

Jumpers J-13A and 13-K transferred approximately 29 and 86 Mgal of supernatant, respectively. Average thicknesses for the sections evaluated in Jumper J-13A (one long radius elbow and two straight sections) were slightly different with Elbow-8 being below nominal, Straight-9 being just above nominal and Straight-10 being significantly above nominal. The different averages for each section do not demonstrate an erosion trend for this jumper. Average thickness measurements for the sections in Jumper 13-K (one 5D elbow, one long radius elbow and two straight sections) were all above the manufacture's nominal thickness and in three of the sections, significantly above nominal. Jumper 13-K transferred approximately three times the supernatant that Jumper J-13A transferred, yet did not have any component below the manufacturer's nominal thickness. This suggests that the variations observed are not due to erosion. The long radius elbows in J-13A and 13-K did have similar longitudinal average trends with thinning at the outer extrados; however, J-13A transferred a lower volume of supernatant, yet had the lower thickness average when compared with 13-K. This is not consistent with any type of erosion. The straight sections in 13-A had fairly consistent longitudinal averages around the circumference; however, one section was slightly above nominal and the other was significantly above nominal. Jumper 13-K straight sections were both significantly above nominal, but each section had different longitudinal average trends.

During early May, reports were provided to WRPS engineers and EM-21 that provided descriptions and analysis of the jumpers in the 242-A Evaporator Pit and the 241-AW-02E Feed Pit. The report also provides the details of comparisons between the sections analyzed for each jumper as well as comparisons of jumpers and their flow volumes. When appropriate, an ERUL was determined that was based on the volume of fluid transferred. The analysis is based on ultrasonic measurements that were taken at various locations of the jumpers (elbows and straight sections). For this summary, an overall discussion for jumpers in the AW-02E Feed Pit is presented. The information for each of the jumpers is provided in Table 1-13, which includes the type of material transferred, volume transferred and the diameter of each jumper.

Table 1-13. Summary of Jumper Information for the AW-02E Feed Pit Jumpers

Jumper	Material Transferred	Volume Transferred (Mgal)	Jumper Diameter (in)
1-4	Feed Waste	17*	3
B-2	Feed Waste	42	3

* 1-4 transferred an unknown amount recirculation waste

Jumper 1-4 transferred at least 17 Mgal of feed waste in addition to an unknown amount of recirculation waste. This uncertainty makes it difficult to assess erosion trends between the two jumpers. Regardless, average thickness measurements for the sections analyzed for both the 1-4 and B-2 jumpers were above the manufacturer's nominal values. Similar trends were observed the straight sections in both jumpers. Longitudinal averages around the circumference of the pipe had thickness trends that were oscillatory but radial averages along the length of the pipe were fairly consistent. Of the three types of components analyzed, the connectors had the least amount of thickness variation. This was also true for both jumpers. The elbows did not show any consistent thickness trends for the two jumpers in terms of longitudinal averages. The radial averages for each of the elbows were all consistent along the length of the pipe.

<u>Task 19 Quarterly Progress– May 18 – June 30, 2014</u>

FIU Year 4 Carryover Work Scope

Subtask 19.1: Pipeline Corrosion and Erosion Evaluation

After the reports for the jumpers in the 242-A Evaporator and the 241-AW-02E Pit were completed, a number of areas in the analysis that need to be addressed were identified. One of the issues is related to the analysis of the different types of elbows in the transfer system – 5D bend and long radius. The 5D bend elbows are generally manufactured by bending the elbow over a die which causes an increase in thickness at the intrados and a decrease in thickness at the extrados. Differentiating the thinning at the extrados due to manufacturing and erosion is key to evaluating the integrity of the pipelines. FIU proposed an approach in which a percentage of the thickness is added to the extrados to account for the thinning due to manufacturing. Various piping standards provide information on the allowable change in thickness due to the bend. For this analysis, a 10% change in thickness was expected at the extrados. Thus, at the outer most location of the elbow, 10% of the nominal thickness was added to the measurements. This approach needs to be discussed and evaluated by WRPS engineers. Unfortunately, the long radius elbows are manufactured with a different procedure and at this point it is not clear what approach, if any, needs to be taken to differentiate thinning due to manufacturing from thinning due to erosion.

Additionally, standards for carbon steel pipe provide nominal thickness and minimum allowable thickness values. They also provide a means to determine maximum thickness values. Standards for stainless steel pipes are less descriptive and only provide nominal thickness values. In terms of our general analysis approach, nominal, minimum and maximum thickness values are used in evaluating the pipelines. A similar analysis is not possible for stainless steel pipes. Thus, an approach needs to be determined that allows for the evaluation of both carbon steel and stainless steel pipe in a similar manner. FIU is currently working with WRPS engineers to determine the best approach for the evaluation.

During June, FIU continued to engage engineers from Hanford regarding issues related to the analysis process for thickness data from jumpers in the 242-A Evaporator and the 241-AW-02E Pit. It was decided that a 12.5% tolerance would be used on the nominal thickness of straight sections to determine minimum and maximum tolerances for the stainless steel piping. This percentage is a typical value used in the associated standards and will be used for the stainless steel pipes. ASTM 312 did not specifically provide minimum and maximum tolerances. Additionally, engineers at Hanford have studied the effects of manufacturing long radius elbows and have developed an approach to approximate allowable thickness reduction on the extrados of the elbow as well as thickness increases on the intrados. This approach will be forwarded to FIU for review and after approval by all parties, will be implemented into our analysis.

Finally, efforts from this task focused on providing information for our Year 5 PTP's, development of our Year End Reports and presentation for the EM-21program review.

Milestones and Deliverables

The milestones and deliverables for Project 1 for FIU Year 4 and FIU Year 5 are shown on the following tables. A summary document associated with milestone 2013-P1-M2.1.1 was sent to EM-21 and site contacts on 4/18/14. This document details the engineering scale testing of the asynchronous pulsing system. A summary document associated with milestone 2013-P1-M2.2.1 was sent to EM-21 on 4/18/14. This document details the modeling of plugs in HLW pipelines and the effects pipeline geometry has on plug formation. A summary document associated with milestone 2013-P1-M19.1.1 was also sent to EM-21 on 4/18/14. This document provides a summary of the data analysis for the jumpers in the 242-A Evaporator Pit and the AW-02E Feed Pit. Lastly, a draft experimental test plan for Subtask 18.1.2 was sent to EM-21 on 4/25/14. The test plan provided information of the phase 2 testing of FIU's SLIM to detect residual waste during PJM cycling.

A draft summary report associated with Subtask 2.2.1 was sent to EM-21 and site contacts on 5/2/14. This document details the computational fluid dynamics modeling of plug formation using the software package Comsol. A draft summary report associated with Subtask 19.1.1 was sent to EM-21 on 5/2/14. This document details the analysis of the data analysis for jumpers in the 242-A Evaporator and the 241-AW-02E Pit. After conversations with the EM-21 POC, the due dates for the three remaining deliverables and two milestones for Project 1 were reforecast to allow for work associated with the carryover scope to continue.

Project Technical Plan for FIU Year 5 was prepared and sent to DOE EM on June 17, 2014. The technical Year End Report for FIU Year 4 was prepared and provided to DOE EM on June 30, 2014. The following reports/deliverables are associated with FIU Year 4 carryover work scope. A draft summary report associated with Subtask 18.2.2 was sent to EM-21 and site contacts on 6/9/14. This document details the development of a dynamic simulation model of the inspection tool for the AY-102 refractory pads. A draft summary document associated with milestone 2013-P1-M17.1.2 was sent to EM-21 and site contacts on 6/9/14. This document details the results on the non-Newtonian modeling of mixing multiphase flows. Draft topical reports for the asynchronous pulsing system and the peristaltic crawler were sent to EM-21 and site contacts on 6/16/14. A draft topical report for task 17.1 was submitted on 6/19/14 to EM-21 and the site contacts. A draft summary document associated with milestone 2013-P1-M2.1.2 was sent to EM-21 and site contacts on 6/18/14.

FIU Year 4 Milestones and Deliverables for Project 1

Task	Milestone/ Deliverable	Description	Due Date	Status	OSTI
Task 2: Pipeline Unplugging and Plug Prevention	2013-P1-M2.1.1	Engineering scale pipeline unplugging using APU with upgraded instrumentation	4/18/2014	Complete	
	Deliverable	Draft Test Plan for Subtask 2.1.1	11/15/2013	Complete	
	2013-P1-M2.1.2	Engineering scale pipeline unplugging testing using PCS with upgraded components	4/18/2014 Reforecast to 6/16/2014	Complete	
	Deliverable	Draft Test Plan for Subtask 2.1.2Deliverable	2/21/2014	Complete	
	Deliverable	Draft Topical Report for Subtask 2.1.1 and 2.1.2	5/16/2014 Reforecast to 6/16/2014	Complete	OSTI
	2013-P1-M2.2.1	Complete 2D multi-physics model development integrating the flow and chemistry interfaces	4/18/2014	Complete	
	Deliverable	Draft Summary Report for Subtask 2.2.1	5/2/2014	Complete	OSTI
Task 17: Advanced Topics for Mixing Processes	2013-P1-M17.1.1	Bubble dynamics simulations in non-Newtonian fluids using the lattice Boltzmann method	3/14/2014	Complete	
	2013-P1-M17.1.2	Lattice Boltzmann method for the simulation of fluid and gas injections in non-Newtonian fluids	5/9/2014 Reforecast to 6/9/2014	Complete	
	Deliverable	Draft Topical Report for Subtask 17.1	5/16/2014 Reforecast to 6/16/2014	Complete	OSTI
Task 18: Technology Development and Instrumentation Evaluation	2013-P1-M18.1.1	Complete functional testing of SLIM to assess imaging speed and ability to quantify solids on tank bottoms	2/28/2014	Complete	
	2013-P1-M18.2.1	Complete proposed conceptual designs	3/14/2014	Complete	
	Deliverable	Experimental Test Plan for Subtask 18.1.2	4/25/2014	Complete	OSTI
	Deliverable	Draft Summary Report for Validation of Conceptual Design Subtask 18.2.2	5/9/2014 Reforecast to 6/9/2014	Complete	OSTI
Task 19: Pipeline Integrity and Analysis	2013-P1-M19.1.1	Complete data analysis of waste transfer system components	4/4/2014	Complete	
	Deliverable	Draft Summary Report for Subtask 19.1.1	5/2/2014	Complete	OSTI

FIU Year 5 Milestones and Deliverables for Project 1

Task	Milestone/ Deliverable	Description	Due Date	Status	OSTI
Task 2: Pipeline Unplugging	2014-P1-M2.2.1	Complete 2D multi-physics simulations evaluating the influence of piping components on the plug formation process	03/02/15	On target	
	Deliverable	Draft summary report for subtask 2.2.1	04/01/15	On target	OSTI
Task 17: Advanced Topics for Mixing Processes	2014-P1-M17.2.1	Complete computational fluid dynamics modeling of jet penetration in non-Newtonian fluids	05/11/15	On target	
	Deliverable	Draft topical report for subtask 17.2.1	05/15/15	On target	OSTI
Task 18: Technology Development and Instrumentation Evaluation	2014-P1-M18.2.1	Complete development of first prototype of the inspection tool	12/19/14	On target	
	Deliverable	Draft summary report for first prototype (subtask 18.2.1)	01/30/15	On target	OSTI
	2014-P1-M18.1.1	Complete pilot-scale testing of SLIM to assess imaging speed and ability to estimate volume of solids on tank bottom during mixing operations	02/20/15	On target	
	Deliverable	Draft summary report of pilot scale testing of SLIM (subtask 18.1.1)	03/13/15	On target	OSTI
	2014-P1-M18.2.2	Complete analysis design and modifications to the peristaltic crawler	03/20/15	On target	
	Deliverable	Final Deployment Test Plan and Functional Requirements for SLIM (subtask 18.1.2)	05/15/15	On target	
Task 19: Pipeline Integrity and Analysis	2014-P1-M19.2.1	Complete test plan for the evaluation of nonmetallic components	11/14/14	On target	
	Deliverable	Draft experimental test plan for subtask 19.2.1	11/14/14	On target	OSTI
	2014-P1-M19.1.1	Complete data analysis of the C-Farm POR 104 Valve Box	05/01/15	On target	
	Deliverable	Draft summary report for subtask 19.1.1	05/01/15	On target	OSTI

Work Plan for Next Quarter

- All Tasks:
  - Draft the Year End Report for FIU Year 4 (September 2013 to May 2014).
- Task 2:
  - For the APS, components needed to perform the entrapped air tests in the engineering scale loop will be procured and installed on the loop. Initial entrapped air test will commence.
  - For the peristaltic crawler, navigational tests in the schedule 40 testbed will be conducted. The performance of the crawler will be evaluated for navigational speed and durability. For these tests, the pneumatic systems (compressor and vacuum pump) will be monitored for reliable long-term operation.
  - For the computational simulation of plug formation subtask, 3D models will be developed, investigating the settling dynamics as a function of operational parameters such as solids volume fraction, particle size, liquid and solids density, etc.
- Task 17:
  - Efforts for this task will be placed on hold for the next few months while the task lead completes a two-month faculty internship.
- Task 18:
  - FIU will purchase the 1 micron diameter, burnt kaolin (a rheological surrogate for HLW undissolved solids) and begin experiments with SLIM. Prior to execution of the test plan, measurements will be taken to ensure that the current pump can mix the water-kaolin slurry so that the volume % solids in the liquid is nearly uniform across the tank. Once uniform mixing is demonstrated, then measurements will be taken at the highest pump power settings to determine: (1) the maximum % volume of solids the pump can entrain in the liquid; and (2) the critical % volume of solids that masks the sonar from imaging the settled solids layer when the sonar is exactly 1 meter from the solids layer. Upon determination of these upper bounds, the test plan execution will commence and the data will be analyzed by the modified imaging software and volume calculation algorithms
  - FIU will continue to compile components for the first prototype of the inspection device. Design concepts will be validated or altered as needed. Additionally, efforts will begin on determining pull force loads required by the tether. This will include obtaining material similar to the refractory pad and an exemplar tether.

Task 19:

- Engineers at Hanford will be providing FIU data obtained from transfer components from the POR 104 Valve Pit. Real time data on some of the components has been obtained, but the reliability of the data needs to be ascertained. Additional data in the valve pit has been obtained on components that have been removed. Transfer data will be provided and erosion and/or corrosion rates will be determined.

Project 2
Rapid Deployment of Engineered Solutions to Environmental Problems

Project Manager: Dr. Leonel E. Lagos

Project Description

In FIU Year 4, Project 2 included two tasks. Each task comprised of two subtasks that were conducted in close collaboration with Hanford and SRS site scientists. FIU ARC continued to provide research support on uranium contamination and remediation at the Hanford Site with two subtasks under Task 1 and conducted remediation research and technical support for SRS under Task 2.

The following tasks were included in FIU Year 4:

- Task 1: Sequestering Uranium at the Hanford 200 Area Vadose Zone by *in situ* Subsurface pH Manipulation using NH_3 Gas
  - 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 on Microbial-meta-autunite Interactions – Effect of Bicarbonate and Calcium Ions
- Task 2: Remediation Research and Technical Support for the Savannah River Site
  - Subtask 2.1 – FIU Support for Groundwater Remediation at SRS F/H Area
  - Subtask 2.2 – Monitoring of U(VI) Bioreduction after ARCADIS Demonstration at F-Area

FIU Year 5 adds a new Task 3 in addition to a new subtask under Task 2. The following tasks are included in FIU Year 5:

- Task 1: Sequestering Uranium at the Hanford 200 Area Vadose Zone by *in situ* Subsurface pH Manipulation using NH_3 Gas
  - Subtask 1.1 – Sequestering Uranium at the Hanford 200 Area Vadose Zone by in situ Subsurface pH Manipulation using NH3 Gas
  - Subtask 1.2 – Investigation on Microbial-meta-autunite Interactions – Effect of Bicarbonate and Calcium Ions
- Task 2: Remediation Research and Technical Support for the Savannah River Site
  - Subtask 2.1 – FIU Support for Groundwater Remediation at SRS F/H Area
  - Subtask 2.2 – Monitoring of U(VI) Bioreduction after ARCADIS Demonstration at F-Area
  - Subtask 2.3 - Sorption Properties of the Humate Injected into the Subsurface System
- Task 3: Evaluation of Ammonia Fate and Biological Contributions during and after Ammonia Injection for Uranium Treatment
  - Subtask 3.1 – Investigation on NH3 Partitioning in Bicarbonate-Bearing Media
  - Subtask 3.2 – Bacteria Community Transformations before and after NH3 Additions

Subtask 1.1: Sequestering Uranium at the Hanford 200 Area by *In Situ* Subsurface pH Manipulation using Ammonia (NH_3) Gas Injection

Subtask 1.1 Overview

The objective of Subtask 1.1 is to evaluate the stability of U-bearing precipitates created after NH3 (5% NH3 in 95% nitrogen) pH manipulation in the synthetic solutions mimicking conditions found in the vadose zone at the Hanford Site 200 Area. The study will examine the deliquescence behavior of formed uranium-bearing solid phases via isopiestic measurements and investigate the effect of environmental factors relevant to the Hanford vadose zone on the solubility of solid phases. Solubility experiments will be conducted at different temperatures up to 50^{o}C using multicomponent samples prepared with various bicarbonate and calcium ion concentrations. In addition, studies will continue to analyze mineralogical and morphological characteristics of precipitates by means of XRD and SEM-EDS. An additional set of samples will be prepared with the intention of minimizing nitratine (NaNO3) formation in order to lessen the obtrusive peaks that shadowed the peaks of the less plentiful components found in the sample XRD patterns.

Subtask 1.1 Quarterly Progress: April 1 – May 17, 2014

FIU has continued the isopiestic experiments with the set of 8 samples that included 2 crucibles containing standard solutions prepared from high purity sodium chloride (NaCl) salt and six (6) crucibles containing the dried multicomponent precipitate samples. Crucibles with multicomponent samples and standards were weighed at regular time intervals to record changes of water activities (a_w). These values were observed to change slightly with each measurement, indicating that the system has not reached equilibrium. Probably, the time required by the system to reach equilibrium conditions is longer for the salts mixture than for a single salt.

The number of moles of each compound was calculated based on its concentration in 50 mL of stock solution (Table 2-1).

Table 2-1 Number of Moles of Each Compound in 50 mL of Solution

	Na_2SiO_3 (100 mM)	$KHCO_3$	$Al(NO_3)_3$ (5 mM)	$CaCl_2$
n of moles	2.37E-04	2.25E-07 (3 mM)	5.00E-06	1.00E-07 (5 mM)
		6.25E-05 (50 mM)		2.00E-07 (10 mM)
v	3	2	4	3

Crucibles with multicomponent samples and standards were weighed to monitor the attainment of equilibrium conditions. Every time the chamber was opened and weights of the crucibles were recorded, the osmotic coefficients and water activities were calculated for all samples. The osmotic coefficient, ϕ, for the NaCl was calculated using an average of its molalities according to the equation proposed in Guo et al. (2012); the ϕ for the solute multicomponent samples were calculated as follows:

$$\phi = \frac{v_{NaCl} * m_{NaCl} * \phi_{NaCl}}{\sum v_i m_i}$$

Where v for NaCl is the number of ions formed by the complete dissociation of one molecule of the reference standard (NaCl=2), and ϕ for the standard was taken from Guo et al. (2012). In calculations of water activities, it was assumed that a_w is the same for all samples.

The respective water activities (a_w) were calculated following the equation below:

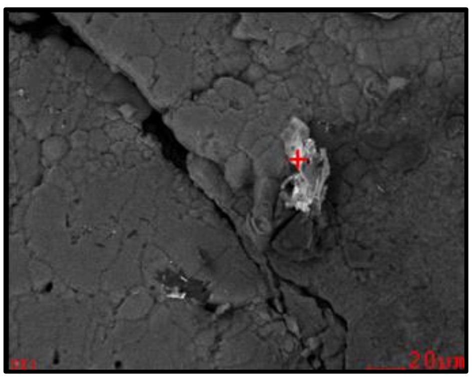
$$\ln a_{NaCl} = m_{NaCl} * \phi_{NaCl}/\mho$$

$$\ln a_i = m_i * \phi_i/\mho$$

Where, omega (molality of water), $\mho$, is 55.5084 mol/kg.

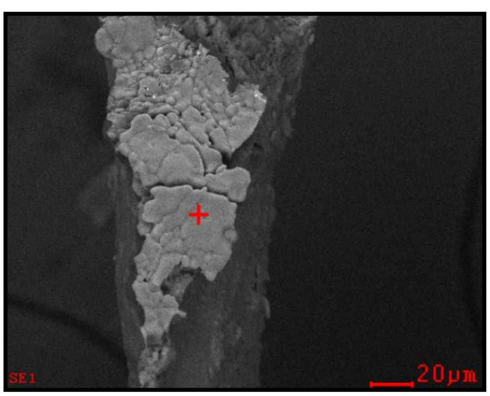
Table 2-2 summarizes the calculated osmotic coefficient ϕ and a_w for standard, NaCl, and solute multicomponent samples obtained each time the sample was weighed. In our case for the sample composition of Na_2SiO_3+ $Al(NO_3)_3$+ $KHCO_3$, the $\sum$ molality of a sample was calculated as (moles Na_2SiO_3*3+ moles $Al(NO_3)_3$*4+ moles $KHCO_3$*2)/(sample water weight at equilibrium). Data obtained in March-April were recalculated, considering the assumption that water activity values for all samples and standards in the chamber are the same. While the values for water activity of the solute multicomponent samples are close in value to each other, they are different from the values of the standard samples.

SEM-EDS analysis of the elevated uranium (500 ppm) samples was completed. The low bicarbonate samples continued to lack any significantly elevated uranium content (Figure 2-1). The trend of spotting sites with elevated uranium content in the high bicarbonate samples was fairly consistent throughout the rest of the samples. One exception to this was the high bicarbonate, 10 mM calcium sample where the atomic percentage of uranium never surpasses 0.5% (Figure 2-2). Though there were still no apparent crystal-like structures spotted, suggesting a mostly amorphous structure, the uranium-rich samples will likely still be analyzed by XRD to attempt a characterization.



Element	Wt%	At%
CK	16.10	22.15
NK	44.71	52.73
NaK	28.29	20.33
AlK	00.47	00.29
SiK	06.81	04.01
UM	02.92	00.20
KK	00.69	00.29

Figure 2-1. SEM-EDS of the 3 mM_HCO3_0 mM_Ca_500 ppm U sample: EDS shows relatively low uranium content



Element	Wt%	At%
CK	16.01	22.20
NK	40.36	47.98
NaK	39.42	28.54
AlK	00.31	00.19
SiK	00.46	00.27
ClK	00.43	00.20
UM	01.85	00.13
KK	00.60	00.26
CaK	00.57	00.24

Figure 2-2. SEM-EDS of the 50 mM_HCO3_10 mM_Ca_500 ppm U sample: EDS shows relatively low uranium content

Table 2-2 Osmatic Coefficient and Water Activities After Each Weight Measurement

Crucible	Sample	Data from weights recorded on April 1st				Data from weights recorded on April 11th				Data from weights recorded on April 29th			
		Final water weight (g)	Isopiestic molality (mol/kg)	ϕ	a_w	Final water weight (g)	Isopiestic molality (mol/kg)	ϕ	a_w	Final water weight (g)	Isopiestic molality (mol/kg)	ϕ	a_w
1	NaCl	0.38880	4.98216	1.18961*	0.80794	0.37044	5.22909	1.20897†	0.79648	0.36543	5.30078	1.21482‡	0.79300
2	NaCl	0.38996	4.96953			0.37132	5.21900			0.36587	5.29674		
7	Na_2SiO_3+ $Al(NO_3)_3$+ $KHCO_3$	0.20788	1.16441	3.36688	-	0.20070	1.20606	3.46828		0.19990	.1.21089	3.52082	
8	Na_2SiO_3+ $Al(NO_3)_3$+ $KHCO_3$	0.25261	1.20475	3.49569	-	0.24380	1.24815	3.599971		0.24081	1.26379	3.62388	
9	Na_2SiO_3+ $Al(NO_3)_3$+ $KHCO_3$ + $CaCl_2$	0.20670	1.17154	3.34640	-	0.20172	1.20046	3.48447		0.20040	1.20837	3.52818	
10	Na_2SiO_3+ $Al(NO_3)_3$+ $KHCO_3$ + $CaCl_2$	0.25869	1.17682	3.57857	-	0.24849	1.22513	3.66767		0.24672	1.23392	3.71151	
11	Na_2SiO_3+ $Al(NO_3)_3$+ $KHCO_3$ + $CaCl_2$	0.20753	1.16734	3.35846	-	0.20061	1.20760	3.46388		0.19912	1.21664	3.50421	
12	Na_2SiO_3+ $Al(NO_3)_3$+ $KHCO_3$ + $CaCl_2$	0.26042	1.16939	3.60124	-	0.25120	1.21231	3.70637		0.24868	1.22459	3.73969	

* calculated using average isopiestic molality of 4.97584 mol/kg
† calculated using average isopiestic molality of 5.22404 mol/kg
‡ calculated using average isopiestic molality of 5.29876 mol/kg

The preparation and analysis of the nitratine/sodium reduced samples was continued with the decanting and drying of the isolated precipitates. The volume of precipitate proved to be significantly less than what was seen in prior sample sets. It was proposed that this was due to the 75% reduction in sodium in the system, as intended by the new sample procedure. The samples spent 2-3 weeks drying in an oven set at 30°C. SEM and further analysis of these dried precipitates is pending.

The recently collected research data was organized and presented in the Project 2 - Subtask 1.1 progress report on the characterization of new samples prepared to minimize nitratine formation, submitted to DOE HQ on 4/21/2014. The report addressed the ongoing research and direction of the subtask moving forward.

The samples prepared with silicic acid to reduce sodium content were analyzed by SEM with EDS. The images showed a solid phase that looked more like a conglomerate of several small particles than prior sample preparations (Figure 2-3). It is possible that this is due to the steps added to the modified methodology not being enough to ensure sufficient dissolution of the silica colloids. Compared to the previously analyzed precipitates, EDS spectra of the reduced sodium samples showed few areas of high uranium content. In the areas that did show elevated uranium-bearing phases, there was a complete lack of any obviously crystalline structures resembling those seen in previous studies. When present, the uranium phases were typically small and amorphous (Figure 2-4).

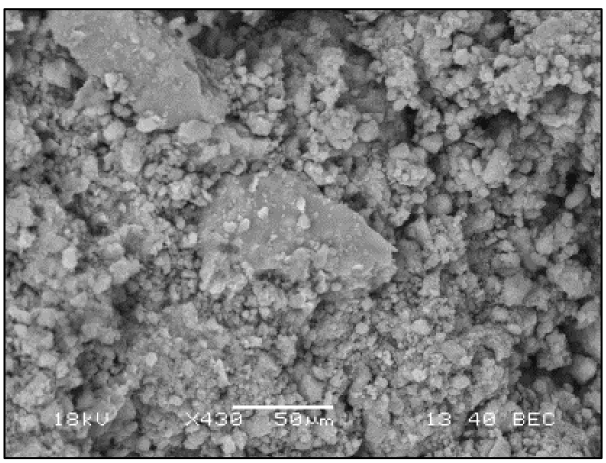


Figure 2-3. SEM micrograph of the precipitate formed from the 50 mM HCO3- + 5 mM Ca solution.

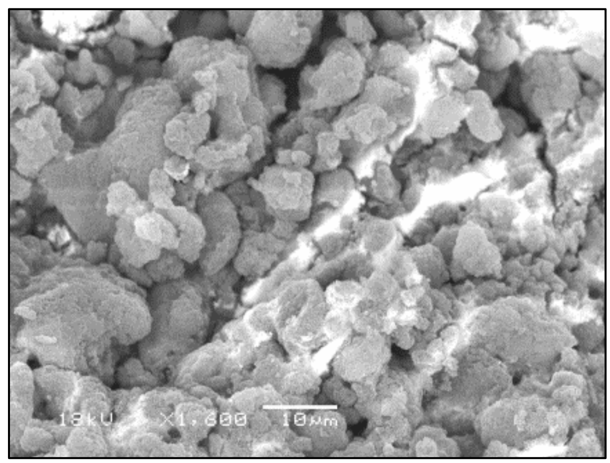


Figure 2-4. SEM micrograph of the uranium phases spotted on the precipitate formed in the 3 mM HCO3- + 5 mM Ca solution.

<u>Subtask 1.1 Quarterly Progress: May 18 – June 30, 2014</u>

Experimentally obtained values for water activities vs. osmotic coefficients using NaCl as a standard solution at 25^{o}C were plotted in Figure 2-5. Data shows a starting water activity of approximately 79%; this means that NaCl should be almost dry at the beginning of the experiment. At 25°C, the solubility of NaCl in water is only 6.144(5) mol/kg and the activity of water over the saturated solution is about 0.753 (from the data of Hamer and Wu, 1972). So, it is not possible to calculate the osmotic coefficient where molalities are higher than the solubility values (except for some small super saturation). In this case, NaCl as an isopiestic standard is only good for humidities higher than about 75% because it is not sufficient for very concentrated solutions. Therefore, it was decided to use new standards with solubilities higher than NaCl to obtain osmotic coefficient values at low humidity.

A literature search suggested two new standards, LiCl and $CaCl_2$, which have higher solubilities than NaCl. Both chemicals were ordered in "ultra dry" grade with metal-basis purities specified by Alfa Aesear Chemical Co. as 0.995 for LiCl and 0.99 for $CaCl_2$. These salts are available in the form of powders or small beads kept in glass ampoules under argon to avoid moisture.

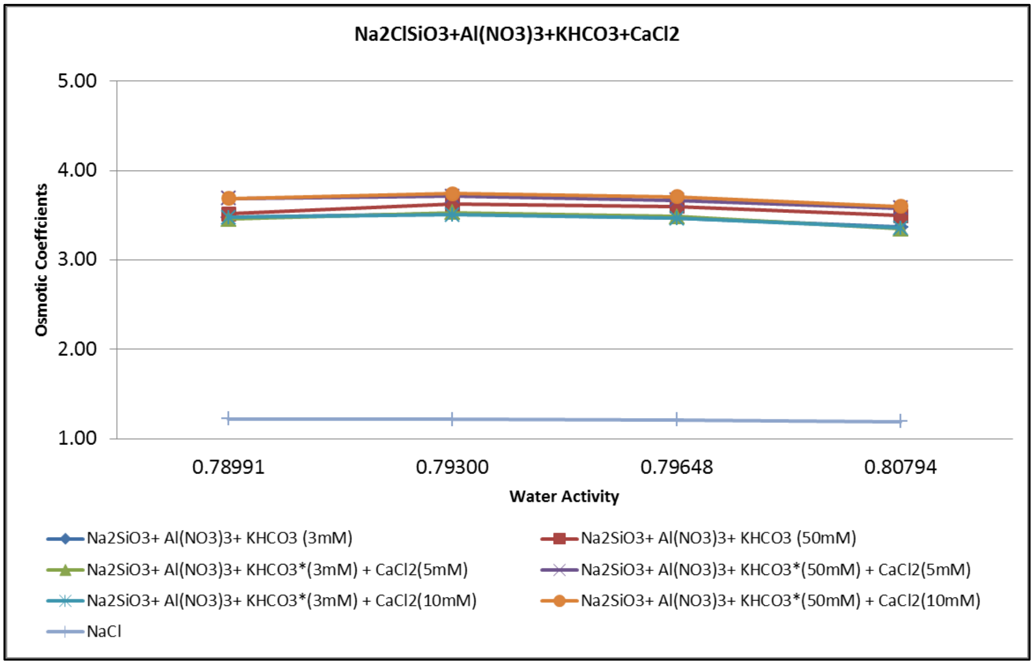


Figure 2-5. Water activity vs osmotic coefficients for the multicomponent samples.

During month of June, FIU has continued studying the deliquescence behavior of multicomponent U(VI)-free precipitates created after NH_3 (5% NH3 in 95% nitrogen) pH manipulation in the synthetic solutions mimicking conditions found in the vadose zone at the Hanford Site 200 Area. The experiment was set up using eight crucibles; two of them contained newly prepared dried sodium chloride (NaCl) as a reference standard with masses of 0.11534 and 0.11644 g, respectively. The high purity NaCl was, Puratronic 99.999% (metal basis) obtained from Alfa Aesar. The composition of the six multicomponent samples containing Si-Al-Ca-HCO_3 ions was presented in the previous reports. The molalities of NaCl after each weighing taking place in June were calculated as 12-13 mol/kg. Due to an inability to calculate water activities for the high molalities values of NaCl, the experiment was extended to include two new reference standard solutions, calcium chlorine ($CaCl_2$) and lithium chlorine ($LiCl_2$), known for their high solubility. The most soluble is LiCl; its maximum molality to obtain osmotic coefficient value for the water activity calculations is 19.219 mol/kg. The $CaCl_2$ and $LiCl_2$ salts were "ultra dry" grade chemicals with metal-basis purities specified by the Alfa Aesar as 0.99 and 0.995, respectively. Powdered salts were received sealed in argon-filled glass ampoules. Two samples of each reference standards solutions were prepared in an anaerobic glove box to avoid moisture. The weighing masses of the reference standards were 0.04685 and 0.03465 g for $CaCl_2$ and 0.02548 and 0.02541g for $LiCl_2$, measured carefully to limit variations between two identical standards. The reference standards are being used to obtain osmotic coefficients for the low water activities values in the multicomponent salt systems. Table 2-3 summarizes the compositions of the $CaCl_2$ and $LiCl_2$ reference standards, solute contents, and initial molalities. The initial results for measurements using calcium and lithium chlorides will be reported in the next monthly report.

Table 2-3. Standard and Multicomponent Samples Weights, Solute Content, and Molalities at the Beginning of Experiment

Cup #	Standard/Solute Multicomponent	Standard and Sample Weight (g)	Solute Content (moles)	Pure Water in Sample (µl)	Initial Sample Molality mol/Kg
1	$CaCl_2$	0.04685	4.22E-04	100	4.22
2	$CaCl_2$	0.03465	3.12E-04	100	3.12
3	$LiCl_2$	0.02548	6.00E-04	100	6.01
4	$LiCl_2$	0.02541	5.99E-04	100	5.99
7	Na_2SiO_3+ $Al(NO_3)_3$+ $KHCO_3$	0.19860	0.00024	0.13099	1.85
8	Na_2SiO_3+ $Al(NO_3)_3$+ $KHCO_3$	0.23900	0.00030	1.15473	0.26
9	Na_2SiO_3+ $Al(NO_3)_3$+ $KHCO_{3*}$ + $CaCl_2$	0.20150	0.00024	0.17987	1.35
10	Na_2SiO_3+ $Al(NO_3)_3$+ $KHCO_{3**}$ + $CaCl_2$	0.24340	0.00030	0.16542	1.84
11	Na_2SiO_3+ $Al(NO_3)_3$+ $KHCO_3$+ $CaCl_2$	0.21020	0.00024	0.15091	1.61
12	Na_2SiO_3+$Al(NO_3)_{3+}$ $KHCO_3$+ $CaCl_2$	0.25610	0.00030	0.18382	1.67

Experiments were continued for the characterization of U-bearing solid phases. Select samples from the previously described batch of elevated uranium samples were analyzed by X-ray diffraction. Similar to previous XRD analyses, a brief observation of the resultant diffraction patterns confirmed the presence of at least one crystalline phase. Analysis of these patterns using Match Software and manual comparisons to known mineral diffraction data is ongoing.

In addition to the samples previously described and prepared for the subtask, a sample was prepared to test a hypothesis about a potential change in sample preparation methodology. This change would primarily entail leaving the post-injection samples open to the lab environment to allow open gas exchange with air. The precipitates produced by this method showed promising results under scanning electron microscopy, warranting further investigation into this potential change in methodology (Figure 2-6). XRD analysis of this sample is pending.

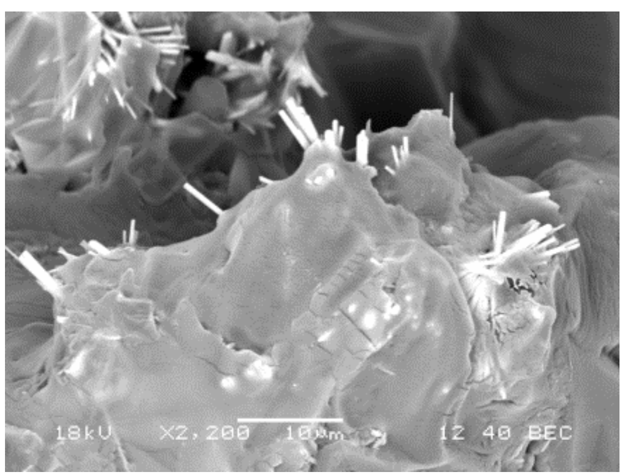


Figure 2-6. SEM micrograph of the precipitate formed using 50 mM HCO3- + 10 mM Ca and left open to air.

The FIU Year End Report for Project 2 presented the experimental results conducted for 2 tasks. Subtask 1.1 conducted a literature search on several solubility measurement approaches necessary to determine the uranium mobility in the post-treated soil and initiated isopiestic measurements that most closely mimic the unsaturated vadose zone environment. FIU-ARC completed a literature review, fabricated an isopiestic chamber equipped with a pressure transducer connected to the acquisition system and initiated preliminary testing to evaluate the experimental procedures. Experimental studies also continued for mineralogical and morphological characterization of NH_3-treated U(VI)-bearing solids precipitated from the solution mixture containing major pore water cations and ions that could be present in pore water from mineral phase dissolution. For this subtask, FIU explored alternative sample preparation methods that help to increase an atomic percentage of U(VI) in the composition of solid phases for more accurate identification of known U phases via X-ray diffraction. This research is still on-going and might require preparation of new samples to continue identification of solid phases. Currently, a graduate student (DOE Fellow Robert Lapierre) is on internship at Pacific Northwest National Laboratory assisting Dr. Jim Szecsody with his research on the influence of NH_3 gas treatment on the uranium remediation in vadose zone sediments. His activities have included assisting in preparing packed soil columns, setting up and running column leaching experiments, and analyzing effluent samples using selective ion electrodes and UV-Vis spectrophotometer. In addition to experimenting, he has participated in radiation training in order to become an independent rad worker at PNNL.

Subtask 1.2: Investigation on Microbial Meta-Autunite Interactions – Effect of Bicarbonate

Subtask 1.2 Overview

The goal of experimental activities under subtask 1.2 is to investigate the bacteria interactions with uranium by focusing on facultative anaerobic bacteria and study their effect on the dissolution of the uranyl phosphate solid phases created as a result of sodium tripolyphosphate injections into the subsurface at the 300 Area. The Columbia River at the site exhibits water table fluctuations, which can vary up to 3 m seasonally. This rising water table over the extent of its annual vertical excursion creates an oxic-anoxic interface that in turn, due to activates of facultative anaerobic bacteria, can affect the stability of uranium-bearing soil minerals. Previous assessments noted the decline in cultivable aerobic bacteria in subsurface sediments and suggested the presence of facultative anaerobic bacteria in sediment samples collected from the impacted area (Lin et al, 2012). Therefore, understanding the role of anaerobic bacteria as one of the factors affecting the outcome of environmental remediation is very important.

Subtask 1.2 Quarterly Progress: April 1 – May 17, 2014

The AFM and Live/Dead fluorescent assessment to illustrate changes in bacterial cells after uranium exposure were summarized in the progress report submitted to DOE HQ on 4/30/2014. This study experimentally analyzed changes on the bacteria surface after uranium exposure and evaluated the effect of bicarbonate ions on U(VI) toxicity of a less uranium tolerant *Arthrobacter* strain, G968, by investigating changes in adhesion forces and cell dimensions via atomic force microscopy (AFM). AFM and viability studies showed that samples containing bicarbonate are able to acclimate and withstand uranium toxicity. Samples containing no bicarbonate exhibited deformed surfaces and a low height profile, which might be an indication that the cells are not viable. In addition, two manuscripts were prepared for the submission to peer-review journals.

FIU also continued working on two manuscripts prepared for submission to peer-review journals: "The Effect of Bicarbonate on the Microbial Dissolution of Autunite Mineral in the Presence of a Low U(VI)-Tolerant Strain, *Arthrobacter oxydans* G968" and "A Study of Cell Viability on DOE Hanford Soil Isolates: Effect of U(VI) and Bicarbonate."

Subtask 1.2 Quarterly Progress: May 18 – June 30, 2014

FIU initiated the preparation of the Project Technical Plan (PTP) for FIU Year 5 and the Year End Report based on the results obtained from the research performed during FIU Year 4. A conference call with PNNL researchers, Hope Lee and Brady Lee, was held in early June to discuss the PTP for the FIU Year 5. FIU then finalized the preparation of the Project Technical Plan (PTP) for this task. Based on the discussions with PNNL researchers, Hope Lee and Brady Lee, experimental work will be conducted to investigate the effect of facultative anaerobic bacteria on the dissolution of autunite minerals. The U-impacted zone features oxic-anoxic conditions due to the Colombia River near-shore water table fluctuations. Previous assessments of subsurface sediments in the 300 Area of the Hanford Site determined a large variety of the anaerobic and facultative microorganisms in this area. This project will focus on the facultative microorganisms (e.g., Shewanella) and their effect on the dissolution of autunite mineral in the presence of the bicarbonate ions.

The Year End Report presented results for Subtask 1.2 on a series of experiments to qualitatively and quantitatively characterize changes on the bacteria surface after uranium exposure and evaluate the effect of bicarbonate ions on U(VI) toxicity of a low uranium tolerant *Arthrobacter oxydans* strain, G968, by analyzing changes in adhesion forces and cell dimensions via profile plots. In addition, supplementing AFM analysis, cell viability was assessed by the Live/Dead BacLight Bacterial Viability Kit (Molecular Probes) to quantitatively illustrate how bacterial cells are affected when exposed to uranium in the presence of varying concentrations of bicarbonate ions. The results of this research were included in the DOE Fellow Paola Sepulveda's thesis who graduated in e spring of 2014 with a master's in biomedical engineering.

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

Task 2 Overview

The objectives of the proposed experimental work for subtask 2.1 are: (i) to evaluate whether a base solution of dissolved silica prepared below the equilibrium solubility of amorphous silica, which is usually assumed to be about 100-150 ppm at circumneutral pH conditions, have enough alkalinity to restore the pH of the treatment zone; (ii) to investigate the hypothesis that some uranium in the current treatment zone is bound to silica; and (iii) to study if any synergy between humic acid (HA) and silica will influence the behavior of uranium.

The objective of subtask 2.2 is to replicate the treatment performed by ARCADIS at SRS and investigate the mineralogical changes that occur in the soil due to the addition of molasses. Specifically, the study aims to determine whether forms of reduced iron such as siderite and pyrite would arise in the reducing zone and if any mineralogical changes can occur in sediments during the re-oxidation period. These experiments will also explain the types of reactions that might occur in the anaerobic aquifer. An understanding of the technology will be useful to determining if it is a viable option for remediation. The study will evaluate the addition of sulfate in the solution mixture for the formation of iron-bound pyrite phases. The objectives for this study include analysis of groundwater from the contaminated area if samples became available and evaluate the diffusion trap sediment samples via XRD and SEM-EDS methods to greater supplement the on-going microcosm studies on processes occurring in a bioreduction zone.

The newly created subtask 2.3 relates to the subtask 2.1 and will focus on the humic acid sorption experiments helping to evaluate the distribution of humate injected into the subsurface during deployment for in situ treatment of radionuclides.

Task 2 Quarterly Progress: April 1 – May 17, 2014

Subtask 2.1: FIU's support for groundwater remediation at SRS F/H Area

During the month of April, FIU initiated troubleshooting of the ICP-OES, fixing the leakage of argon gas. A service call has been scheduled for the service engineer's visit. FIU also continued to work on the kinetic phosphorescence analyzer (KPA) to improve the reading's intensities, changed dye solution followed by the aligning of the laser; however, there were no improvements in the performance of the instrument. The KPA was sent for service and laser alignment was performed. Once FIU received the kinetic phosphorescence analyzer (KPA) from service, several tests were performed to ensure the intensities are in agreement with manufacture specifications. Triplicates of pH 3 samples prepared using 1% HNO_3 with a 1:10 dilution ratio were analyzed for U(VI) via the KPA. Uranium removal was calculated from the KPA results and the data are presented in Table 2-4. As the data suggested, the percent removal of U(VI) at pH 3 was very small, ranging between 8.4-23.6% for all batches. At this pH, the uranyl cations are the major existing U(VI)- bearing species in the solution. The sorption of U(VI) on Si colloids was negligible at pH 3. However, the presence of HA and sediments increased U(VI) sorption from the solution; the average removal efficiency increased from 8.4 to 23.6%.

Table 2-4. Uranium and Silica Removal at pH 3 for Batches 1 through 7

Sample-Description, pH 3	U(VI) Avg. Removal, %	Std.	Si Avg Removal, %	Std.	Fe, ppm
Batch 1	8.45	1.79	91.28	0.69	No soil
Batch 2	16.63	2.05	87.68	0.45	No soil
Batch 3	15.62	1.90	No Si	NA	No soil
Batch 4	12.73	2.17	92.71	0.73	0.007-0.18
Batch 5	22.43	0.24	89.26	0.69	0.23-0.32
Batch 6	23.58	0.14	No Si	NA	0.21-0.43
Batch 7	19.85	5.76	No Si	NA	0.09-0.28
Batch 1 Filtered	8.04	0.94	98.34	0.03	0

Subtask 2.2: Monitoring of U(VI) bioreduction after ARCADIS demonstration at F-Area-Quarterly progress

During the month of April, FIU initiated the final testing stage of the microcosm experiment for molasses treated samples by testing the re-oxygenated period of the samples. Each of the samples was sacrificed after 6 weeks of treatment and divided into three different environments. The three environments consisted of the regular anaerobic chamber with no oxygen, a smaller chamber with a low oxygen content of 2000 ppm, and the work bench where they were exposed to atmospheric oxygen levels. In each environment, there are four samples from different depths (65, 80, 90, and 100 feet) for each batch. After the samples had dried in their respective environments, they were sieved and transported for X-ray diffraction analysis. The same process was followed for the control samples; however, only 3 of the control samples were selected for analysis (one from each environment at a depth of 90 feet). There are 27 samples in total that need to be analyzed, 16 of which have been analyzed during the month of April. The X-ray diffraction analysis was run at 35 kV and 40 mA via a Bruker 5000D XRD instrument. Diffraction patterns were obtained using a copper Cu Kα radiation source (λ=0.154056 nm) with a tungsten filter in a 2-theta (2θ) range from 2.5° to 90° with a 0.02° step size and 3 second counting per step. The sieved sample was packed into the small recess of a plastic sample holder that was designed specifically for the small amount available. The results were plotted using sigma plot software (Figures 2-7, 2-8, and 2-9). FIU is currently working on the interpretation of the results; however, it initially appears that pyrite and siderite solid phases are not present in the XRD pattern.

FIU completed XRD analysis for all 27 samples sacrificed after 6 weeks of treatment with molasses. All samples, including controls that were molasses-free but kept in a mineral media solution to promote bacterial growth were divided into three different environments to examine the re-oxidation period of reduced iron phases. FIU continued interpretation of XRD results obtained for Batch 2 samples augmented with anaerobic bacteria. Results suggested that samples from Batch 2 produced similar diffraction patterns to those obtained from Batch 1 samples.

Task 2 Quarterly Progress: May 18 – June 30, 2014

Subtask 2.1: FIU's support for groundwater remediation at SRS F/H Area

The ICP-OES instrument was serviced and several tests were conducted to ensure proper operation of the instrument. Samples from batches for pH 3, 7 and 8 were analyzed using ICP-OES for Si and Fe. Data obtained in those analyses are presented in Tables 2-5 and 2-6.

Table 2-5. Uranium and Silica Removal at pH 7 for Batches 1 through 7

Sample-Description, pH 7	U(VI) Avg Removal, %	Std.	Si Avg Removal, %	std	Fe, ppm
Batch 1	67.53	10.28	75.45	0.94	No soil
Batch 2	49.69	10.82	81.19	0.05	No soil
Batch 3	41.17	10.68	No Si	NA	No soil
Batch 4	98.06	1.45	95.96	0.78	0.038-0.047
Batch 5	85.47	2.19	90.28	1.27	0.59-0.82
Batch 6	85.70	2.19	No Si	NA	1.22-1.88
Batch 7	98.64	0.98	No Si	NA	0.032-0.065
Batch 1 filtered	NR	NR	92.45	0.82	No soil

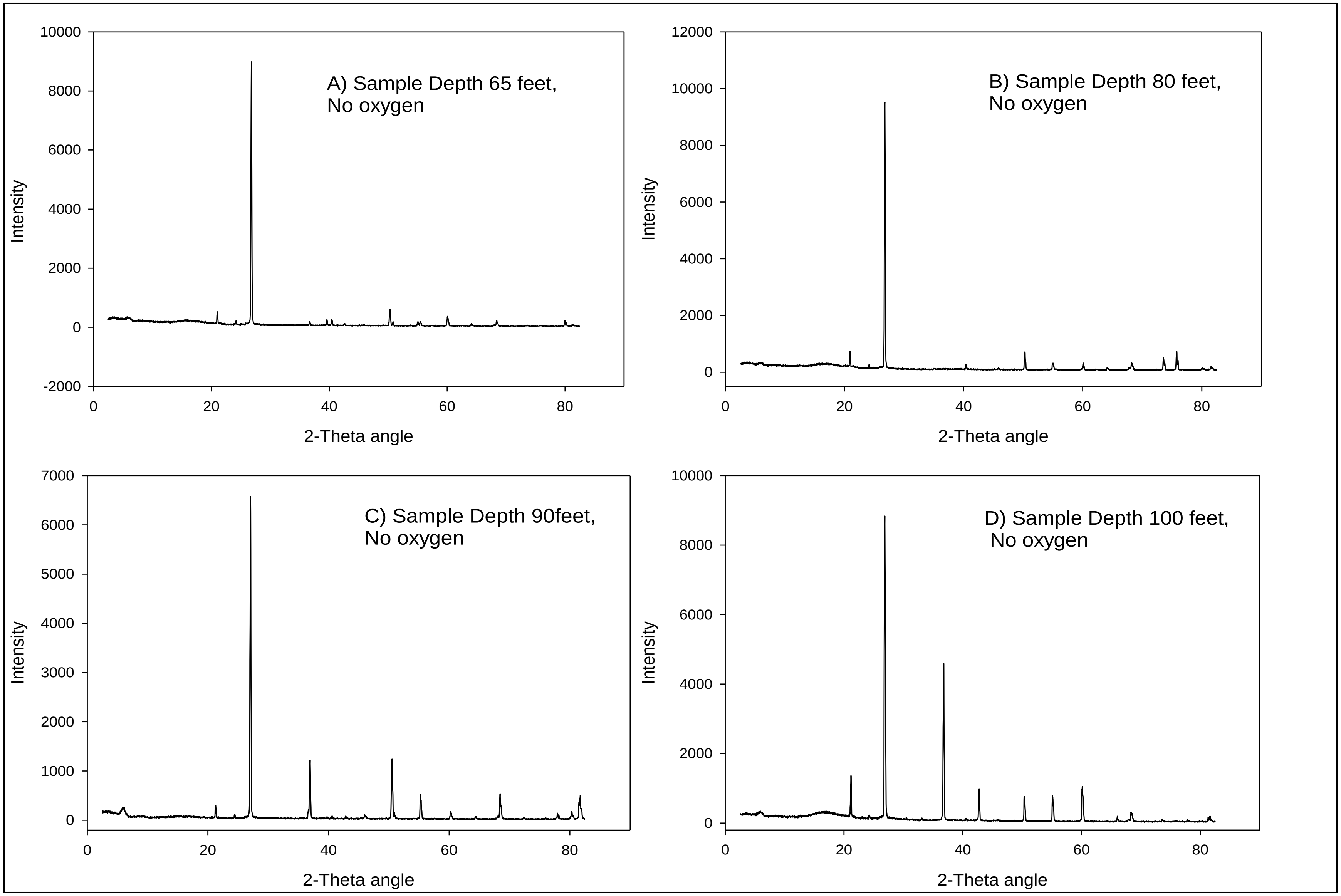


Figure 2-7. XRD results for Batch 1, Environment I: No Oxygen.

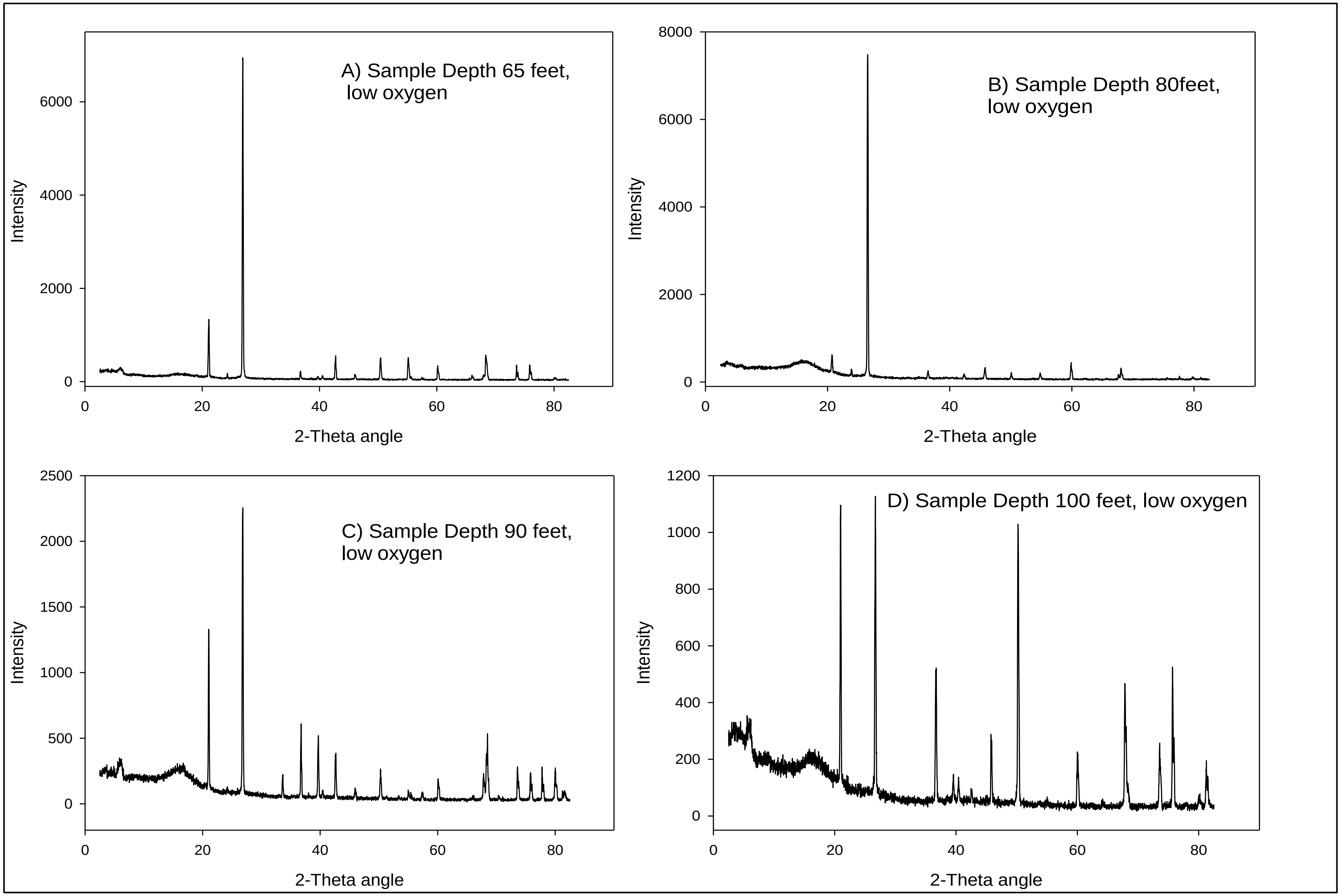


Figure 2-8. XRD results for Batch 1, Environment II: Low Oxygen.

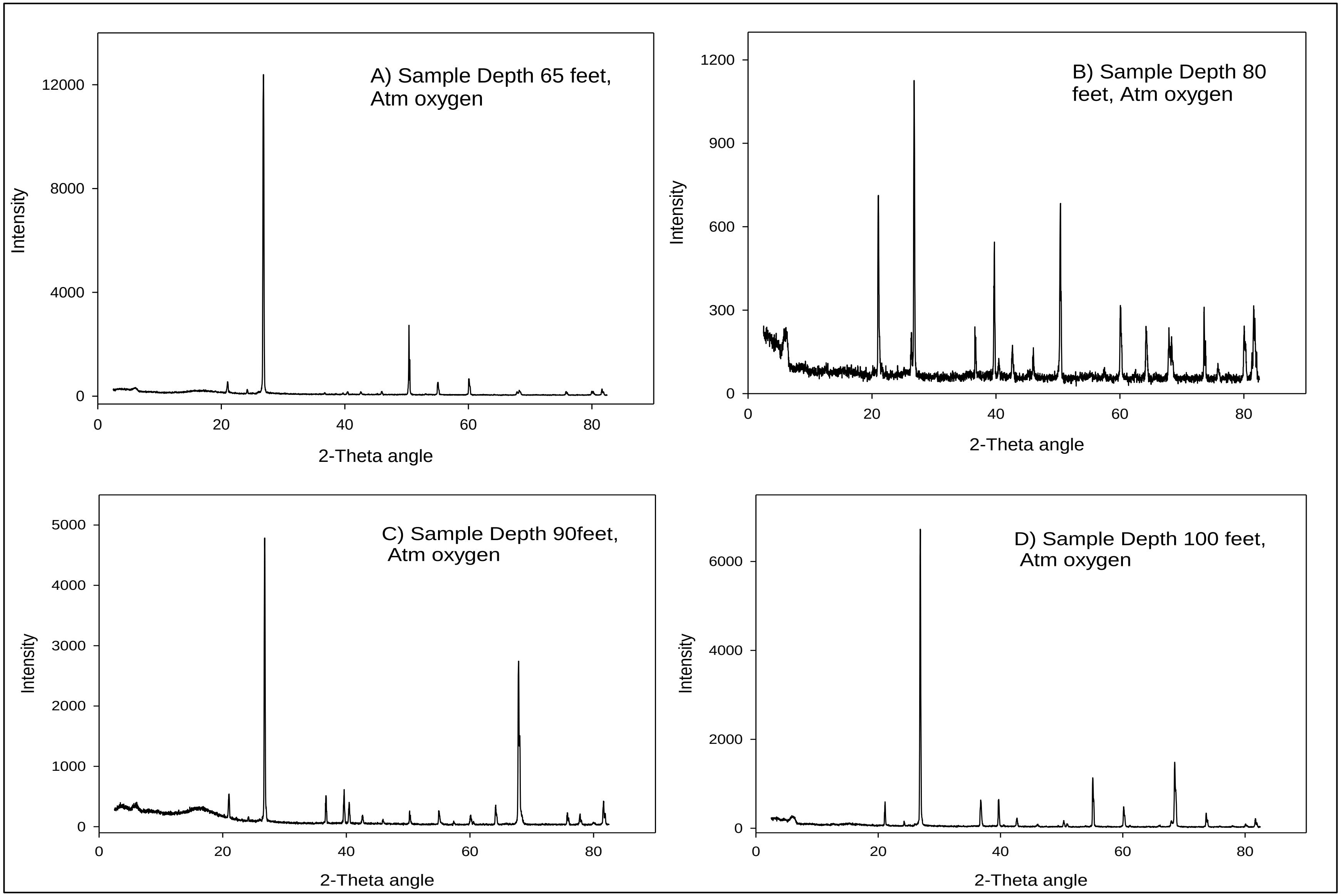


Figure 2-9. XRD results for Batch 1, Environment III: Atmospheric Oxygen.

Table 2-6. Uranium and Silica Removal at pH 8 for Batches 1 through 7

Sample-Description, pH 8	U(VI) Avg Removal, %	Std.	Si Avg Removal, %	std	Fe, ppm
Batch 1	96.48	1.44	90.69	0.96	No soil
Batch 2	96.34	0.55	71.28	1.11	No soil
Batch 3	94.05	0.68	No Si	NA	No soil
Batch 4	99.45	0.24	92.05	0.48	0.10-0.14
Batch 5	98.07	0.33	88.90	0.46	0.64-1.2
Batch 6	98.21	0.64	No Si	NA	1.2-1.4
Batch 7	99.93	0.07	No Si	NA	0.03-0.04
Batch 1 filtered	99.96	0.07	98.05	0.08	No soil

The Project Technical Plan (PTP) for this task for FIU Year 5 includes: (i) evaluation whether a base solution of dissolved silica prepared below the equilibrium solubility of amorphous silica, which is usually assumed to be about 100-150 ppm at circumneutral pH conditions, have enough alkalinity to restore the pH of the treatment zone; (ii) to investigate the hypothesis that some uranium in the current treatment zone is bound to silica; and (iii) to study if any synergy between humic acid (HA) and silica will influence the behavior of uranium.

The Year End Report presented results for subtask 2.1 on FIU's support for groundwater remediation for the SRS F/H Area. Thus far, experiments were performed on the designed experimental matrix that involved 3.5 mM colloidal silica, 10 ppm humic acid, and natural sediments collected from the F/H Area, to simulate the uranium removal process from the solution in the pH range from 3 to 8. Uranium analyses were done on filtered and unfiltered samples to account for uranium adsorbed to the colloidal Si or HA particles. Analysis by means of ICP-OES provided information on Si and Fe in the solution. Currently, DOE Fellow Hansell Gonzalez is on internship at Savannah River National Laboratory assisting Dr. Miles Denham with his research on humate sorption experiments with Huma-K and F-Area sediments. The primary objective of the experiment is to understand the sorption of humic substances versus pH values.

Subtask 2.2: Monitoring of U(VI) bioreduction after ARCADIS demonstration at F-Area-Quarterly progress

Evaluation of the XRD data for sieved samples was continued. After analysis of the results, it was clear that for each environment (no oxygen, low oxygen and atmospheric oxygen), the only match was for quartz (Figure 2-10). The most intense peaks for each of the samples occurred near the 2-theta values of 27 and 21. There was a slight peak at the 2-theta value of about 5.89 which would indicate the presence of montmorillonite (a clay mineral), though it is of low intensity, which was probably overshadowed by the presence of quartz. The intensities for all the samples vary, though the 2-theta peaks stayed consistent. This variance could be due to the inconsistencies in the size of the sample crystals, which would lead to different intensities being observed. FIU initiated preparation of the Year End Report based on the findings from the research.

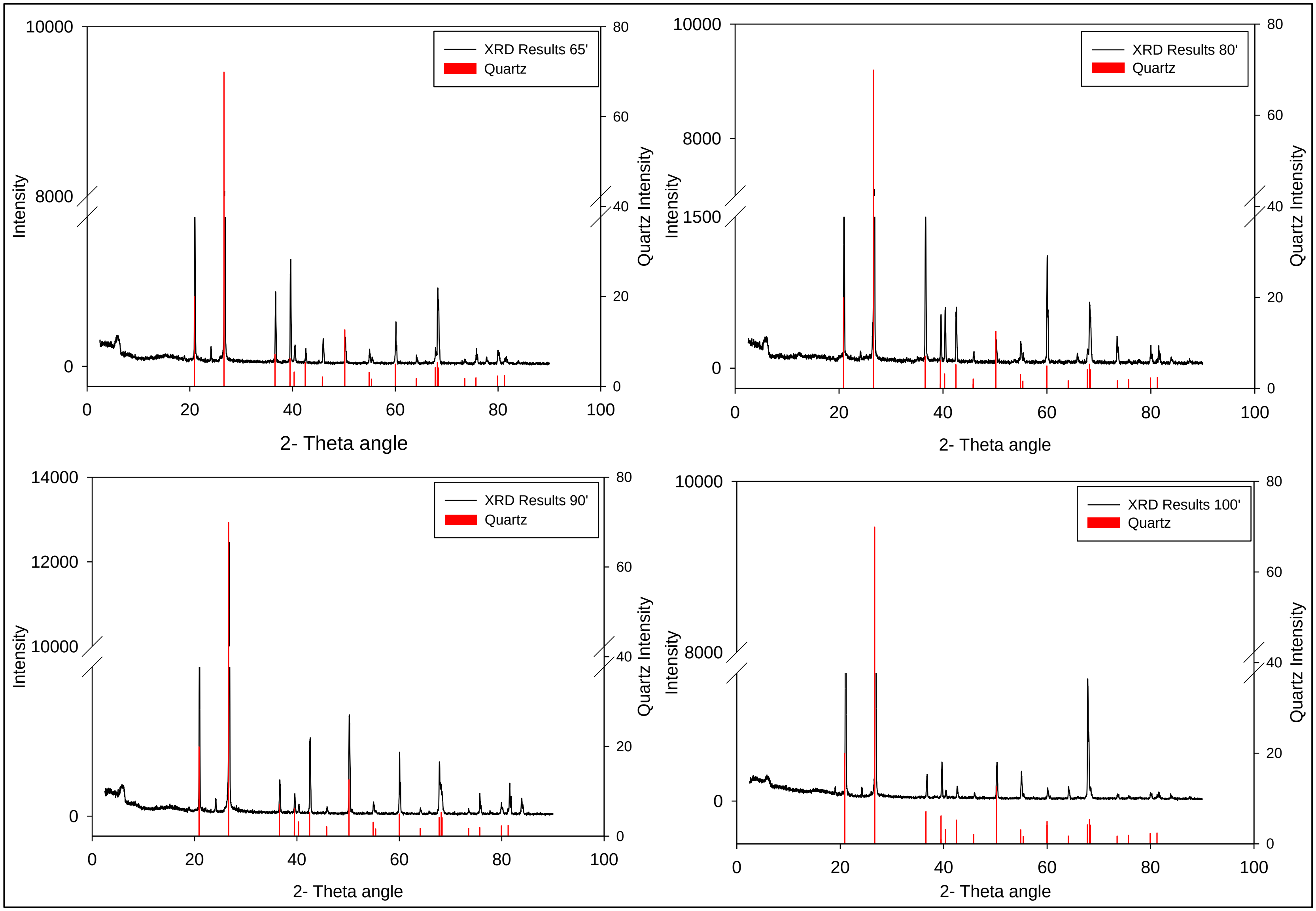


Figure 2-10. XRD results for Batch 2, Environment I: No Oxygen.

The Project Technical Plan for this task includes setting up microcosm experiments prepared with SRS sediments, augmenting the solution mixture with molasses and sulfate. The sulfate reduction process leads to an increase in the pH of the water, often to a near neutral condition. SRS sediments contain iron, which in the anaerobic conditions will be reduced to the ferrous iron. The addition of sulfate might promote the precipitation of ferrous iron solid phases such as pyrite. These experiments will also explain the types of reactions that might occur in the anaerobic aquifer. The preparations of the samples will follow the same procedures as described in the FIU Year 4 Year End Report.

Previously conducted X-ray diffraction (XRD) analysis identified high intensity peaks for quartz in the soil samples that prevented observation of fine clay fractions in the mineralogical results. The expectation was to see quartz along with other common clay minerals such as mullite, goeliite, kaolite, and muscovite that are present in the SRS soil. To increase the percentage of fine fractions, soil was sieved by hand through 3 layers of mesh stacked top to bottom consisting of sizes 180 µM, 125 µM, and 63 µM. The soil samples were first pulverized using a glass mortar and pestle to ensure that the finer clay particles would be detached from the larger quartz particles. The sieving took place for each of the various depths of the soil samples collected from the SRS site. The depths of the sieved samples were 65 ft, 80 ft, 90 ft, 95 ft, 100 ft, and 105 ft.

Sieved samples gathered from each mesh size were placed in labeled containers; this was done to see at which mesh size the desired clay particles could be obtained. Later, it was decided that the 180 µM, 125 µM, and 63 µM fractions could be combined for each depth since, in many of the SRS core samples, the sands tend to be coated with clay and iron oxides. So, the 180 µM fraction could possibly be useful to represent coated sand. The total amounts of sieved soil varied by depth and are in the range of 11.8 g to 47.3 g. Using finer fractions of soil during the batch experiments will give a better chance of detecting any sulfides and ferrous carbonate by XRD or SEM. The collected amount of fine fractions obtained at 100 ft and 105 ft depths so far is not sufficient for sample preparation; arrangements are being made to get more soil samples from SRS to continue with samples preparation to set up the experiment.

During FIU Year 4, as reported in the Year End Report, Task 2.2, Monitoring of U(VI) bioreduction after ARCADIS demonstration at F-Area, focused on microcosm experiments to replicate the treatment performed by ARCADIS at SRS and investigated the mineralogical changes that occur in the soil due to the addition of molasses. The study aimed to determine whether forms of reduced iron such as siderite and pyrite would arise in the reducing zone and if any mineralogical changes occurred in sediments during the re-oxidation period when treated sediments were exposed to air. A new undergraduate DOE Fellow student, Aref Shehadeh, will continue this research in FIU Year 5 using media solutions augmented with sulfate and molasses.

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

A new subtask 2.3 will focus on the sorption properties of the humate injected into the subsurface system. The primary objective of the batch sorption experiments is to understand the sorption versus pH and to correlate results with HA injection tests. Batch sorption experiments will include a series of reactors prepared with HA and U(VI) in the pH range adjusted between 4 and 9. Batch sorption experiments will include a series of reactors prepared with HA and U(VI) in the pH range adjusted between 4 and 9.

Hansell Gonzalez, a DOE Fellow, initiated experiments on humic acid sorption under the mentorship of Dr. Miles Denham at SRS. Four types of samples collected from different locations at the Savannah River Site were used for the sorption experiments. Six different concentrations of Huma-K (humic substance extract from leonardite) 50, 100, 150, 200, 250, and 300 ppm will be tested for each sediment sample in order to determine the maximum adsorption capacity. An analysis will be conducted by using an UV-vis spectrophotometer. First, sediment samples (1 gram) were weighed and placed in a centrifuge tube. Then samples were equilibrated for 24 hours at pH 4 and pH 9 by addition of acid or base. Afterwards, a humate stock solution will be injected and the pH will be adjusted again. Then samples will be placed on the shaker for 24 hours followed by centrifugation. The aliquot will be analyzed using a spectrophotometer to determine the amount of humic substance adsorbed by the sediment. One type of sediment has been equilibrated, and the process for the humate injection has been initiated.

Task 3: Evaluation of Ammonia Fate and Biological Contributions during and after Ammonia Injection for Uranium Treatment

Task 3 Overview

The newly created Task 3 relates to the Hanford Site and aims to evaluate the potential biological and physical mechanisms associated with the fate of ammonia after injection into the unsaturated subsurface. These tests will identify and quantify factors controlling the relative rate of these processes. Expected processes include biological transformation, partitioning and geochemical reactions. Tests will examine the mechanisms of potential importance using controlled laboratory systems to complement efforts underway at PNNL.

Task 3 Quarterly Progress - May 18 – June 30, 2014

A new task 3 was added in the Project Technical Plan for FIU Year 5. Task 3 will focus on an evaluation of ammonia fate and biological contributions during and after ammonia gas injection for uranium remediation at Hanford. This task will evaluate the potential biological and physical mechanisms associated with the fate of ammonia after injection into the Hanford Site unsaturated subsurface. These tests would identify and quantify factors controlling the relative rate of these processes.

The initial phase of Subtask 3.1 focuses on the investigation of NH_3 partitioning in the presence of bicarbonate-bearing media examined under different pH and temperature conditions. In addition, it is expected to collect further information regarding the solubility of NH_3, according to the mentioned parameters. A better understanding of the partitioning of NH_3 with bicarbonate is necessary to predict the potential results after NH_3 gas injection into Hanford's vadose zone.

In order to achieve this knowledge, a literature review on the various procedures and methods for the determination of ammonia gas partitioning is currently underway. Preliminary review of the literature has revealed different methods and procedures that may potentially provide the measurements or values needed to assess the behavior of NH_3 at the conditions expected. Such methods of assessment include manometer-type set ups, which vary depending on the gas used as well as the experimental advantages such as constancy of ratios, and time for equilibration. Other methods suggest batch-type experiments using various gas concentrations, which can be modified to further determine how the presence of bicarbonate may influence ammonia gas partitioning within the media. Another option observed is the use of gas chromatography through column-type studies and through headspace gas or vapor testing.

Milestones and Deliverables

The milestones and deliverables for Project 2 for FIU Year 4 and FIU Year 5 are shown on the following tables. For task 1, two deliverables titled "Progress report on characterization of new samples prepared to minimize nitratine impact" and "Progress report on Atomic Force Microscopy (AFM) assessment of bacterial cells exposed to U(VI)" were completed and sent to DOE contacts on 4/21/2014 and 4/30/2014, respectively. A Project Technical Plan for FIU Year 5 was prepared and sent to DOE EM on June 17, 2014. The technical Year End Report for FIU Year 4 was prepared and provided to DOE EM on June 30, 2014.

FIU Year 4 Milestones and Deliverables for Project 2

Task	Milestone/ Deliverable	Description	Due Date	Status	OSTI
Task 1: Sequestering Uranium at the Hanford 200 Area Vadose Zone by *In Situ* Subsurface pH Manipulation Using NH3 Gas	2012-P2-M1	Complete experimental plan on solubility measurements via isopiestic method	1/30/2014	Complete	
	2013-P2-M2	Completion of experimental plan including modifications for new samples preparations via ion exchange resin	2/14/2014	Complete	
	Deliverable	Subtask 1.1 Progress report on literature review and experimental plan on solubility measurements via isopiestic method	2/25/2014	Complete	
	Deliverable	Subtask 1.1.Progress report on characterization of new samples prepared via ion exchange resin	4/11/2014	Complete	
	Deliverable	Subtask 1.2 Progress report on bacterial growth in the present of 5-20ppm of U(VI) in bicarbonate-bearing solutions and AFM assessment on bacteria exposed to U(VI).	4/30/2014	Complete	
Task 2: Remediation Research and Technical Support for Savannah River Site	2012-P2-M3	Completion of testing of Dead/Live bacteria	1/20/2014	Complete	
	2013-P2-M4	Completion of batch experiments using colloidal silica, humate, sediments and U(VI)	2/5/2014	Complete	
	2013-P2-M5	Completion of microcosm studies prepared with SRS sediments	1/31/2014	Complete	
	Deliverable	Subtask 2.1 Progress report on the results of batch experiments using colloidal silica, humate, sediments and U(VI)	3/15/2014	Complete	
	Deliverable	Subtask 2.2 Progress report on microcosm studies prepared with SRS sediments, & Groundwater analysis	2/7/2014	Complete	

FIU Year 5 Milestones and Deliverables for Project 2

Task	Milestone/ Deliverable	Description	Due Date	Status	OSTI
Task 1: Sequestering uranium at Hanford	2014-P2-M5	Obtain anaerobic facultative microorganisms, Shewanella sp., from PNNL and complete preparations to set up autunite leaching experiments.	10/03/14	On Target	
	2014-P2-M3	Completion of sample preparation using a reduced amount of silica (50 mM)	11/07/14	On Target	
	2014-P2-M4	Complete preparation of a draft manuscript on the removal of uranium via ammonia gas injection method	12/15/14	On Target	
	2014-P2-M1	Completion of solubility measurements of U(VI)-free samples (FIU Year 5 scope) **<u>and</u>** Completion of solubility measurements using standards such as calcium chloride and lithium chloride to get better deliquescence predictions at low water activities values (carryover scope).	01/30/15	On Target	
	Deliverable	Prepare a progress report on the solubility measurements via isopiestic method (subtask 1.1)	02/16/15	On Target	OSTI
Task 2: Groundwater remediation at SRS	2014-P2-M6	Complete preparations for the microcosm experiments prepared with SRS sediments using sulfate additions.	09/12/14	On Target	
	Deliverable	Progress report on microcosm studies prepared with SRS sediments augmented with molasses and sulfate (subtask 2.2)	01/30/15	On Target	OSTI
	Deliverable	Progress report on batch experiments prepared with SRS sediments, colloidal Si and higher HA concentration up to 50ppm (carryover scope under subtask 2.1).	03/30/15	On Target	OSTI
	Deliverable	Prepare a progress report on sorption properties of the humate injected into the subsurface system (subtask 2.3)	04/03/15	On Target	OSTI
Task 3: Evaluation of ammonia for uranium treatment	2014-P2-M2	Completion of literature review on physical mechanisms associated with the fate of ammonia after injections into subsurface	10/31/14	On Target	

Work Plan for Next Quarter

- Subtask 1.2: Continue working on two manuscripts prepared based on the experimental results on G968 strain dissolution of autunite minerals and cells viability assessment to peer-review journals.
- Subtask 2.2: Initiate samples preparation amended with sulfate for ARCADFIS work. DOE Fellow Aref Shehadeh will take XRD training to continue with XRD analysis.
- Subtask 2.3: Obtain SRS soil and initiate sorption experiments with HA and U(VI) in the pH range between 4 and 9.
- Task 3: Continue literature search for task 3 on evaluation of ammonia fate and biological contribution before and after ammonia gas injection.

- Subtask 1.1: As part of the carryover scope, FIU will continue testing different standards such as calcium chloride and lithium chloride to get better deliquescence predictions at low water activities values. Prepare a new set of samples for testing of uranium-bearing precipitates via SEM/EDS and XRD.
- Subtask 2.1: As part of the carry over scope, initiate sample preparation to explore the effect of the higher humic acid concentrations up to 50 ppm. The experimental matrix will be the same as for the study conducted last year using 10 ppm of HA

Project 3
Environmental Remediation Technologies (EM-12)

Project Manager: Dr. Georgio Tachiev

During this reporting period, Project 3 tasks were put on hold due to recommendations by DOE-HQ to re-scope these tasks. During April and May, following several re-scoping discussions with DOE representatives from DOE-SRS and DOE-HQ (EM-12 & EM-13), new work scope for Project 3 which focuses on remediation and treatment technology at SRS and utilizes the capabilities developed under Project 3 was drafted and submitted for approval. For FIU Year 5, the work scope will utilize and build upon the capabilities developed under Project 3 in the area of soil and groundwater remediation and treatment technology. Tasks will be synergistic with the work SRNL is performing and will involve (1) Modeling of the migration and distribution of natural organic matter injected into subsurface systems; (2) Surface water modeling of Tims Branch; and (3) Development of a sustainability plan for the A/M Area groundwater remediation system.

Project Description

The overall objective of this project during FIU Year 4 was to provide technical assistance and perform research in support of the remediation efforts at the Oak Ridge Reservation. The main emphasis of this project was on numerical modeling and experimental work of the fate and transport of inorganic and organic pollutants. Research efforts were executed in collaboration with DOE EM and DOE ORO and were closely aligned with the ASCEM program objectives.

For FIU Year 5, FIU will utilize and build upon the capabilities developed under Project 3 in the area of soil and groundwater remediation and treatment technology. FIU will coordinate closely with the Savannah River Site during FIU Year 5 in the execution of the work scope. Tasks will be synergistic with the work SRNL is performing and will involve (1) Modeling of the migration and distribution of natural organic matter injected into subsurface systems; (2) Fate and transport modeling of Hg, Sn and sediments in surface water of Tims Branch; and (3) Analysis of baseline, optimization studies and development of a system improvement plan for the A/M Area groundwater remediation system.

Task 1: Modeling of the migration and distribution of natural organic matter injected into subsurface systems

<u>Task 1 Overview</u>

For FIU Year 4, Task 1 was titled **Task 1: East Fork Poplar Creek Model Update, Calibration & Uncertainty Analysis**. FIU used the numerical model of EFPC to determine the impact of remediation alternatives on the complete hydrologic cycle, the transport overland and in surface water and rivers, sediment transport and reactions, and mercury exchange with sediments. The research was coordinated with the site and ORNL personnel. The major objective of this task was to provide analysis of the coupling between hydrology and mercury transport within the context of decreasing the risk of deactivation and decommissioning (D&D) activities. The work for FIU Year 4 supported a PhD student and included model simulations that implement selected thermodynamic equilibria and reactions. The major deliverable of this task was numerical and stochastic analysis of observed and computed time series for flow and contaminant concentration for NPDES-regulated outfalls within the watershed. Model simulations were used to account for a range of hydrological impacts related to plan remediation alternatives.

For FIU Year 5, Task 1 is titled **Task 1: Modeling of the migration and distribution of natural organic matter injected into subsurface systems.** This work aims to assemble, integrate and develop a practical and implementable approach to quantify and model potential natural organic matter (NOM, such as humic and fulvic acids, humate, etc.) deployment scenarios for the range of conditions at DOE sites. SRNL has performed initial laboratory experiments and generated an initial set of simplified models and is currently planning to extend these studies (additional batch and column testing) with the support of FIU DOE Fellows and interns.

Task 1 Quarterly Progress - April 1 – May 17, 2014

The final report for this task was drafted but re-forecasted for completion by 7/31/14. This task was closed in April 2014 as recommended by DOE HQ and the site contacts at Oak Ridge. The final technical report will be developed to close-out this task and will contain a summary of the work completed for this project during this year, including a description of the model for EFPC and a summary of completed simulations and results. The main emphasis of the report will be on the development of the kinetic model and the thermodynamic database for mercury speciation. Sections of the document were revised and updated to reflect the overall efforts in this task:

- The report documents the application of a hydrology and transport model developed to support the total maximum daily load (TMDL) analysis of mercury for the East Fork Poplar Creek (EFPC) watershed. The integrated surface/subsurface model is built using the numerical package MIKE- 11 coupled with MIKE-SHE and ECOLAB. A working model of EFPC has been developed and optimized to execute flow and water quality simulations throughout the various zones of the sub-domain: overland flow, subsurface flow (vadoze and saturated zone), and river flow, including the sediment layer, sorption/desorption and chemical reactions.
- The modeling efforts include the entire EFPC down to station EFK 6.4 and Bear Creek (BC). The water quality and sedimentation modules were extended to include the entire EFPC, down to station EFK 6.4 and the BC. The model simulated the entire hydrological cycle. The exchange of mercury between sediments and stream flow was accounted for by implementing a sedimentation module. Water quality, transport, and sediment related parameters have been developed based on DOE experimental reports and journal publications to include observed data of flow, stage, and mercury concentrations in soil, surface water, groundwater and sediments at Station 17 as well as the stations previously mentioned.
- Simulations were executed for a range of input parameters to correlate stochastic hydrologic events with mercury distribution patterns and total suspended solid patterns at Station 17. The simulations were analyzed using a range of techniques, primarily comparative schematics of timeseries plots, probability exceedance curves, and load duration curves. The modeling was intended to aid in the development of flow duration curves and mercury loads probability exceedances for selected stations, where applicable.

FIU Year 4 Carryover Work Scope

Task 1. Technical Report for EFPC Model Update, Calibration and Uncertainty Analysis

The task was closed in April 2014. The final technical report was drafted and will be submitted by July 31, 2014. The final report contains a summary of the work completed for this project during this year and includes a description of the model for EFPC, a summary of completed simulations and results. The main emphasis of the report is on the work conducted during the last year and more specifically on the development of the kinetic model and the thermodynamic database for mercury speciation. Efforts were made in this past month to update the drafted report for final submission.

The objective of this task is to assemble, integrate and develop a practical and implementable approach to quantify and model potential natural organic matter (NOM, such as humic and fulfic acids, humate, etc.) deployment scenarios for the range of conditions at DOE sites. Various DOE laboratories (SRNL, LBNL and PNNL) are performing basic and applied research related to the use of NOM for enhanced attenuation and subsurface remediation. Understanding and development of strategies for effective deployment in the subsurface are key to the real-world success of NOM-based technology concepts. Traditional models (e.g., Langmuir and Freundlich isotherms) can be used for scoping evaluation, but do not accurately represent the geochemical factors governing the deployment. Limitations of the isotherm models include: a) NOM is a complex mixture of compounds and not a single constituent, b) NOM solubility is a function of pH (e.g., humic acid evolves and forms a solid at low pH) impacting behavior in acidic groundwater systems, c) NOM sorption is a strong function of pH (partitioning increases as pH decreases), d) deployment will require injection of high concentrations of alkaline-high pH stock solution and the pH will vary over space as a function of distance from the injection point and vary over time as groundwater flows through the deployment zone (resulting in the need for creative spatial and temporal calculation paradigms). 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.

Task 1 started with the download of currently available data provided by SRNL. The data, which includes numerous journal articles, technical reports, and presentations, is undergoing review. The review of SRS site environmental data focused on the soil and groundwater in the F/H area to assist in development of a work plan for the column studies. The column studies will test the migration and distribution of humate injected into the subsurface system.

Subtask 1.1: Work plan for experimental column studies

A work plan is under development which includes:

- Review of currently available data from SRNL for soils within the area, contaminants, and water quality data is underway. Data obtained from SRS includes scientific articles, technical reports, presentations, and papers from the waste management conferences.

- Approximately 150 documents have been received from SRS. The documents were classified into different areas and data is being extracted to understand the operating parameters of the proposed column studies. Additional journal articles have also been downloaded related to the contaminants of concern.
- A review of the biogeochemistry's significance on the fate and transport of metals in different soils has begun to determine potential soil substitutes to be used in the column studies, which will provide data that is similar to the soils at SRS (if no representative soil samples can be obtained or transferred to FIU for the column studies).

Subtask 1.2: Column testing of the migration and distribution of humate injected into subsurface systems

Subtask 1.2, conducting column tests, will be initiated after completion of the work plan under Task 1, Subtask 1.1.

Subtask 1.3: Development a subsurface flow, fate and transport model of humic acid

This task includes modeling of the migration and distribution of humate injected into subsurface systems during deployment for *in situ* treatment of radionuclides, metals and organics. Relevant hydrological data from SRS technical reports and journal articles is being downloaded and reviewed. Data for the subsurface properties required for development of a flow and transport model is being collected and categorized.

A request has been made for access to available GIS data for the development of a geodatabase in support of the model development.

Task 2: Surface Water Modeling of Tims Branch

<u>Task 2 Overview</u>

The title of Task 2 during FIU Year 4 was **Simulation of NPDES and TMDL Regulated Discharges from Non-Point Sources for EFPC and Y-12 NSC.** This task developed a surface flow model for Y-12 NSC similar to the model developed for ORNL. The purpose of the model was to determine the discharges from the stormwater drainage system (based on measured data of flow and concentration) and for each of the outfalls along the Upper East Fork Poplar Creek to provide simulations that extend to the present.

The new title for Task 2 for FIU Year 5 is **Surface Water Modeling of Tims Branch.** The task will perform modeling related to water, sediment, mercury and tin in Tims Branch at Savannah River Site (SRS). This site is 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 experienced controlled step changes in boundary conditions.

<u>Task 2 Quarterly Progress - April 1 – May 17, 2014</u>

The final report for this task was drafted but re-forecasted for completion by 7/31/14. This task was closed in April 2014 as recommended by DOE HQ and the site contacts at Oak Ridge. The final technical report will be developed to close-out this task and will contain a summary of the work completed for this project during this year with the main emphasis on providing an update of the hydrological and water quality data from the outfalls at the upper portion of EFPC (within the Y-12 NSC).

- A TMDL analysis using the numerical model from Task 1 was conducted for the entire EFPC. The main pollutant sources in the creek were identified as stormwater and industrial wastewater outfalls (point sources) and contaminated streambed sediments, floodplain and streambank soils (non-point sources). The numerical model was used to develop flow and load duration curves at several stations along the creek.
- Historical mercury deposition in the EFPC watershed and the highly contaminated soil on the floodplain and streambank surfaces along the entire length of the stream (covering more than 200 acres of contaminated soil). That model accounts for contamination of the aquatic system by surface erosion of floodplain soils or by erosion and collapse of streambank soils where the contaminated soil is directly exposed to flow of the stream during storm events.
- One of the main aspects of the analysis includes the analysis of the concentrations of mercury at Station 17 on a daily basis. Observed and computed results are in agreement that during storm events there is a decrease in concentration due to the dilution as a consequence of the increase in flow volume; however there was an increased load based on a higher volume of mercury (based on resuspension of sediment contaminated with mercury).

Task 2 Quarterly Progress – May 18 – June 30, 2014

FIU Year 4 Carryover Work Scope

Task 2. Technical Report for Simulation of NPDES- and TMDL- Regulated Discharges from Non-Point Sources for EFPC and Y-12 NSC

The task was closed in April 2014. The final technical report was drafted and will be submitted by July 31, 2014. The final report contains a summary of the work completed for this project during this year with the main emphasis on an update of the hydrological and water quality data from the outfalls at the upper portion of East Fork Poplar Creek (within the Y-12 NSC). Efforts were made in this past month to update the drafted report for final submission.

During FIU Year 5, Task 2 will perform modeling of water, sediment, 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. During this performance period, the major focus was on initiating Task 2.3

Subtask 2.3: Modeling of surface water and sediment transport in the Tims Branch system.

A review of available data was initiated to collect SRS site characterization data required for model development of the Tims Branch ecosystem. This data includes: i) River discharges and stages, ii) Water quality parameters relevant to flow and transport of contaminants (pH, total suspended solids, contaminant concentrations, and iii) Timeseries of boundary conditions (rainfall, evapotranspiration, outfalls, river stages and discharges). A request had also been made for access to GIS data which will be collected, stored and managed in a geodatabase.

- The task conducted initial review of the capabilities of the integrated surface and subsurface models which are capable of modeling flow, fate and transport of contaminants and can be used with reaction kinetics and thermodynamic speciation models.

- Considering that the ASCEM code will not be available until December 2014, three models were shortlisted: i) COMSOL, ii) DHI's coupled MIKE SHE and MIKE 11 (which provides analysis for overland flow and subsurface flow), and iii) DHI's MIKE FLOOD (which is coupled MIKE 21 and MIKE 11 that provides analysis only for overland flow) to develop flow and transport within the site.

- Based on multiple selection criteria, coupled MIKE SHE and MIKE 11 was selected since it has shorter run times, provides the ability to exchange flow and contaminants with subsurface, and can potentially provide sophisticated implementation of subsurface layers, lenses and various hydrogeological properties if the initial study points of those subsurface interactions are significant. Additionally, the coupled MIKE SHE and MIKE 11 provide possibilities for implementing a vadose zone, which can be of significance.

- Data requirements, which include timeseries, spatial data and boundary conditions, are being summarized. The data requirements for ASCEM and DHI's models are being analyzed (currently only for DHI's models) to be able to minimize the efforts of replacing DHI's models with ASCEM models once they become available.

- Previous reports and literature of the hydrology, monitoring data, and conceptual model are under review to develop (or update) existing conceptual models in a way that is implementable in the proposed numerical models.

Task 3: Sustainability Plan for the A/M Area Groundwater Remediation System

Task 3 Overview

Task 3 was titled **Environmental Remediation Optimization: Cost Savings, Footprint Reductions, and Sustainability Benchmarked on DOE Sites** for FIU Year 4. The objective for this task was to provide benchmarking and evaluation of the cost-benefit of green & sustainable remediation (GSR) practices applied to cleanup and closure projects at the field sites and DOE Headquarters' management of those projects. The objective was to greatly lower costs and improve effectiveness of remediation strategies applicable to soil, groundwater, radioactive waste, and facility D&D.

For FIU Year 5, Task 3 is titled **Sustainability Plan for the A/M Area Groundwater Remediation System.** This work will be performed in support of EM-13 (Office of D&D and

Facilities Engineering) under the direction of Mr. Albes Gaona to develop a set of proposed actions for the existing infrastructure of the groundwater remediation system that will reduce the environmental burden of the SRNL A/M Area groundwater remediation system. Improvements in system performance, increased contaminant recovery, or decreased energy consumption, will have positive enduring benefits due to the long time frame over which the benefits will accrue. This work will directly support the EM-12/EM-13 Green and Sustainability Remediation (GSR) program and will be coordinated with the GSR program lead.

Task 3 Quarterly Progress - April 1 – May 17, 2014

The project-related work scope for this task was finalized in collaboration with EM and SRS.

- Natalia Duque (undergraduate DOE Fellow) will conduct her summer internship under the direction and mentorship of Mr. Albes Gaona, Physical Scientist/Sustainability Specialist at DOE HQ in Washington D.C.
- A review of the green and sustainability remediation (GSR) framework was conducted and a series of flowcharts depicting the planning and implementation phases were developed as shown in the graphics further in the document.
- The first step in the framework is the planning phase. This involves an analytical process which consists of the evaluation or update of the conceptual site model (CSM); the establishment of GSR goals and the stakeholder involvement; the selection of metrics, evaluation level and boundaries; and the documentation of GSR efforts.
- The second phase of the GSR framework is the implementation stage. This step is dependent on the phase in which GSR practices are going to be implemented and consists of the identification of GSR options; the performance of GSR evaluations; implementation of GSR approaches; and monitoring, tracking, and documentation.
- It is also important to note that these goals can relate to remediation and non-remediation activities such as facility operations.

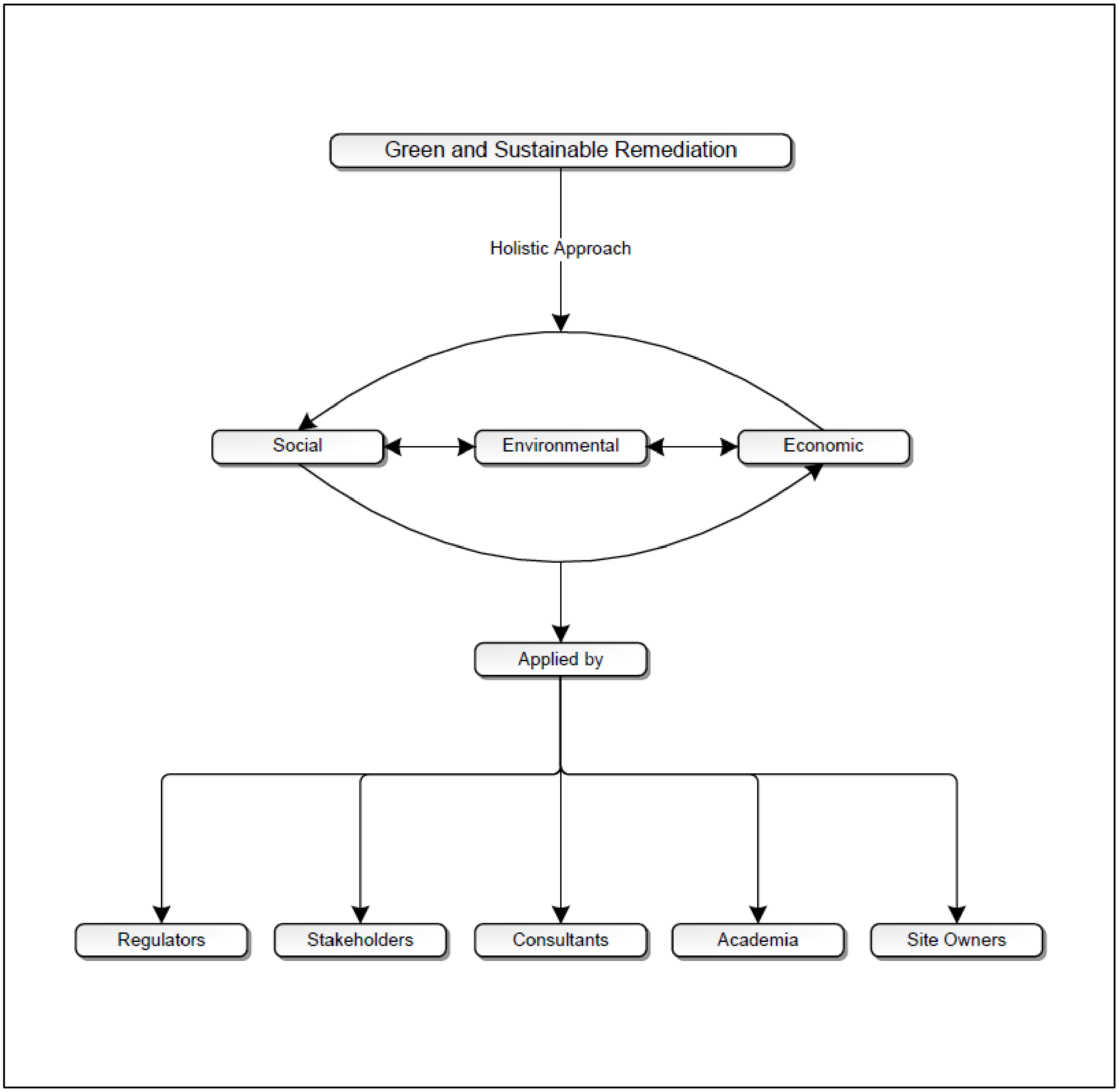


Figure 3-1. GSR Definition Flowchart.

- The work during this month developed an initial understanding of the planning phase, which consists of the evaluation or update of the conceptual site model (CSM); the establishment of GSR goals and the stakeholder involvement; the selection of metrics, evaluation level and boundaries; and the documentation of GSR efforts. The implementation stage is dependent on the phase in which GSR practices are going to be implemented and consists of the identification of GSR options; the performance of GSR evaluations; implementation of GSR approaches; and monitoring, tracking, and documentation.
- Furthermore, the project reviewed the criteria for stakeholder investment, which is a very important part of GSR and is a key consideration for sustainable remediation.

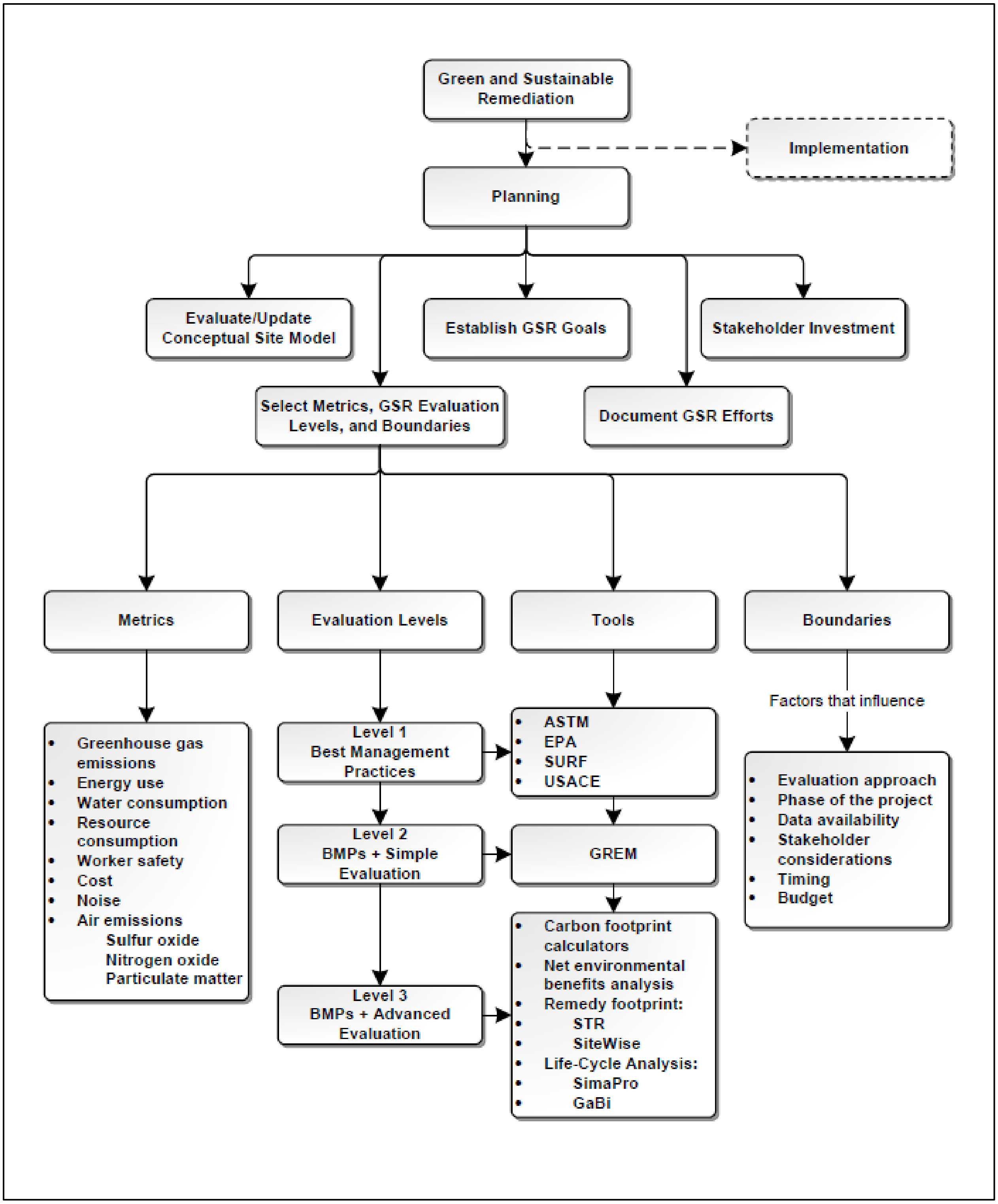


Figure 3-2. Planning Stage Flowchart.

- For each of the GSR goals identified, metrics were reviewed to assess, track, or evaluate the GSR goals. Simultaneous with the selection of metrics, the level of detail was analyzed to aid the metric selection process and the type of tools and resources that can be used to expedite the GSR evaluation and to develop the boundaries for a GSR evaluation.

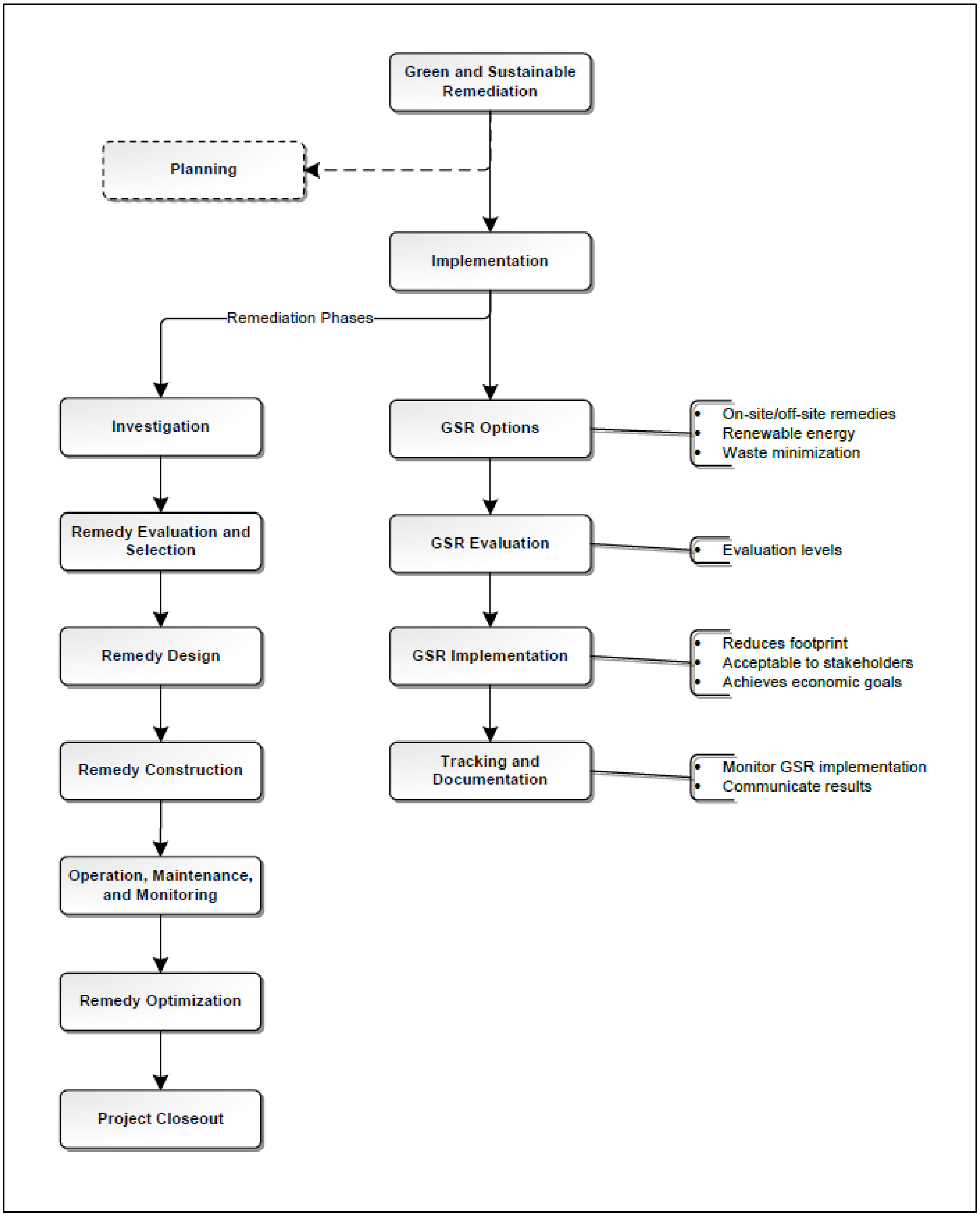


Figure 3-3. GSR Implementation Flowchart.

- Metrics which form a basis for the evaluation of actions during any phase of site remediation, from investigation to project closeout, were reviewed. Quantitative metrics which rely on calculations, tools, or life cycle models were analyzed and taken into consideration, including but not limited to: greenhouse gas emissions, energy use, water consumption, resource consumption, worker safety, cost, noise, and air emissions.
- Three levels of GSR evaluations (based on different ranks of detail and scalability) were considered: Level 1 as a qualitative, Level 2 as a semi-qualitative, and Level 3 as a quantitative approach.
- Level 1 includes Best Management Practices (BMP) with the objective to adopt BMPs based on common sense to promote resource conservation and process efficiency. The net impact on the environment, community, or economics is not evaluated with this approach.
- Level 2 includes BMPs + simple evaluation, which combines the selection and implementation of BMPs with some degree of qualitative and/or semi-quantitative evaluation. Qualitative evaluations may reflect tradeoffs associated with different remedial strategies or use value judgments for different GSR goals to determine the best way to proceed.
- Level 3 includes BMPs + advanced evaluation, which combines the selection and implementation of BMPs with a rigorous quantitative evaluation relying on life-cycle assessment (LCA) or footprint analysis approaches.

Task 3 Quarterly Progress – May 18 – June 30, 2014

FIU Year 4 Carryover Work Scope

Task 3. Technical Report for Sustainable Remediation and Optimization: Cost Savings, Footprint Reductions, and Sustainability Benchmarked at EM Sites

The task was postponed while re-scoping discussions were held with DOE-HQ. A final report will be issued for the work completed for this task by August 29, 2014. DOE-HQ in collaboration with Savannah River Site personnel has provided further direction for this task which will now focus on a sustainability plan for the A/M Area Groundwater Remediation System at SRS. This work aims to develop a set of proposed actions for the existing infrastructure of the groundwater remediation system that will reduce the environmental burden of the system while potentially reducing the duration of operation needed. The A/M Area groundwater remediation system has operated continuously for 27 years and is expected to operate continuously for the foreseeable future. Improvements in system performance, increased contaminant recovery or decreased energy consumption, will have positive enduring benefits due to the long time frame over which the benefits will accrue. This work will directly support the EM-13 Green and Sustainability Remediation (GSR) program and will be coordinated with the GSR program lead.

This work will be performed in support of EM-13 (Office of D&D and Facilities Engineering) under the direction of Mr. Albes Gaonas. FIU will develop a set of proposed actions for the existing infrastructure of the groundwater remediation system that will reduce the environmental burden of the A/M Area groundwater remediation system. Reducing the duration of operation for the treatment system could be a recommendation of these studies. The A/M Area groundwater remediation system has operated continuously for 27 years and is expected to operate continuously for the foreseeable future. Improvements in system performance, increased contaminant recovery, or decreased energy consumption, will have positive enduring benefits due to the long time frame over which the benefits will accrue. This work will directly support the EM-12/EM-13 Green and Sustainability Remediation (GSR) program and will be coordinated with the GSR program lead.

Subtask 3.1: Analyze Baseline.

The existing environmental burden associated with operating the A/M Area groundwater remediation system will be determined. This baseline will serve as the basis for identifying opportunities and evaluating remediation options. The following outlines the work completed this past month in support of this project's goals.

- Currently reviewing the report "Annual 2011 M-Area and Metallurgical Laboratory Hazardous Waste Management Facilities Groundwater Monitoring and Corrective Action Report (U)" provided by Ralph Nichols from SRNL, as well as other relevant literature.
- Participated in two conference calls with Ralph Nichols to discuss the type of analyses that need to be done.
- Downloaded the contaminant (PCE/TCE) data spreadsheets provided by Ralph and created GIS shapefiles of the well data.

Work on this task has also been initiated by DOE Fellow Natalia Duque during a student summer internship at DOE HQ (EM-13) in Washington, D.C. under the mentorship of the GSR lead Albes Gaona. Her contribution will provide meaningful input to the sustainability analysis. The following is her work accomplished to date.

Activity 1. Investigation on tools/approaches which are currently used for sustainability analysis.

- Investigation conducted for tasks 3 and 4 is being used to add to the sustainability analysis.

Activity 2. Analyze Baseline.

- Reviewed the report "Annual 2011 M-Area and Metallurgical Laboratory Hazardous Waste Management Facilities Groundwater Monitoring and Corrective Action Report (U)" provided by Ralph Nichols from SRNL, as well as other relevant literature.
- Made important annotations and got acquainted with SRS A/M Area and its groundwater remediation system.
- Started editing some of the report's tables in MS Excel in order to conduct an analysis.

Activity 3. Assist EM in developing its GSR/Sustainability Powerpedia page.

- Started developing the Sustainable Remediation and Sustainability pages on Powerpedia.
- Currently working on a "sandbox". (When information is approved, will change to the actual page.)

- Sustainable Remediation page:
  - Added information on History, Regulations, Metrics, Approaches, Technologies, Organizations/Information Portals, and Guidance Documents.
- Sustainability page:
  - Added information on "Sustainability at DOE", and graphs.
- Created new pages on Powerpedia related to sustainability. (Energy Savings Performance Contract, Best Management Practices, Scope 1 Emissions)

Activity 4. Assist EM in developing final version of GSR Catalog.

- Researching remediation techniques normally used at DOE sites as well as new technologies developed by the laboratories.
- Started developing the Sustainable Remediation Catalog.
- Created a schematic for the catalog where technologies for monitoring and characterization, ground and surface water, and soil remediation are discussed.
- Created preliminary format for description of sustainable technologies available for remediation.
- Developed description for some of the sustainable technologies available for remediation.

Task 4: Geodatabase Development for Hydrological Modeling Support (FIU Year 4)

Task 4 Overview

This task provided support to the hydrological modeling work being performed by FIU-ARC at Oak Ridge Reservation (ORR) through development of a GIS-based database (geodatabase) which provides an advanced spatial data structure for management, processing, and analysis of spatial and temporal numerical modeling data derived from multiple sources. During FIU Year 4, the existing database was updated with more recent ORR site and environmental data. FIU also improved the complexity of the existing Python scripts developed during FIU Year 3 to enhance database querying capabilities and develop additional customized scripts to perform statistical analyses. This task did not continue into FIU Year 5.

Task 4 Quarterly Progress - April 1 – May 17, 2014

This is the final work provided for this task. The task provides support to the hydrological modeling work being performed by FIU-ARC at the Oak Ridge Reservation (ORR) through development of a GIS-based database (geodatabase) which provides an advanced spatial data structure for management, processing, and analysis of spatial and temporal numerical modeling data derived from multiple sources. ArcGIS ModelBuilder coupled with Python scripting was used to extend the geodatabase capabilities to more easily query data and automate many of the repetitive geoprocessing tasks required for pre- and post-processing of hydrological modeling data.

Additional customized Python scripts were developed to calculate model performance statistics for a subset of existing flow and contaminant monitoring stations. This was achieved by implementing a library of scripts coupled with existing libraries used for mathematics, science, and engineering such as NumPy and SciPy.

There has also been progress on research related to the publishing of hydrological modeling results via the Internet. The ArcGIS for Server architecture being implemented includes three software technologies including: (1) ArcMap for creating, editing, and viewing the geospatial data and maps; (2) ArcGIS Server, which provides the platform for storing and sharing GIS resources with the user community; and (3) the Web Adaptor, which adds an intermediate layer of protection between the end user viewing published maps and ArcGIS Server where the information is actually stored.

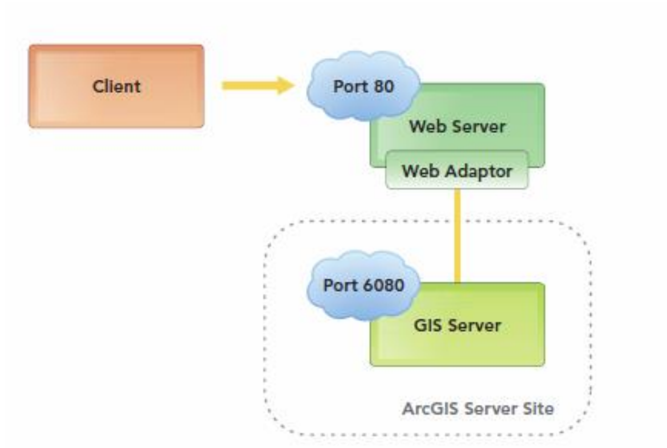


Figure 3-4. ArcGIS for Server architecture.

In order to display project data on the web, a map containing GIS-based hydrological data was created using ArcMap and then published using ArcGIS Server. Once published on the server, the map and associated data files become accessible as a GIS service or web service through port 80. However, to add an extra layer of protection and control to the web service, ArcGIS Web Adaptor was installed on an ARC-FIU GIS server, which ensures restricted access to the GIS service exclusively through the Web Adaptor.

With the Web Adaptor installed, a website was created that communicates with the web adaptor and consumes the GIS web service information displaying it in an interactive map that users can view. The website uses ESRI’s JavaScript API to create a map object from the web service created and using the map information, generates different map layers which are added to the map object to show all the different features in the map document.

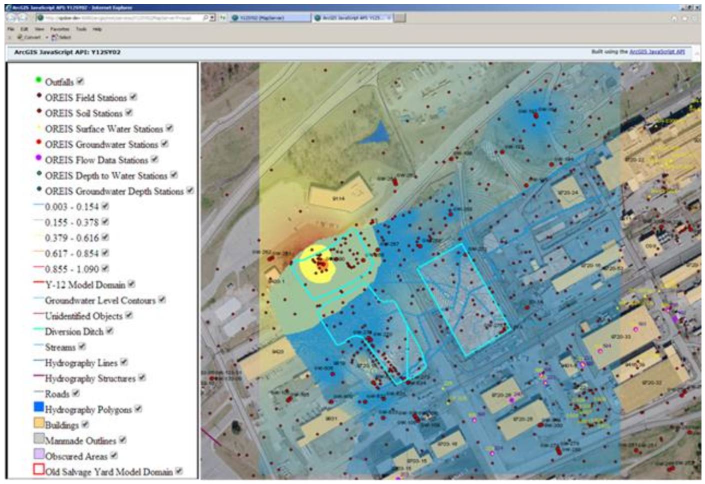


Figure 3-5. Preliminary website development.

A map Legend was also created to inform the user what the different geometries on the map represent. This functionality also uses JavaScript to retrieve the different map layer information from the web service and manipulates the web page to visually display this information to the user. Another feature added to the website is the ability to toggle different map layers on and off using checkboxes in the legend. Large maps can be crowded with many different layers and points of data; therefore, the layer toggle feature allows the user to view meaningful layers of information and omit irrelevant data crowding the map. Zooming and panning are also features implemented on the map, allowing users to move and pan to any location within the map object.

Future development of the website will incorporate a layer selection feature. This feature allows the user to select a layer from the Legend which will also highlight and select the respective layer on the map. The Layer Selection feature will also work in conjunction with the popup feature. Once a user has selected a Layer, it will then be possible to click on a particular feature on the map from that layer and a popup will appear displaying the feature's attribute information, geometry and an interactive chart showing timeseries data.

A technical report on the geodatabase structure, customizations and scripting capabilities was submitted to DOE via email on 4/18/2014.

Task 4 Quarterly Progress – May 18 – June 30, 2014

FIU Year 4 Carryover Work Scope

Task 4. Technical Report for Geodatabase Development for Hydrological Modeling Support

The task was closed in April 2014 and the final technical report was completed and submitted as an Appendix to the FIU Year 4 Year End Report on 6/30/14. The report details the final work provided for this task. The task has provided support to the hydrological modeling work being performed by FIU-ARC at the Oak Ridge Reservation (ORR) through development of a GIS-based database (geodatabase) which provides an advanced spatial data structure for management, processing, and analysis of spatial and temporal numerical modeling data derived from multiple sources. ArcGIS ModelBuilder coupled with Python scripting was used to extend the geodatabase capabilities to more easily query data and automate many of the repetitive geoprocessing tasks required for pre- and post-processing of hydrological modeling data. Finally, a web-based GIS map which depicts hydrological modeling results was created to so that project derived data can be more easily shared project stakeholders including DOE personnel and ORR site contractors.

Milestones and Deliverables

The milestones and deliverables for Project 3 for FIU Year 4 are shown on the following table. New FIU Year 5 milestones/deliverables will be presented in the next monthly report.

The four (4) technical report deliverables that were originally due May 16, 2014, have been re-forecasted for completion during the next few months as detailed in Table shown below. Tasks 3.1, 3.2, and 3.4 were closed in April 2014 as recommended by DOE HQ and the site contacts at Oak Ridge. The final technical reports will be developed to close-out these tasks. Task 3.3 was put on hold by DOE HQ while re-scoping discussions were held between FIU, DOE, and SRS. The technical report for this task will detail the work completed to date for this task. The re-forecasted due dates are identified in the table below. Milestone 2013-P3-M4 has been re-forecasted to a date to be determined as it is intended to be part of the overall Final Year Review presentation to DOE of the work completed for all subprojects of the entire FIU-DOE Cooperative Agreement which has not yet been scheduled. Milestone 2013-P3-M5 is complete and no further journal publications will be submitted as these project tasks will be discontinued based on recommendations made by DOE HQ and the Oak Ridge Site.

FIU Year 4 Milestones and Deliverables for Project 3

Task	Milestone/ Deliverable	Description	Due Date	Status	OSTI
Task 3.1: EFPC Model Update, Calibration, Uncertainty Analysis	Deliverable	Technical Report for "EFPC Model Update, Calibration and Uncertainty Analysis" (Task 3.1)	5/16/2014 Reforecast to 7/31/14	Reforecast	OSTI
Task 3.2: Simulation of NPDES- and TMDL-Regulated Discharges from Non-Point Sources for the EFPC and Y-12 NSC	Deliverable	Technical Report for "Simulation of NPDES- and TMDL-Regulated Discharges from Non-Point Sources for the EFPC and Y-12 NSC" (Task 3.2)	5/16/2014 Reforecast to 7/31/14	Reforecast	OSTI
Task 3.3: Sustainable Remediation and Optimization: Cost Savings, Footprint Reductions, and Sustainability Benchmarked at EM Sites	2013-P3-M1	Task 3.3: Memo for the four alternative sites for benchmarking with SITEWISE™	1/15/2014	Complete	
	2013-P3-M3	Task 3.3: Complete analysis of the alternative sites for benchmarking with SITEWISE™ and select the first site for analysis	3/14/2014	Complete	
	Deliverable	List of selection of four alternative sites for benchmarking with SITEWISE™ (Task 3.3, associated with milestone 2013-P3-1)	1/15/2014	Complete	

	Deliverable	Complete analysis of the alternative sites for benchmarking with SITEWISE™ and select the first site for analysis (Task 3.3, associated with milestone 2013-P3-M3)	3/14/2014	Complete	
	Deliverable	Technical Report for "Sustainable Remediation and Optimization: Cost Savings, Footprint Reductions, and Sustainability Benchmarked at EM Sites" (Task 3.3)	5/16/2014 Reforecast to 8/29/14	Reforecast	OSTI
Task 3.4: Geodatabase Development for Hydrological Modeling Support	Deliverable	Technical report on geodatabase structure, customizations and scripting capabilities	4/18/2014	Complete	OSTI
	Deliverable	Technical Report for "Geodatabase Development for Hydrological Modeling Support" (Task 3.4)	5/16/2014 Reforecast to 6/30/14	Complete	OSTI
Project-wide	2013-P3-M2	All tasks: Presentation overview to DOE ORO/DOE HQ of the project progress and accomplishments (Mid-Year Review)	2/18/2014 Rescheduled to 2/27/2014	Complete	OSTI
	Deliverable	Presentation and midyear report of project progress and accomplishments (all tasks)	2/18/2014 Rescheduled to 2/27/2014	Complete	OSTI
	2013-P3-M4	All tasks: Presentation overview to DOE ORO/DOE HQ of the project progress and accomplishments (Project Closeout Summary)	5/12/2014 Reforecast to 7/21/14	Reforecast	OSTI
	2013-P3-M5	All tasks: Submit publications to relevant journals	5/16/2014	Complete	OSTI[4]

FIU Year 5 Milestones and Deliverables for Project 3

Task	Milestone/ Deliverable	Description	Due Date	Status	OSTI
Task 1: Modeling of natural organic matter	2014-P3-M1	Completion of work plan for experimental column studies (subtask 1.1)	09/30/14	On Target	
	Deliverable	Work plan for experimental column studies (subtask 1.1)	09/30/14	On Target	
	Deliverable	Technical Report for Task 1	06/03/15	On Target	OSTI
Task 2: Modeling of Tims Branch	2014-P3-M2	Completion of literature review (subtask 2.2)	12/30/14	On Target	
	Deliverable	Literature review summary (subtask 2.2)	12/30/14	On Target	
	2014-P3-M3	Development of preliminary	12/30/14	On Target	

		site conceptual model of Tims Branch (subtask 2.2)			
	Deliverable	Technical Report for Task 2	06/10/15	On Target	OSTI
Task 3: Sustainability Plan	2014-P3-M4	Completion of baseline analysis (subtask 3.1)	02/27/15	On Target	
	Deliverable	Baseline analysis summary (subtask 3.1)	02/27/15	On Target	
	Deliverable	Technical Report for Task 3	06/17/15	On Target	OSTI
Project-wide	Deliverable	Two (2) technical abstract submissions to WM15	08/15/14	On Target	
	2014-P3-M5	SRS site visit and meeting	08/05/14	On Target	
	2014-P3-M6	Meeting and presentation of project progress at SRS	03/18/15	On Target	

Work Plan for Next Quarter

Task 1: Submit Technical Report for "EFPC Model Update, Calibration and Uncertainty Analysis by 7/31/14".

Task 2: Submit Technical Report for "Simulation of NPDES- and TMDL-Regulated Discharges from Non-Point Sources for the EFPC and Y-12 NSC by 7/31/14".

Task 3: Submit Technical Report for "Sustainable Remediation and Optimization: Cost Savings, Footprint Reductions, and Sustainability Benchmarked at EM Sites by 8/29/14".

Project-wide

- Prepare two (2) technical abstracts for submission to WM15 by 08/15/14.
- Coordinate a meeting and site visit at SRS for 8/5/14 (date subject to change pending availability of SRS site personnel).

Task 1: Modeling of the migration and distribution of natural organic matter injected into subsurface systems

- Complete and submit work plan for experimental column studies by 09/30/14.
- Begin laboratory preparation for column testing of the migration and distribution of humate injected into subsurface systems.
- Begin collection of relevant hydrological data for the subsurface properties required for development of a subsurface flow, fate and transport model of humic acid, including geological layers, hydraulic conductivity, porosity, bulk density, etc.
- Develop a GIS database (geodatabase) to store and manage the spatial and temporal data collected in support of the modeling work to be conducted under Subtask 1.3.

Task 2: Surface Water Modeling of Tims Branch

- Conduct a review of available spatial and temporal data as well as a literature review of SRS site characterization data required for model development and begin drafting a literature review summary.
- Begin development of a preliminary site conceptual model of Tims Branch.
- Begin development of a detailed GIS-based representation of the Tims Branch ecosystem.

Task 3: Sustainability Plan for the A/M Area Groundwater Remediation System

- Continue with the baseline analysis which includes a literature review of existing reports related to A/M Area groundwater remediation system; compilation of data available from the site to establish a baseline; development of detailed baseline mass flow charts for each unit (wells and spargers), loading rates, removal efficiencies, energy expenditures and additional parameters as function of time and operation scenarios; statistical analysis of the available data and provide correlations between system performance and operating parameters; development of performance metrics for the operation of each unit and for the entire system and develop performance targets; and determination of potential areas of improvement based on the proposed performance targets and based on the statistical correlations.
- Work will also begin on analysis of energy efficiency of the A/M area groundwater remediation and hydraulic containment systems.

Project 4
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 were included in FIU Year 4:

- Task 1: Waste Information Management System (WIMS)
- Task 2: D&D Support to DOE EM for Technology Innovation, Development, Evaluation and Deployment
- Task 3: D&D Knowledge Management Information Tool (KM-IT)
- Task 4: Centralized Knowledge Base System and FIU-DOE Research Website (NEW)
- Task 5: Cyber Security Compliance and Deployment of Environmental Contamination and Remediation Models (NEW)

The following tasks are included in FIU Year 5:

- Task 1: Waste Information Management System (WIMS)
- Task 2: D&D Support to DOE EM for Technology Innovation, Development, Evaluation and Deployment
- Task 3: D&D Knowledge Management Information Tool (KM-IT)

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 – April 1 – May 17, 2014

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. The waste forecast information is updated annually. During this performance 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.

FIU received the new set of waste stream forecast and transportation forecast data from DOE on April 1, 2014. FIU received the revised waste forecast data as formatted data files and to incorporate these new files, FIU built a data interface to allow the files to be received by the WIMS application and import it into SQL Server. SQL server is the database server where the actual WIMS data is maintained. FIU completed the data import and deployed onto the test server. FIU performed quality review and testing of the data on the test server. FIU then sent the link to the new data on the test server to DOE for further testing and review on April 30, 2014, completing project milestone 2013-P4-M1.1. FIU incorporated feedback from the data review and the new data was deployed on the public server on May 9, 2014. The 2014 waste data replaces the existing previous waste data and is now fully viewable and operational in WIMS. Figure 4-1 shows a sample screenshot of a waste disposition map with the new data set and Figure 4-2 shows a sample GIS screenshot with the new data set.

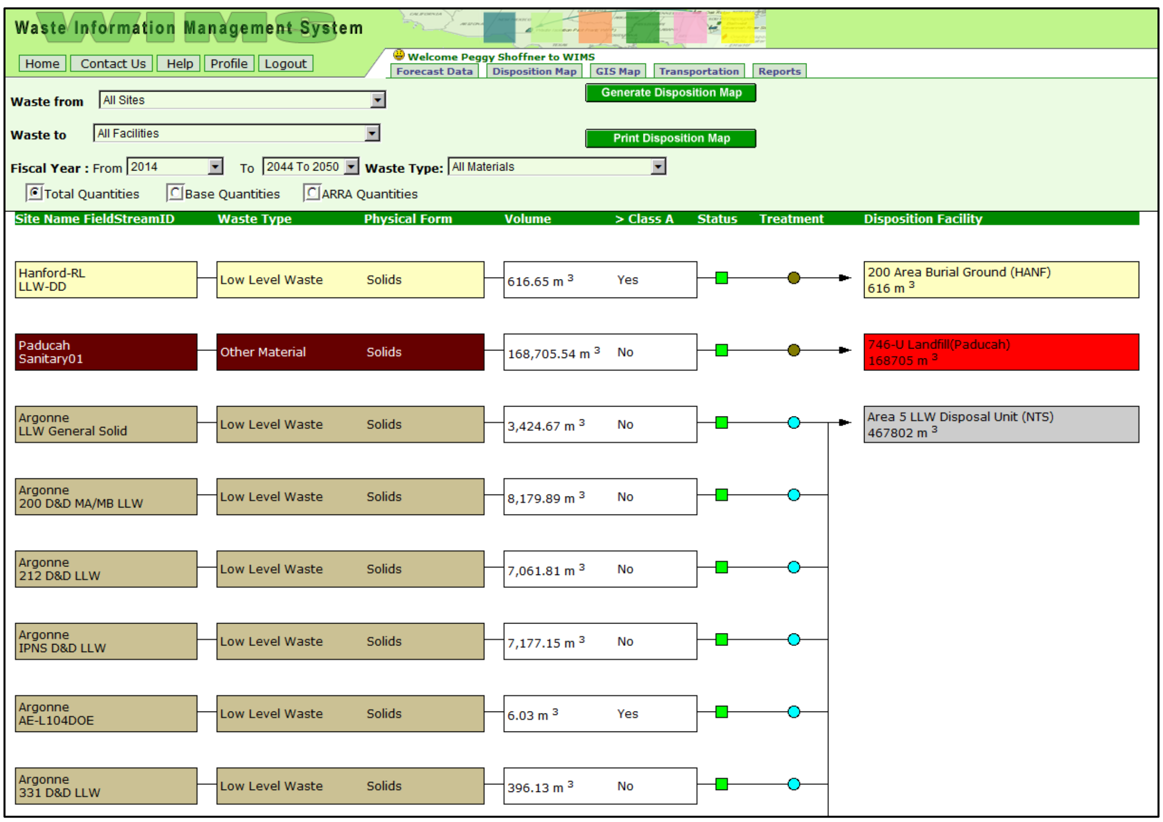


Figure 4-1. WIMS screenshot displaying new 2014 data set as a waste disposition map.

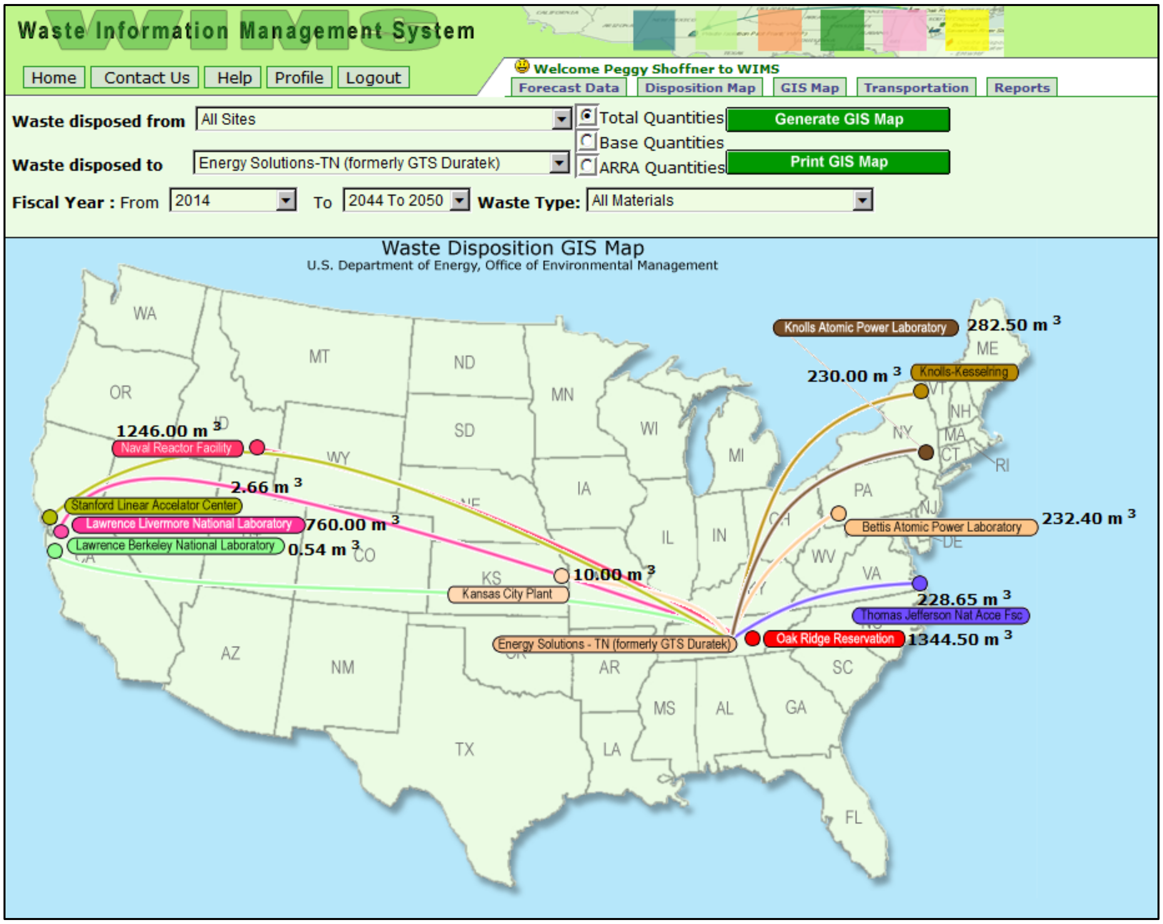


Figure 4-2. WIMS screenshot displaying new 2014 data set as GIS map.

Task 1 Quarterly Progress – May 18 – June 30, 2014

During this performance 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.

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 Year 5, FIU will assist DOE EM-13 in meeting the D&D needs and technical challenges around the DOE complex. FIU will concentrate its efforts this year on working with the Savannah River Site to identify and evaluate innovative technologies in support of the SRS 235-F project. In addition, FIU will continue to support DOE EM-13 in their interactions with EFCOG via the development of lessons learned and best practices from across the DOE Complex. 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.

Contamination Control Fixative/Coating Decision Tool

FIU continued to develop the decision making model that will better guide end users in the selection of the appropriate strippable and fixative coatings depending on their specific needs. During April, FIU focused on completing the pair-wise comparison method. Pair-wise comparisons match each parameter one-on-one and prioritize those of greater significance to find the optimal solutions for the specific facility. A screenshot of the pair-wise comparison Excel sheet that was developed to perform these comparisons is shown in Figure 4-3.

Pair-Wise Comparison of Parameters

Enter Number of Criteria : 5

Parameters	Type of Radiation	Surface Properties	Location	Surface Type	Itoropes Involved	Normalized Weight
Type of Radiation	1.0	2.0	2.0	2.0	2.0	0.320
Surface Properties	0.5	1.0	2.0	2.0	2.0	0.242
Location	0.5	0.5	1.0	2.0	2.0	0.187
Surface Type	0.5	0.5	0.5	1.0	2.0	0.143
Itoropes Involved	0.5	0.5	0.5	0.5	1.0	0.108
sum	3.0	4.5	6.0	7.5	9.0	1.0

Consistency Check	
Lambda max	5.22
CI	0.05
RI	1.12
Consistency Ratio	0.05

Pair-Wise Comparison of Sub-Criteria

Number of Sub Criteria: 3

Type of Radiation	Alpha	Beta	Gamma	Weight
Alpha	1.0	1.0	1.0	0.333
Beta	1.0	1.0	1.0	0.333
Gamma	1.0	1.0	1.0	0.333
sum	3.0	3.0	3.00	1.0

Consistency Check	
Lambda max	3.00
CI	0.00
RI	0.58
Consistency Ratio	0.00

Figure 4-3. Preliminary work on decision model

During May, the DOE Fellow who was supporting this task left the FIU/DOE Workforce Development Program. The current contamination control product matrix and the pair-wise comparison Excel sheets were saved to the project drives for transitioning to a new DOE Fellow.

Going forward, the list of decontamination products will need to be periodically updated with new products as well as with additional information on each product. In addition, to further develop the model, more data/information is needed on the efficiency of each product under the conditions and circumstances that are compared throughout the pairwise comparison chart.

Aging Infrastructure

FIU worked in collaboration with the EFCOG DD/FE working group on the issue of aging infrastructure. The poor physical condition and the presence of hazardous materials at inactive

DOE facilities can pose serious risks to workers in and around them. During April, FIU completed a literature search on this issue to gather any existing articles, papers, reports, and other documents on this issue within the DOE complex. FIU also reached out to DOE site points of contact through the EFCOG DD/FE Working Group members to solicit information on the efforts being taken at the DOE sites to identify all the excess facilities, prioritize the maintenance/surveillance activities, and prioritize D&D when funding becomes available. The resulting information has been compiled into a technical report to provide an overall picture on the status of aging infrastructure across the DOE complex. The resulting information has been compiled into a technical report to provide an overall picture on the status of aging infrastructure across the DOE complex. The report was sent to DOE on May 2, 2014, completing milestone 2013-P4-M2.2.

The challenges presented by aging infrastructure across the DOE complex are multifaceted. Limited funding requires difficult decisions be balanced across multiple priorities, including reducing footprint and risks by completing D&D of deteriorated excess facilities, repairs and surveillance and maintenance for empty facilities as needed to reduce risk to future D&D workers, as well as refurbishment and modernization to aging operating facilities and infrastructure needed for the current and future site missions. The approaches and processes used to make these determinations vary from one DOE site to the next. Efforts to gain an understanding of the challenges and needs complex-wide include FIMS, the D&D Map, and a current undertaking between DOE and NNSA to develop a comprehensive identification and prioritization process for the aging infrastructure across the complex. Figure 4-4 shows the typical end of life phases of a nuclear facility. Figure 4-5 shows some examples of the aging infrastructure at DOE facilities.

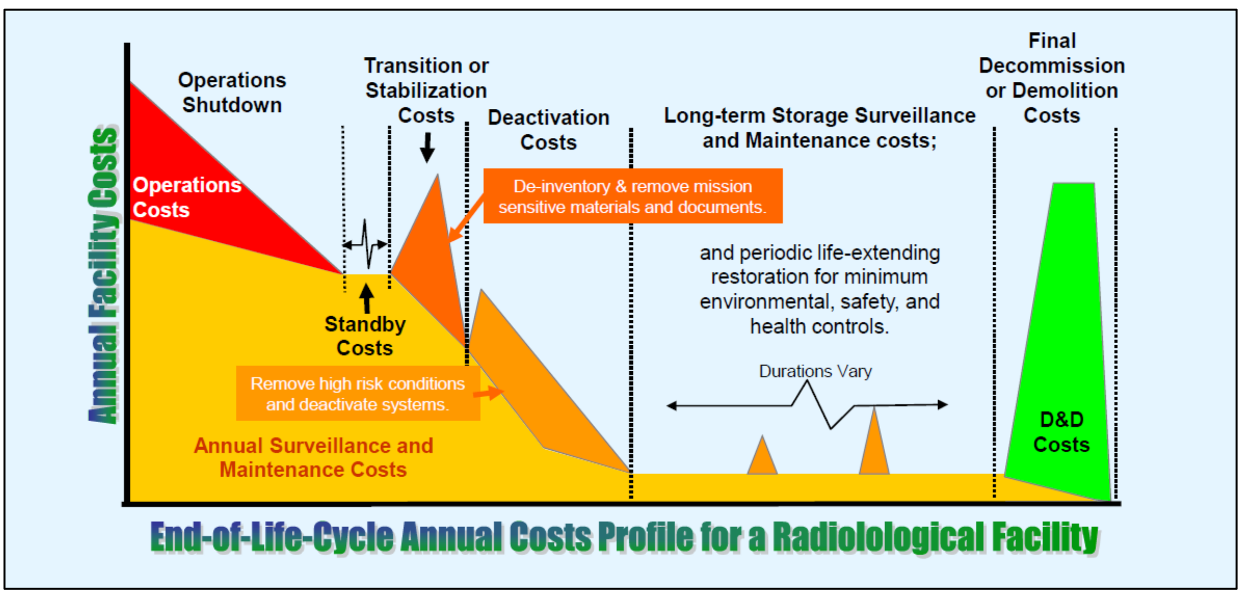


Figure 4-4. Typical End of Life Phases of a Nuclear Facility (D&D Map, DOE 2011).

Figure 4-5. Aging infrastructure at DOE facilities.

EFCOG Lessons Learned and Best Practices

FIU also provided support to EFCOG in the development of lessons learned and best practices for deactivation and decommissioning (D&D) throughout the DOE complex. The objective of these efforts is to capture previous work performed by the D&D community and facilitate the transfer of knowledge and lessons learned. Status for all the lessons learned and best practices are provided under Project 5.

<u>Task 2 Quarterly Progress – May 18 – June 30, 2014</u>

FIU participated in the Decommissioning and Remote Systems (D&RS) conference at the American Nuclear Society (ANS) 2014 Annual Meeting in Reno, Nevada, on June 15-19, 2014. ARC staff co-chaired a technical session on "International Decommissioning" on June 17, 2014, in which presentations were given on decommissioning projects in Germany, France, and Canada. One (1) professional oral presentation was also given by ARC staff on June 17, 2014, during a session titled "Robotics D&D" (Figure 4-6). The presentation was titled "Remote Platform for the Performance of Deactivation and Decommissioning Tasks" and was based on the work FIU performed in collaboration with the technology vendor, International Climbing Machine, demonstrating proof-of-concept abilities of the remote system to spray fixatives, strippable coatings, and decontamination gels as well as the feasibility for the remote system to remove the strippable coatings and decontamination gels in hazardous areas that prevent worker entrance.

Figure 4-6. FIU presenting remote platform during Robotics D&D technical session at D&RS Conference

Contamination Control Fixative/Coating Decision Tool

During FIU Year 4, FIU conducted a focused literature review (using D&D KM-IT, archived ALARA Reports, internet research, and vendor info) on contamination control products for radiological surface decontamination in support of the SRS 235-F Risk Reduction Project. The resulting summary report will help the project team develop their decontamination concepts for the PuFF process cells and define the out year's technical activities. FIU compiled data on each of the 40 products identified in the study and developed a matrix spreadsheet.

Due to the large variety of products available for decontamination, FIU found it appropriate to begin work on a decision making model capable of receiving inputs and respectively returning appropriate outputs. Criteria being taken into consideration include the type of radiation being encountered, the properties of the surface where the radiation is found as well as the surface type, the location, and the isotopes involved. Each one of these criteria was then further expanded into sub-criteria in order to improve the accuracy of the model.

For FIU Year 5, FIU will interact with SRS and other major DOE sites to identify the product search parameters based on project-specific needs and site applications. A selection of these search parameters will be used to develop a preliminary decision model to better guide the product end users in the selection of the appropriate products. FIU will incorporate DOE site feedback and additional search parameters into the decision model to begin development of a more robust decision model.

FIU is performing a literature search to determine which decision making software will be implemented in addition to our pair-wise comparison decision model framework. The decision will be based on standards such as advantages, disadvantages, price, and user-friendliness.

EFCOG Lessons Learned and Best Practices

FIU provides support to DOE's Energy Facility Contractors Group (EFCOG) in the development of lessons learned and best practices for deactivation and decommissioning (D&D) throughout the DOE complex. The objective of these efforts is to capture previous work performed by the D&D community and facilitate the transfer of knowledge and lessons learned. During FIU Year 5, FIU will focus on the collaboration in identifying topics related to D&D and development of

Lessons Learned and Best Practices documents. Topics that have been proposed by the EFCOG DD/FE Working Group for development include asbestos best practices for D&D and sodium treatment best practices. DOE Fellows at FIU will work closely with the DD/FE Working Group members as well as site contacts in the collection of information and the development of these documents. Once approved by EFCOG and DOE, these documents will be made available via D&D KM-IT and the EFCOG website. Status for all the lessons learned and best practices are provided under Project 5.

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 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 – April 1 – May 17, 2014

FIU completed the development and deployment of the popular content module for D&D KM-IT. The popular content feature has been implemented on the D&D KM-IT homepage where the section "Popular Destinations" displays 3 columns with D&D Technologies, Popular Pages and Popular Problems & Solutions (Figure 4-7).

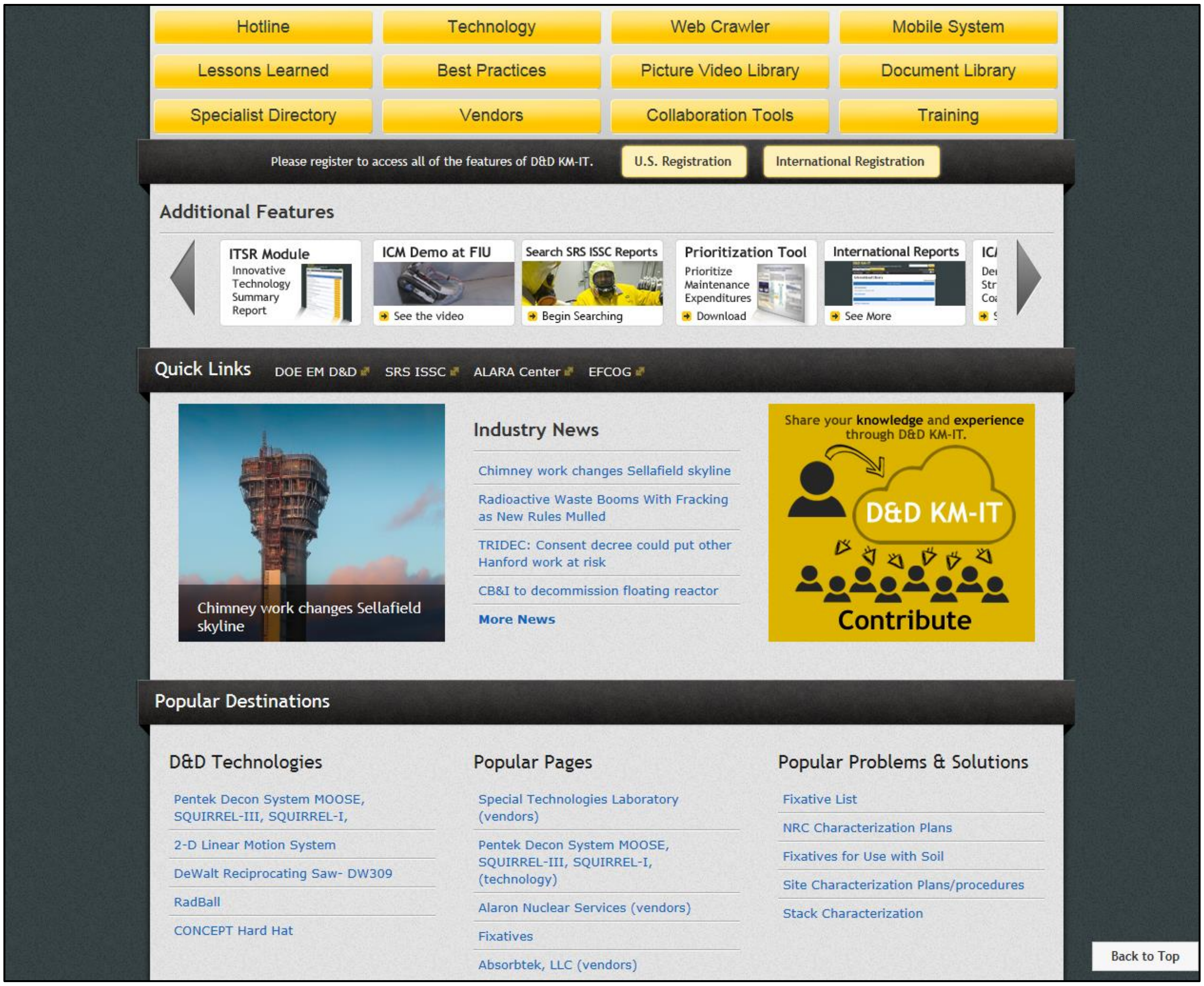


Figure 4-7. Screenshot of D&D KM-IT homepage showing new popular content feature.

Popular content is also displayed on the landing pages for the following modules: Hotline, Technology, Lesson Learned, Best Practices, Document Library, Specialist Directory Profile and Vendor. Figure 4-8 shows a screenshot of the Document Library with the popular content displayed. FIU developed a light weight and efficient internal tracking algorithm for the purpose of displaying popular & related content to the user for Technology, Hotline, and Vendor. The algorithm tracks the page views of each page in real-time and updates the database with the page information (name, URL, module and count). The algorithm categorizes visited and searched pages according to the parent module. This allows for the isolation of the pages in order to return the appropriate popular pages for each module.

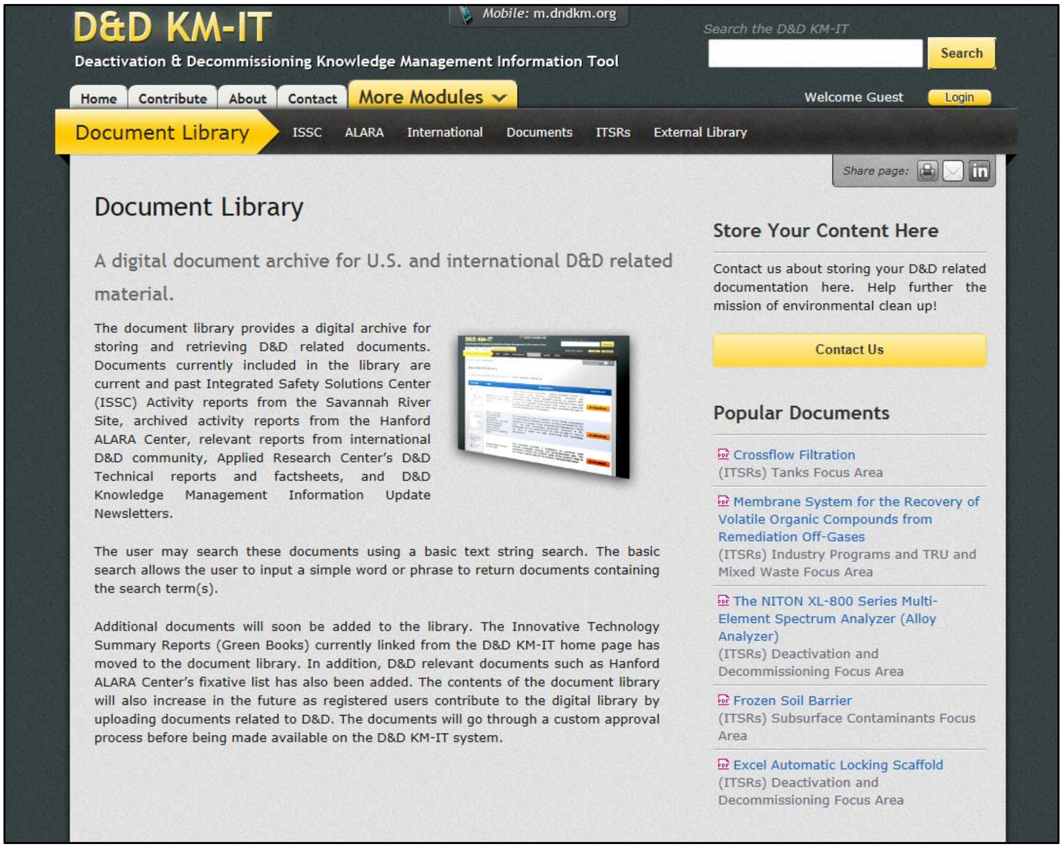


Figure 4-8. Screenshot of the D&D KM-IT Document Library with popular documents displayed.

To display the popular content, a User Control was developed to render the information from the database based on the custom parameters. The result is a list of popular pages for the requested module, keywords or site wide pages. User Control displays the name of the page with the appropriate URL link in each module. A manual approach for popular content is used based on Google Analytics for PDF documents on the site where the tracking algorithm could not be implemented (i.e. Lessons Learned, Best Practices and Document Library).

The Popular Content feature will improve internal linking on D&D KM-IT. It will allows users to find related and popular content easier. As a result, it will help with retaining users on the site which ultimately could be reflected in the analytic report with increased page views, pages visited per session and average time on site.

FIU held bi-weekly teleconferences with DOE on project task status and action items.

DOE Fellows and FIU graduate students continue to perform data management activities in order to add current and relevant data to the D&D KM-IT system. Under this task, new vendors and technologies from industry journals and conference publications are data mined and added to the Technology and Vendor modules of D&D KM-IT. As of May 17, 2014, the number of vendors in the Vendor module is 664 and the number of technologies in the Technology module is 696.

Search Engine Optimization process continues to be deployed on the D&D KM-IT web application.

D&D knowledge management through contributions in Wikipedia was a part of the outreach and training (D&D community support) subtask. FIU completed the related milestone, 2013-P4-M3.6, and sent a draft summary report to DOE on May 9, 2014. The general D&D knowledge which has been gained through this project offers an opportunity to expand access to a broad audience via Wikipedia, which has a significant presence on the web, thereby offering greater opportunities for collaboration on D&D knowledge. ARC researched and targeted D&D information on Wikipedia where D&D KM-IT could provide additional relevant information while citing the source of the original information on D&D KM-IT. The information sources focused on for this initial effort were the EFCOG lessons learned and best practices that have been developed in collaboration between FIU and EFCOG and published on D&D KM-IT.

During the completion of this task, four Wikipedia articles were edited with information from the an EFCOG best practice or lessons learned document. For each of these articles, relevant and significant text was added to the body of the article and a reference to the information source (EFCOG lesson learned or best practice on D&D KM-IT) was included in the article's list of references. The edited Wikipedia articles included: 1) Area 25 (Nevada National Security Site) with information from the lesson learned titled, "Accelerated Demolition of the Reactor Maintenance Assembly, and Disassembly Facility and the Pluto Disassembly Facility;" 2) Building Implosion with information from the following two best practices: "The Use of Explosives to Demolish the 185-3K Cooling Tower at SRS" and "Explosive Demolition of Buildings 337, 337B and 309 Stack at the Hanford's 300 Area;" 3) National Electrical Code with information from the best practice titled, "Electrical Code Guidance for Decontamination and Decommissioning Activities at DOE Facilities;" and 4) Heavy Water Components Test Reactor with information from the lesson learned titled "Unanticipated High Dose during the Removal of Wire Flux Monitor Cabling form the HWCTR Reactor Vessel."

Task 3 Quarterly Progress – May 18 – June 30, 2014

FIU received comments and suggestions from DOE on the draft "D&D Knowledge Management through Wikipedia Contributions" report on May 16, 2014. FIU incorporated the comments and suggestions into the report and sent a revision back to DOE on May 19. Once final comments were resolved, FIU sent the final report to DOE on May 20, 2014. DOE subsequently provided some comments and suggestions on the Wikipedia article contributions on May 21, 2014. FIU incorporated these suggestions on Wikipedia and provided resolutions to DOE on May 27, 2014.

During FIU's participation in the Decommissioning and Remote Systems (D&RS) conference at the American Nuclear Society (ANS) 2014 Annual Meeting in Reno, Nevada, on June 15-19, 2014, FIU introduced the Deactivation and Decommissioning Knowledge Management Information Tool (D&D KM-IT) during an oral presentation (Figure 4-9). A brief overview of its Technology Module and a demonstration for how searches can be performed for "remote" or "robotic" technologies from the almost 700 technologies related to D&D currently in the system was provided. D&D KM-IT is a web-based knowledge management information tool custom built for the D&D user community (www.dndkm.org). The ARC staff who participated in the conference also distributed postcards with information on D&D KM-IT to all the technical sessions related to decommissioning as well as remote technologies. Conference attendees expressed interest in the system and a significant number noted that they were already familiar with and have used D&D KM-IT.

Figure 4-9. Overview of D&D KM-IT Technology module presented at D&RS Conference

FIU revised the D&D KM-IT Website Analytics Performance Report for the first quarter of calendar year 2014 (January to March 2014) and incorporated the suggestions received from DOE EM. The final report was sent to DOE on June 25, 2014. The following figure provides an infographic for the website analytics during the first quarter of 2014.

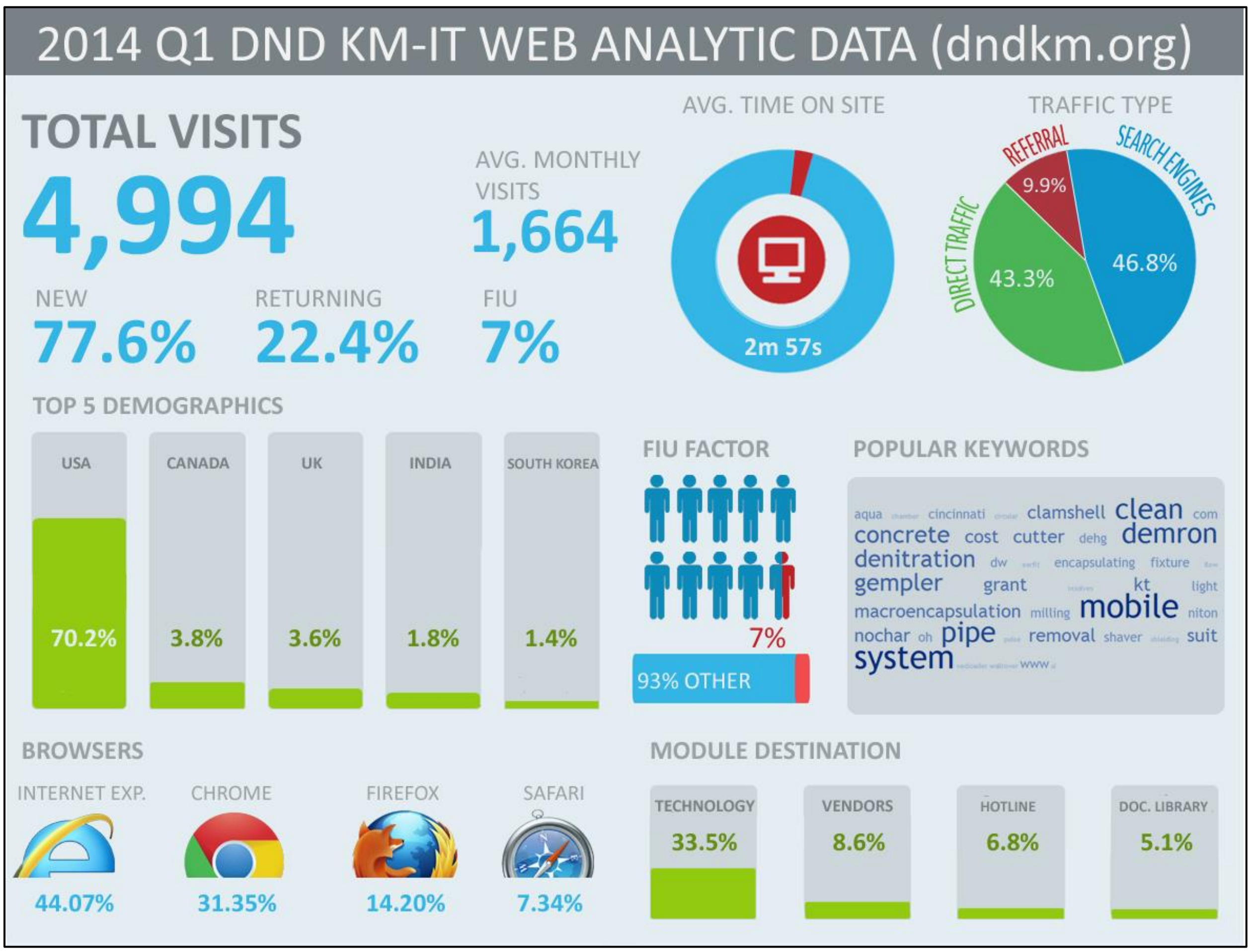
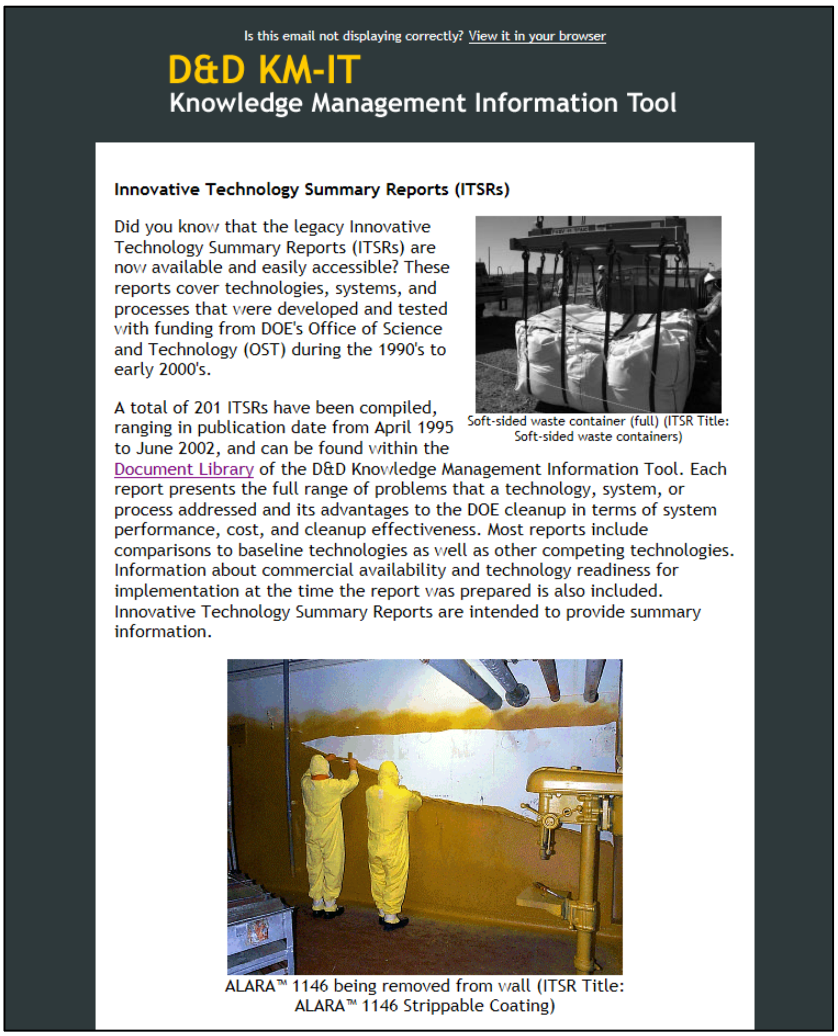


Figure 4-10. Infographic based on Web Analytic Data for D&D KM-IT for January-March 2014

FIU developed a newsletter and sent it out to all D&D KM-IT registered users to announce the availability of the Innovative Technology Summary Reports on D&D KM-IT (Figure 4-11). These reports cover technologies, systems, and processes that were developed and tested with funding from DOE's Office of Science and Technology (OST) during the 1990's to early 2000's. A total of 201 ITSRs have been compiled, ranging in publication date from April 1995 to June 2002, and can be found within the Document Library of the D&D KM-IT. Each report presents the full range of problems that a technology, system, or process addressed and its advantages to the DOE cleanup in terms of system performance, cost, and cleanup effectiveness. Most reports include comparisons to baseline technologies as well as other competing technologies. Information about commercial availability and technology readiness for implementation at the time the report was prepared is also included. Innovative Technology Summary Reports are intended to provide summary information. The ITSR module on D&D KM-IT was developed to make a repository of the ITSRs available and easily retrievable to the D&D community. The ITSRs can be browsed by focus area (D&D, Tanks, Subsurface Contaminants, TRU and Mixed Waste, and Crosscutting).



Is this email not displaying correctly? View it in your browser

D&D KM-IT
Knowledge Management Information Tool

Innovative Technology Summary Reports (ITSRs)

Did you know that the legacy Innovative Technology Summary Reports (ITSRs) are now available and easily accessible? These reports cover technologies, systems, and processes that were developed and tested with funding from DOE's Office of Science and Technology (OST) during the 1990's to early 2000's.

Soft-sided waste container (full) (ITSR Title: Soft-sided waste containers)

A total of 201 ITSRs have been compiled, ranging in publication date from April 1995 to June 2002, and can be found within the Document Library of the D&D Knowledge Management Information Tool. Each report presents the full range of problems that a technology, system, or process addressed and its advantages to the DOE cleanup in terms of system performance, cost, and cleanup effectiveness. Most reports include comparisons to baseline technologies as well as other competing technologies. Information about commercial availability and technology readiness for implementation at the time the report was prepared is also included. Innovative Technology Summary Reports are intended to provide summary information.

ALARA™ 1146 being removed from wall (ITSR Title: ALARA™ 1146 Strippable Coating)

Figure 4-11. Newsletter announcing ITSR availability on D&D KM-IT

Also during this reporting period, FIU finalized the update of the DOE Technical Fact Sheet for D&D KM-IT and sent the document to DOE on June 27, 2014. The updated fact sheet was also posted to the D&D KM-IT Document Library.

FIU received a request from DOE on June 2, 2014, to propose the best ways to make information related to a new technology (Omni Jaw 5) available to the D&D community (Figure 4-12). The Omni Jaw 5 is a hand-held tool used to safely shear bolt heads during demolition and collect the shavings. FIU worked with the DOE to explore the options for disseminating information on the Omni Jaw 5 technology. The actions taken include: 1) FIU posted the news article about the technology to the homepage of D&D KM-IT under Industry News; 2) FIU added the technology vendor (Green Arc Labs) that will be manufacturing the technology to the Vendor module of D&D KM-IT; and 3) FIU added the technology description of the Omni Jaw 5 to the Technology module of D&D KM-IT and attached available literature related to the technology.

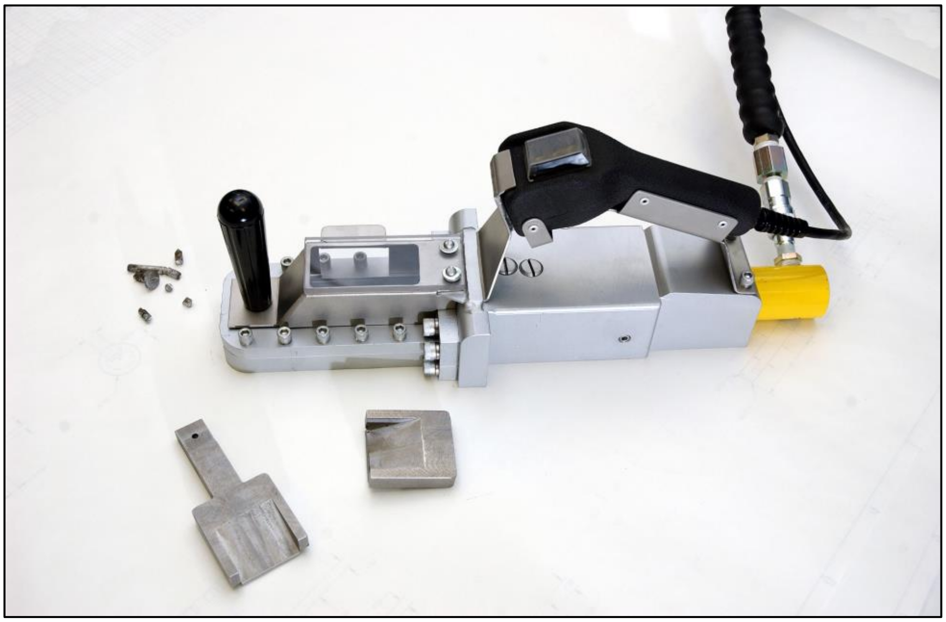


Figure 4-12. Omni Jaw 5 Technology added to D&D KM-IT

Task 4: Centralized Knowledge Base System and FIU-DOE Research Website

Task 4 Overview

This was a task under Project 4 for FIU Year 4. The centralized knowledge base system and FIU-DOE research website serve to capture and make easily available the work that FIU performs for DOE under the FIU-DOE Cooperative Agreement. These virtual tools function as a point-of-access for easy retrieval by the users. In addition, these features could be expanded over time to provide additional functionality.

The objective of this task was to centralize the virtual systems that FIU uses to capture and make available the work they perform for DOE under the FIU-DOE Cooperative Agreement. Under this task, FIU created and maintained two centralized virtual systems: 1) a centralized system to connect all the knowledge management base work under the FIU-DOE Cooperative Agreement, and 2) the DOE Research website to capture and make available all the resulting research, reports, publications developed under the Cooperative Agreement.

Task 4 Quarterly Progress – April 1 – May 17, 2014

The DOE Research website was completed in December 2013 and is available at www.doeresearch.fiu.edu to provide a centralized location for the research information developed under the Cooperative Agreement and includes technical reports, quarterly progress reports, end of year reports, presentations, journal articles, conference papers, and more. The DOE Research webpage is updated on a continual basis with the most recent research documents.

Task 4 Quarterly Progress – May 18 – June 30, 2014

Task 4 did not continue into FIU Year 5.

Task 5: Cyber Security Compliance and Deployment of Environmental Contamination and Remediation Models

Task 5 Overview

This was a task under Project 4 for FIU Year 4. Under this task, FIU published and deployed one environmental contamination and remediation model, developed under Project 3, through the secured KM-IT platform.

During FY2008-2012, FIU developed integrated flow and transport models of East Fork Poplar Creak (EFPC), Upper EFPC (Y-12 NSC) and White Oak Creek (WOC) watersheds for Oak Ridge, TN. In addition, a variable density model which was developed by site contractors for the Moab Site was used by FIU to provide simulations of several scenarios related to creating a hydraulic barrier between the mine tailings stored at the site and ecologically sensitive areas of the Colorado River. These models currently reside on servers and personal computers at the Applied Research Center at FIU in Miami. This task published and deployed one of these models on a secured platform to improve access to the models by project stakeholders.

Task 5 Quarterly Progress – April 1 – May 17, 2014

During April and May, FIU completed the research for deploying an environmental contamination and remediation model from a server/personal computer onto the secured KM-IT platform. FIU also investigated the programming/scripting necessary for customization of the web viewers for visualization of project data and determined how to implement the necessary security protocols. FIU completed the deployment of an environmental contamination and remediation model from a server/personal computer onto the secured KM-IT platform. The completed milestone, 2013-P4-M5.1, was sent via link to the website (http://131.94.112.150) to DOE for review/testing on May 16, 2014.

The current system capabilities include:

- Ability to share GIS models through websites accessible from desktop computer and mobile devices.
- Common GIS functionality such as zoom, hiding of layers, selecting of layers for field analysis, etc.
- Ability to pan, zoom by rectangle and arbitrarily zoom around the map.
- Ability to show raster data overlaid on the map.

- Print functionality.

A website was created that displays an interactive map that users can view (Figure 4-13). The website uses ESRI's JavaScript API to create a map object from the web service created and using the map information.

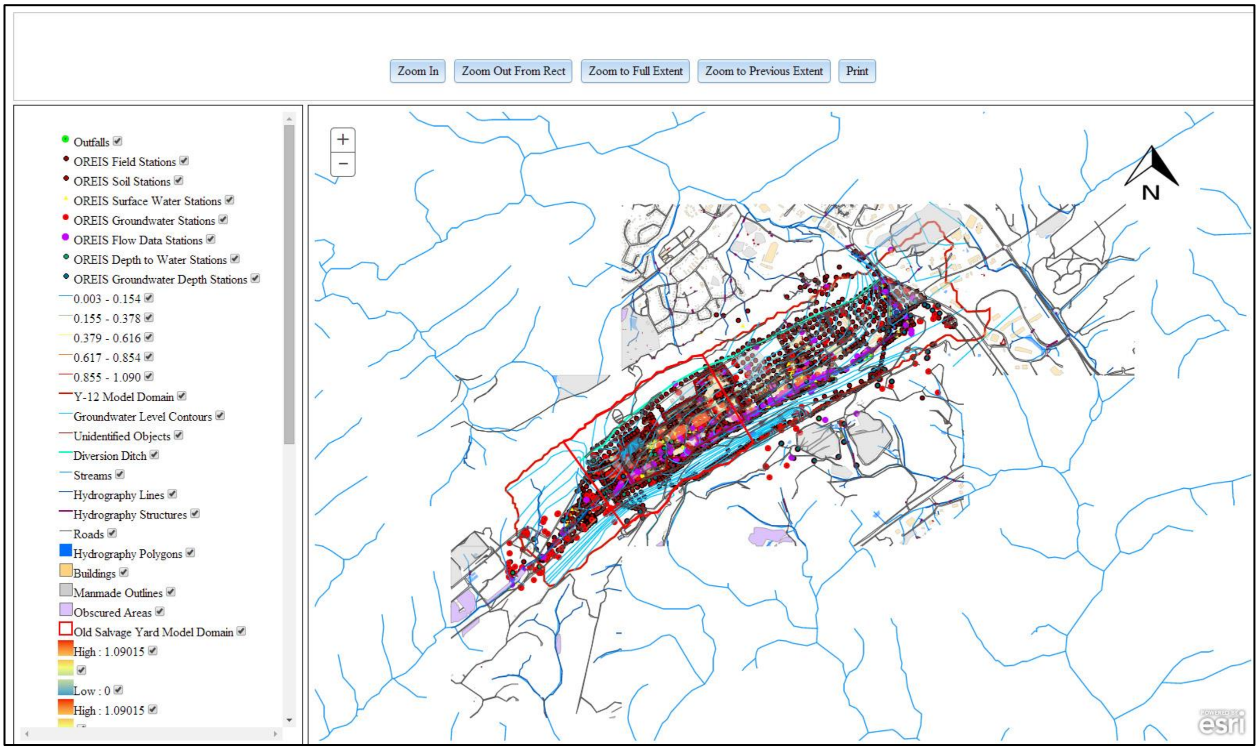


Figure 4-13. Interactive GIS map.

A map legend was also created to inform the user what the different geometries on the map represent. This functionality also uses JavaScript to retrieve the different map layer information from the web service and manipulates the web page to visually display this information to the user. Another feature added to the website is the ability to toggle different map layers on and off using checkboxes in the legend. Large maps can be crowded with many different layers and points of data, therefore the layer toggle feature allows the user to view meaningful layers of information and omit irrelevant data crowding the map. Zooming and panning are also features implemented on the map allowing users to move and pan to any location within the map object.

<u>Task 5 Quarterly Progress – May 18 – June 30, 2014</u>

Task 5 did not continue into FIU Year 5.

Milestones and Deliverables

The milestones and deliverables for Project 4 for FIU Year 4 and FIU Year 5 are shown on the following tables. FIU completed milestone 2013-P4-M3.5, deployment of the popular content module for D&D KM-IT and sent the link to DOE for review/testing, on April 24, 2014. FIU also completed the importing the 2014 data set for waste forecast and transportation data into WIMS and provided the link to the test server to DOE for review and testing on April 30, 2014, completing milestone 2013-P4-M1.1. FIU completed milestone 2013-P4-M2.2, draft report on the aging infrastructure across the DOE complex and sent the report to DOE on May 2, 2014.l. FIU also completed milestone 2013-P4-M3.6, D&D management through contributions in Wikipedia and sent a draft summary report to DOE on May 9, 2014. Finally, FIU completed milestone 2013-P4-M5.1, the development and deployment of the environmental contamination and remediation model and sent the link to DOE for review/testing on May 16, 2014. A Project Technical Plan for FIU Year 5 was prepared and sent to DOE EM on June 17, 2014. The technical Year End Report for FIU Year 4 was prepared and provided to DOE EM on June 30, 2014.

FIU Year 4 Milestones and Deliverables for Project 4

Task	Milestone/ Deliverable	Description	Due Date	Status	OSTI
Task 1: Waste Information Management System (WIMS)	2013-P4-M1.1	Import 2014 data set for waste forecast and transportation data	Within 60 days after receipt of data from DOE	Complete	
	2013-P4-M1.2	Submit draft paper on WIMS to Waste Management Symposium 2014	11/07/2013	Complete	
Task 2: D&D Support to DOE EM for Technology Innovation, Development, Evaluation, and Deployment	2013-P4-M2.1	Draft summary report for SRS 235-F Facility on decontamination agents/materials for radiological surface contamination (subtask 2.1.1)	09/30/2013	Complete	OSTI
	2013-P4-M2.2	Draft report on aging infrastructure (subtask 2.2.1)	05/02/14	Complete	OSTI
	Deliverable	Lessons Learned and Best Practices	30 days after final approval from DOE & EFCOG	Complete	
	Deliverable	Draft technical reports for demonstrated technologies	30-days after evaluation/demo	On Target	OSTI
	Deliverable	Draft Tech Fact Sheet for technology evaluations/ demonstrations	30-days after evaluation/demo	On Target	
Task 3: D&D Knowledge Management Information Tool (KM-IT)	2013-P4-M3.1	Submit draft paper on D&D KM-IT to Waste Management Symposium 2014	11/07/2013	Complete	
	2013-P4-M3.2	Help videos development complete and sent to DOE for review	01/31/2014	Complete	
	2013-P4-M3.3	Deployment of hotline lite mobile application to DOE for review/testing	02/28/2014	Complete	
	Deliverable	Draft D&D KM-IT workshop agenda	02/03/2014	Complete	
	2013-P4-M3.4	Deployment of community contribution module to DOE for review/testing	03/28/2014	Complete	
	2013-P4-M3.5	Deployment of popular content displays to DOE for review/testing	04/25/2014	Complete	
	2013-P4-M3.6	Integrate four Wikipedia edits/articles	05/09/2014	Complete	
	Deliverable	Draft Security Audit Report	30-days after completion of audit	On Target	
	Deliverable	D&D KM-IT Performance 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 or capability	Complete	
Task 4: Centralized Knowledge	2013-P4-M4.1	Deployment of centralized knowledge base system to DOE for review/testing	11/27/2013	Complete	
	2013-P4-M4.2	Deployment of DOE research website to DOE	12/20/2013	Complete	

Base System		for review/testing			
Task 5: Deployment of Models	2013-P4-M5.1	Deployment of environmental contamination and remediation model to DOE for review/testing	5/16/2014	Complete	

FIU Year 5 Milestones and Deliverables for Project 4

Task	Milestone/ Deliverable	Description	Due Date	Status	OSTI
Task 1: Waste Information Management System (WIMS)	2014-P4-M1.1	Import 2015 data set for waste forecast and transportation data	Within 60 days after receipt of data from DOE	On Target	
	2014-P4-M1.2	Submit draft paper on WIMS to Waste Management Symposium 2015	11/07/14	On Target	
Task 2: D&D Support to DOE EM for Technology Innovation, Development, Evaluation, and Deployment	2014-P4-M2.1	Preliminary decision model for contamination control products (subtask 2.1.1)	03/06/15	On Target	
	2014-P4-M2.2	Draft summary report for SRS 235-F Facility on organic semiconductor thin films (subtask 2.1.2)	04/10/15	On Target	OSTI
	Deliverable	Lessons Learned and Best Practices	30 days after final approval from DOE & EFCOG	On Target	
	Deliverable	Draft technical reports for demonstrated technologies	30-days after evaluation/demo	On Target	OSTI
	Deliverable	Draft Tech Fact Sheet for technology evaluations/ demonstrations	30-days after evaluation/demo	On Target	
Task 3: D&D Knowledge Management Information Tool (KM-IT)	Deliverable	First D&D KM-IT Workshop to DOE EM staff	8/29/14**	On Target	
	2014-P4-M3.2	Deployment of popular display on homepage of KM-IT to DOE for review/testing	09/05/14	On Target	
	Deliverable	Second D&D KM-IT Workshop to DOE EM staff at HQ	9/30/14**	On Target	
	Deliverable	Metrics Definition Report on Outreach and Training Activities	9/30/14	On Target	
	2014-P4-M3.1	Submit draft paper on D&D KM-IT to Waste Management Symposium 2015	11/07/14	On Target	
	2014-P4-M3.3	Deployment of lessons learned lite mobile application to DOE for review/testing	11/07/14	On Target	
	2014-P4-M3.4	Deployment of best practices mobile application to DOE for review/testing	01/16/15	On Target	
	Deliverable	Preliminary Metrics Progress Report on Outreach and Training Activities	1/16/15	On Target	
	2014-P4-M3.5	Four Wikipedia edits/articles	03/20/15	On Target	
	Deliverable	First D&D KM-IT Workshop to D&D community	3/31/15	On Target	
	Deliverable	First D&D KM-IT Workshop to D&D community	4/30/15	On Target	
	Deliverable	Metrics report on outreach and training activities	05/09/15	On Target	
	Deliverable	Draft Security Audit Report	30-days after completion of audit	On Target	
	Deliverable	D&D KM-IT Performance Analysis Report	Quarterly	On Target	
	Deliverable	Draft Tech Fact Sheet for new modules or capabilities of D&D KM-IT	30-days after deployment of new module or capability	On Target	

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

Work Plan for Next Quarter

- All Tasks: Finalize Project Technical Plan for FIU Year 5.
- Task 1: Perform database management, application maintenance, and performance tuning to WIMS.
- Task 1: Submit abstract on WIMS to WM15. Begin preparation of technical paper for the conference.
- Task 2: Florida International University will continue providing support to the Savannah River Site team for the SRS 235-F facility. FIU will continue to work on a decision model for mobile application use to better guide the product end users in the selection of the appropriate products depending on their specific needs and site application.
- Task 2: FIU will begin a new subtask in support of the SRS 235-F facility by conducting a focused literature search to identify suitable organic materials that could be fused using low temperature. Needs for the fused material include high flexibility and low cost.
- Task 3: Complete draft of D&D KM-IT website analytics report for the April to June 2014 time period and submit to DOE for review.
- Task 3: Complete development of the popular content displays on homepage for D&D KM-IT and send to DOE for review and testing.
- Task 3: 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.
- Task 3: Submit abstract on D&D KM-IT to WM15. Begin preparation of technical paper for the conference.

Project 5
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 Progress – April 1 – May 17, 2014

DOE 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. During each of these meetings, one DOE Fellow presents the work they performed during their summer internship and/or EM research work they are performing at ARC.

DOE Fellows Spring recruitment efforts continued during April. The current DOE Fellows and program director hosted an Information Session for potential candidates on April 2. In addition, recruitment campaigns were conducted by placing recruitment tables at the College of Engineering and at the main FIU campus in the Physics & Chemistry building and Computer Science building. Additionally, short presentations at targeted classes within the College of Engineering were conducted.

A total of 15 applications were received during the DOE Fellow recruitment application period that ended on April 25, 2014. Applications were reviewed by ARC researchers and scientists and by the selection committee that includes professors from other departments. FIU completed formal interviews of the 12 selected applicants for the DOE Fellows Spring recruitment efforts on 05/15/14 and 05/16/14.

FIU completed the selection and began the hiring process for the new DOE Fellows. A total of 6 students were extended offers of which all 6 accepted and were hired as DOE Fellows. The selected student will start the DOE Fellowship on June 9, 2014. A list of the new selected Fellows, their classification, and areas of study is provided in the following section.

A total of 9 DOE Fellows have been placed for summer internships and will start their summer internship assignments in June. Figure 5-1 shows the Program Director along with the DOE Fellow summer 2014 interns. Details of the DOE Fellows summer 2014 internships are provided in the next section of this report.

Figure 5-1. DOE Fellows summer 2014 interns with program director Dr. Lagos

DOE Fellows continued to assist EFCOG in developing Lessons Learned and Best Practices documents. A total of 9 Best Practices and Lessons Learned documents are final. During April, FIU followed up with the members of the EFCOG DD/FE Working Group who offered to review the active best practice documents. Comments for the best practices were received from these EFCOG members in mid and late April. FIU worked to incorporate the comments and suggestions received from the EFCOG DD/FE working group review on the four open best practices and lessons learned.

Project Progress – May 18 – June 30, 2014

Fellows continue their support to DOE-FIU Cooperative Agreement by actively engaging in EM applied research and supporting ARC staff in the development and completion of the various tasks. Also, 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.

The six new DOE Fellows started the DOE Fellowship on June 9, 2014. A list of the new selected Fellows, their classification, areas of study, ARC mentor, and assigned project is provided below:

Name	Classification	Major	ARC Mentor	Project Support
Brian Castillo	Undergrad - B.S.	Biomedical Engineering	Dwayne McDaniel	Project 1
John Conley	Undergrad - B.S.	Mechanical Engineering	Amer Awwad Jairo Crespo	Project 1
Maria Diaz	Undergrad - B.S.	Environmental Engineering	Yelena Katsenovich	Project 2
Anthony Fernandez	Undergrad - B.S.	Mechanical Engineering	Amer Awwad Jairo Crespo	Project 1
Meilyn Planas	Undergrad - B.S.	Electrical Engineering	Jose Rivera Jairo Crespo	Project 4
Aref Shehadeh	Undergrad - B.S.	Environmental Engineering	Yelena Katsenovich	Project 2

The DOE Fellows program director and nine (9) DOE Fellows made final plans and arrangements to start their summer internship assignments in June. The following table details the DOE Fellows summer 2014 internships.

	DOE Fellow	Location	Summer Site Mentor
1	Deanna Moya	DOE-HQ EM-12, Cloverleaf, MD	Justin Marble/Patricia Lee
2	Natalia Duque	DOE-HQ EM-13, Forrestal, Washington D.C.	Albes Gaona
3	Carmela Vallalta	WRPS, Hanford, WA	Dennis Washenfelder
4	Sasha Philius	WTP (Bechtel), Hanford, WA	Brad Eccleston/Joel Peltier
5	Anthony Fernandez	WRPS, Hanford, WA	Ruben Mendoza
6	Christian Pino	PNNL, Richland, WA	Amoret Bunn
7	Robert Lapierre	PNNL, Richland, WA	Dawn Wellman/Jim Szecsody
8	Hansell Gonzalez	SRNL, Savannah River, SC	Brian Looney/Miles Denham
9	Steve Noel	SRNL, Savannah River, SC	Mary K. Harris

The DOE Fellows will spend their summer of 2014 working at DOE program offices or on environmental research projects under the guidance of their site mentors as described below:

Deanna Moya (DOE Fellow - Class of 2013) is working for EM-12's Office of Soil and Groundwater Remediation at the DOE-HQ Cloverleaf facility in Germantown, Maryland during the summer of 2014. Under the mentorship of Dr. Justin Marble and Dr. Patricia Lee, Deanna's main role is to learn and test the Advanced Simulation Capability for Environmental Management (ASCEM) toolset. The ASCEM Project's goal is to provide sustainable and cost effective solutions towards the DOE-EM cleanup mission. It is a tool comprised of advanced simulation capabilities that is used to understand and predict the subsurface flow and contaminant transport behavior in natural and engineered systems. With its modular and open source toolsets, ASCEM can provide standardized assessments of performance and risk analysis for EM activities, which ultimately aids in protecting human health and the environment for current and future generations.

Natalia Duque (DOE Fellow - Class of 2013) has been given the opportunity to intern with the Department of Energy, Office of Environmental Management (DOE-EM) Headquarters located in Washington, D.C. Natalia is assisting Mr. Albes Gaona and EM-13 in the development of its Green and Sustainable Remediation (GSR) and Sustainability Powerpedia pages, as well as in the development of the final GSR Catalog. During her internship, Natalia will also be working on the acquisition and analysis of data from the A/M Area located in Savannah River Site in order to identify opportunities for the incorporation of sustainability metrics in the environmental management decisions.

Carmela Vallalta (DOE Fellow - Class of 2013) is participating in an internship at Washington River Protection Solutions (WRPS), Hanford. Ms. Vallalta is working under the supervision of Mr. Dennis Washenfelder, and will prepare waste mitigation and annulus ventilation operating chronologies for the double shell tanks, beginning with the earliest tanks, AY-101 and AY-102.

Anthony Fernandez (DOE Fellow - Class of 2014) is at Washington River Protection Solutions (WRPS), Hanford. He is working with two engineering groups, Waste Transfer and Waste Storage, under the supervision of Mr. Ruben Mendoza. Currently Mr. Fernandez is updating the Single Shell Tank's (Enraf's) tank level, monitoring reference level documentation and supporting the baseline change requests to Enraf's levels. Anthony will be verifying and updating the waste transfer Safety Equipment Compliance Database, which requires review and comparison to various different design drawings and specifications. AutoCAD software will be used to create layout drawings of the waste transfer routes used in all the tank farms. Lastly, he will be tracking the changes necessary to overlay the ground penetrating radar scans onto the updated tank farm route maps.

Sasha Philius (DOE Fellow - Class of 2013) has been given the opportunity to intern with the Department of Energy's Office of River Protection (ORP) located at the Hanford Site, WA. Sasha is assisting Mr. Brad Eccleston and ORP in their partnership with Bechtel National Inc. to establish a new standard vessel design that would be capable of managing the most challenging waste slurries, with high solids and non-Newtonian fluid characteristics. In addition, he will accompany DOE staff in discussions related to vessel design features, test planning, and facility test readiness.

Robert Lapierre (DOE Fellow - Class of 2012) is on his second trip to the Tri-Cities. This summer Robert is working at Pacific Northwest National Laboratory with Dr. Jim Szecsody, studying the influence of NH_3 gas treatment on uranium remediation in Hanford vadose zone sediments. During summer 2012, Robert spent his summer as an intern at Pacific Northwest National Laboratory (Richland, WA) under the guidance of Dr. Dawn Wellman of the Environmental Systems Group.

Christian Pino (DOE Fellow - Class of 2013) is working under the mentorship of Amoret Bunn at Pacific Northwest National Laboratory (PNNL). He is aiding Amoret in completing a pilot study focused on the environmental concentrations of lead in soil. Hanford site, before the land was owned by the government, used to be orchard fields where lead arsenate pesticides were applied. There is still residual lead from this use, and the fields are being surveyed in order to determine whether the lead still poses harm as its concentration may be above EPA's standard. If this is the case as expected, the end goal of the project will be to focus on remediation methods to bring these levels to a safe threshold.

Hansell Gonzalez (DOE Fellow - Class of 2013) is working at Savannah River National Laboratory under the mentorship of Dr. Miles Denham. During his internship, Hansell will study the effect of pH on the adsorption of humic substances on different sediments present at Savannah River Site. He will also analyze the ratio of absorbance of humate used during these adsorption experiments, at 465nm and at 665nm (E4/E6 ratio), to better understand the interaction of these heterogeneous humic substances with the sediments.

Steve Noel (DOE Fellow - Class of 2013) is participating in a summer internship at Savannah River National Laboratory (SRNL) under the mentorship of Mary Harris. His focus during the internship is to develop web applications for Savannah River National Laboratory, converting on-site desktop applications into web applications using the "Aptana" program. These web applications will enable employees across the DOE complex and national laboratories to use applications/software that were previously only available through on-site computers.

DOE Fellows continued to assist EFCOG in developing Lessons Learned and Best Practices documents. A total of 9 Best Practices and Lessons Learned documents are final. During June, FIU completed incorporating the comments and suggestions received from the EFCOG DD/FE working group review on the four open best practices and lessons learned. Two of the documents were then sent to DOE for review on June 26: 1) SRS R and P -Reactor Disassembly Basin In Situ Decommissioning; and 2) Use of a Remote Tapping Tool at Idaho National Laboratory to Minimize Worker Exposure and Avoid Future Contamination Accidents. The other two documents were sent to the new site point of contact for review on June 26: 1) Use of Earthen Benches and other Technologies to Support River Structures' Demolition Activities; and 2) 327 Facility Source Term Stabilization and/or Removal Prior to Demolition.

Doc	BP/LL	Title	POC	Status as of 6/30/2014
1	BP	Explosive Demolition of Buildings 337, 337B, and the 309 Stack at the Hanford's 300 Area	Daniel Beckworth, Bob Smith, Thomas Kisenwether	Final & Published
2	BP	Open Air Demolition of Asbestos Gunite by Using a Track Mounted Wet Cutting Saw	Rob Vellinger	Final & Published
3	BP	185-3K Cooling Tower Demolition	Bill Austin	Final & Published
4	BP	Historical Hazard Identification Process for D&D	Paul Corrado	Final & Published
5	LL	Closure of the Reactor Maintenance, Assembly, and Disassembly Facility and the Pluto Disassembly Facility at the Nevada National Security Site	Annette Primrose	Final & Published
6	LL	Unanticipated High Dose During the Removal of Wire Flux Monitor Cabling from the HWCTR Reactor Vessel	Bill Austin	Final & Published
7	LL	Radiological Contamination Event during Separations Process Research Unit (SPRU) Building Demolition	Mike Montini	Final, Publication on hold by POC request
8	BP	Structural Code Guidance for D&D Activities at DOE Facilities	Kirk Dooley	Final & Published
9	BP	Electrical Code Guidance for D&D Activities at DOE Facilities	Kirk Dooley	Final & Published
10	BP	SRS R and P -Reactor Disassembly Basin In Situ Decommissioning	Jack Musall	EFCOG review comments received on 4/22/14. Revisions complete. Sent to DOE for review on 6/26/14.
11	BP	Use of Earthen Benches and other Technologies to Support River Structures' Demolition Activities	Bill Kirby	EFCOG review comments received on 4/15 – 4/17/14. Revisions complete. Sent to new site POC on 6/26/14.
12	BP	327 Facility Source Term Stabilization and/or Removal Prior to Demolition	Bill Kirby	EFCOG review comments received on 4/15 – 4/17/14. Revisions complete. Sent to new site POC on 6/26/14.

13	BP	Use of a Remote Tapping Tool at Idaho National Laboratory to Minimize Worker Exposure and Avoid Future Contamination Accidents	Kirk Dooley	EFCOG review comments received on 4/22/14. Revisions complete. Sent to DOE for review on 6/26/14.

The Fellows continued their research in the four DOE-EM applied research projects under the cooperative agreement and research topics identified as part of their summer 2013 internships at DOE sites, national labs, and/or DOE HQ.

Milestones and Deliverables

The milestones and deliverables for Project 5 for FIU Year 4 and FIU Year 5 are shown on the following tables. A Project Technical Plan for FIU Year 5 was prepared and sent to DOE EM on June 17, 2014. The technical Year End Report for FIU Year 4 was prepared and provided to DOE EM on June 30, 2014.

FIU Year 4 Milestones and Deliverables for Project 5

Milestone/ Deliverable	Description	Due Date	Status	OSTI
2013-P5-M1	Draft Summer Internships Reports	10/04/13	Complete	
2013-P5-M2	Selection of new DOE Fellows – Fall 2013	10/31/13	Complete	
2013-P5-M3	Submit draft paper to Waste Management Symposium 2014	11/07/2013	Complete	OSTI
2013-P5-M4	Conduct Induction Ceremony – Class of 2013	11/13/13	Complete	
2013-P5-M5	Submit student poster abstracts to Waste Management Symposium 2013	12/31/2013	Complete 1/10/2014	
Deliverable	Deliver Summer 2013 Interns reports to DOE	10/18/13	Complete	
Deliverable	List of identified/recruited DOE Fellow (Class of 2013)	10/31/13	Complete	
Deliverable	Update Technical Fact Sheet	30 days after end of project	On Target	

FIU Year 5 Milestones and Deliverables for Project 5

Milestone/ Deliverable	Description	Due Date	Status	OSTI
2014-P5-M1	Draft Summer Internships Reports	10/04/14	On Target	
Deliverable	Deliver Summer 2014 interns reports to DOE	10/17/14	On Target	
Deliverable	List of identified/recruited DOE Fellow (Class of 2014)	10/31/14	On Target	
2014-P5-M2	Selection of new DOE Fellows – Fall 2014	10/31/14	On Target	
2014-P5-M3	Conduct Induction Ceremony – Class of 2014	11/13/14	On Target	
2014-P5-M4	Submit student poster abstracts to Waste Management Symposium 2015	01/15/15	On Target	
Deliverable	Update Technical Fact Sheet	30 days after end of project	On Target	

Work Plan for Next Quarter

- Complete DOE Fellow internships for summer 2014 at DOE sites, national laboratories, DOE-HQ, and DOE contractors.
- Begin preparation of summer internship technical reports.
- 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 2014 internships.
- Begin preparation and coordination for the DOE Fellows Poster Exhibition & Competition.
- Finalize Project Technical Plan for FIU Year 5.