# DOE-FIU Cooperative Agreement Annual Research Review – FIU Year 3

| Wednesday, August 23, 2023 | | |
|---|---|---|
| 9:00 - 9:05 am EDT | Kick-Off /Welcoming Remarks (DOE-EM) | Rod Rimando (Acting Director, Technology Development) – DOE EM-3.2 |
| 9:05 - 9:10 am EDT | Welcoming Remarks (DOE-LM) | Ms. Jalena Dayvault (Site Manager) – DOE LM |
| 9:10 - 10:40 am EDT | Project 2: Environmental Remediation Science & Technology | FIU, DOE HQ, SRNL, PNNL, ORNL, LANL, LBNL, CBFO |
| 10:40 am - 12:10 pm EDT | Project 1: Chemical Process Alternatives for Radioactive Waste | FIU, DOE HQ, PNNL, WRPS, SRNL, SRS |
| LUNCH BREAK [12:10 – 1:30 pm] | | |
| 1:30 - 3:00 pm EDT | Project 3: Waste and D&D Engineering & Technology Development | FIU, DOE HQ, SRNL, PNNL, LBNL, INL, ANL |
| **Thursday, August 24, 2023** | | |
| 9:00 - 10:30 am EDT | Projects 4 & 5: STEM Workforce Development and Training | FIU, DOE HQ (EM & LM), SRNL, PNNL, WIPP, SRS, ORP, LBNL, WRPS, INL, Grand Junction |
| BREAK [10:30 – 10:35 am] | | |
| 10:35 - 12:00 pm EDT | Wrap Up (FIU Projects 1, 2, 3, 4 & 5) | FIU, DOE HQ (EM & LM) |

## PROJECT 3

# Waste and D&D Engineering & Technology Development

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# FIU Personnel and Collaborators

**Project Manager:** Leonel Lagos

**Faculty/Researcher:** Himanshu Upadhyay, Joseph Sinicrope, Walter Quintero, Clint Miller, Santosh Joshi, Jayesh Soni, Masudur Siddiquee, John Dickson, Mellissa Komninakis, Kexin Jiao*

**DOE Fellows/Students:** Roger Boza, Aurelien Meray, Alejandro De-La-Noval, Aris Duani Rojas, Fabiola Rivera-Noriega, Bryan Torres, Nicholas Espinal

**DOE-EM:** Nancy Bushman, Dinesh Gupta, Genia McKinley, Jean Pabon, Jonathan Kang, Douglas Tonkay, Jennifer McCloskey, Nick Machara, Rod Rimando, Daniel Scott Boyd

**SRNL:** Nixon Peralta, Jeff Crenshaw, Hansell Gonzalez-Rayma, Thomas Danielson, Jennifer Wohlwend, Austin Coleman, Justin Kidd*, Connor Nicholson, Carol Eddy-Dilek

**SRS:** Jack Musall

**PNNL:** Rob Mackley, Xuehang Song

**LBNL:** Haruko Wainwright

*Former staff/student contributors

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# Project Tasks and Scope

| | |
|---|---|
| **TASK 1: WASTE INFORMATION MANAGEMENT SYSTEM (WIMS) (HQ)** | |
| **Subtask 1.1** | WIMS System Administration - Database Management, Application Maintenance & Performance Tuning |
| **Subtask 1.2** | Waste Stream Annual Data Integration |
| **Subtask 1.5** | Cyber Security of WIMS Infrastructure |
| **TASK 2: D&D SUPPORT TO DOE EM FOR TECHNOLOGY INNOVATION, DEVELOPMENT, EVALUATION AND DEPLOYMENT** | |
| **Subtask 2.1** | Development of Uniform Testing Protocols and Standard Specifications for Dust Suppressant Technologies in Support of Open-Air Demolition during D&D |
| **Subtask 2.2** | Applications of Intumescent Foams and Other Fire-Retardant Materials to Mitigate Contaminant Release during Nuclear Pipe Dismantling and other D&D Activities |
| **Subtask 2.3** | Certifying Fixative Technology Performance when Exposed to Impact Stressors as Postulated in Contingency Scenarios Highlighted in Safety Basis Documents |
| **Subtask 2.4** | Multi-functional 3D Polymer Framework for Mercury Abatement |

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# Project Tasks and Scope

| TASK 3: D&D KNOWLEDGE MANAGEMENT INFORMATION TOOL (KM-IT) (HQ, SRNL, INL, ANL) | |
|---|---|
| **Subtask 3.4** | Content Management |
| **Subtask 3.5** | Marketing and Outreach |
| **Subtask 3.6** | D&D KM-IT System Administration |
| **Subtask 3.7** | Cyber Security of D&D KM-IT Infrastructure |
| **Subtask 3.8** | KM-IT Tech Talks |

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# Project Tasks and Scope

| | |
|---|---|
| **TASK 7: AI FOR EM PROBLEM SET (SOIL AND GROUNDWATER) - EXPLORATORY DATA ANALYSIS AND MACHINE LEARNING MODEL FOR HEXAVALENT CHROMIUM (CR [VI]) CONCENTRATION IN 100-H AREA (PNNL)** | |
| **Subtask 7.3** | Algorithm development for spatiotemporal relationship identification |
| **Subtask 7.4** | Publishing AI/ML models on AAML System |
| **TASK 8: AI FOR EM PROBLEM SET (SOIL AND GROUNDWATER) - DATA ANALYSIS AND VISUALIZATION OF SENSOR DATA FROM WELLS AT THE SRS F-AREA USING MACHINE LEARNING (LBNL, SRNL)** | |
| **Subtask 8.6** | Publishing AI/ML models on AAML System |
| **TASK 9: AI for EM Problem Set (Waste Processing) - Nuclear Waste Identification and Classification using Deep learning (NEW)** | |
| **Subtask 9.1** | Algorithm & Model Development to Identify and Classify Nuclear Wastes |
| **Subtask 9.2** | Transition Previously Trained Deep Learning Models to the Advance Automated Machine Learning (AAML) System |

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# Task 1

## Waste Information Management System (WIMS)

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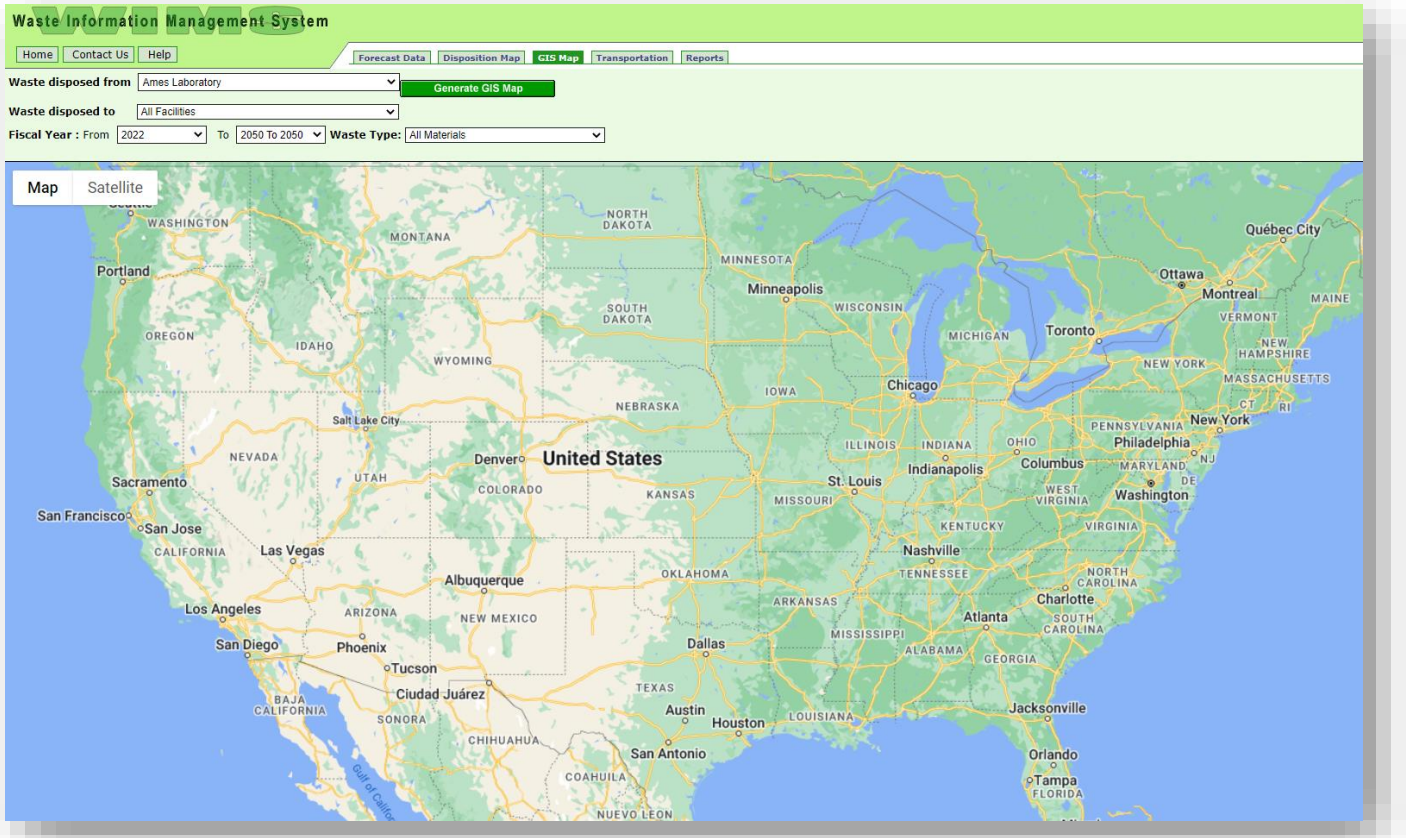
# Waste Information Management System (WIMS)

| | |
|---|---|
| **Subtask 1.1** | WIMS System Administration - Database Management, Application Maintenance & Performance Tuning |
| **Subtask 1.2** | Waste Stream Annual Data Integration |
| **Subtask 1.3** | Cyber Security of WIMS Infrastructure |



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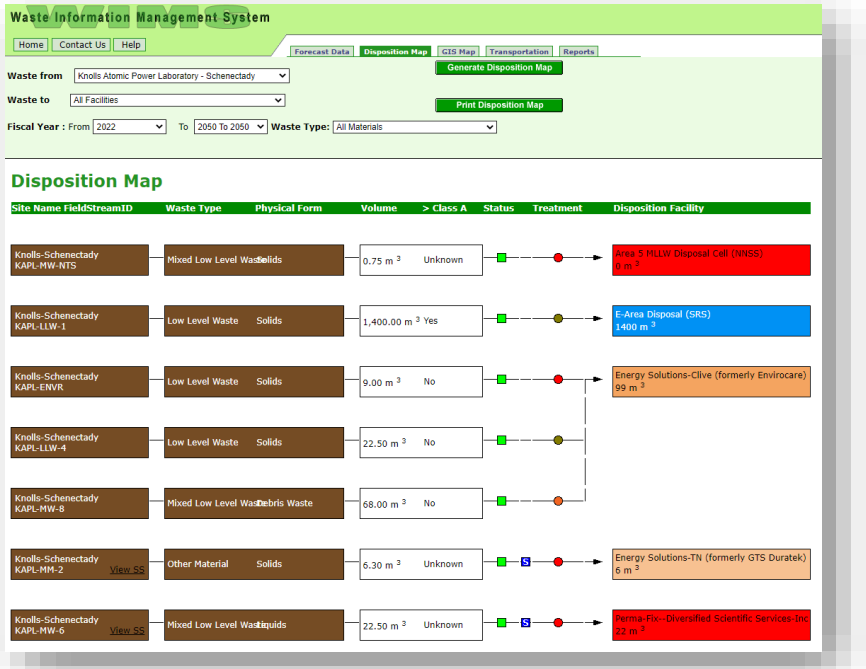
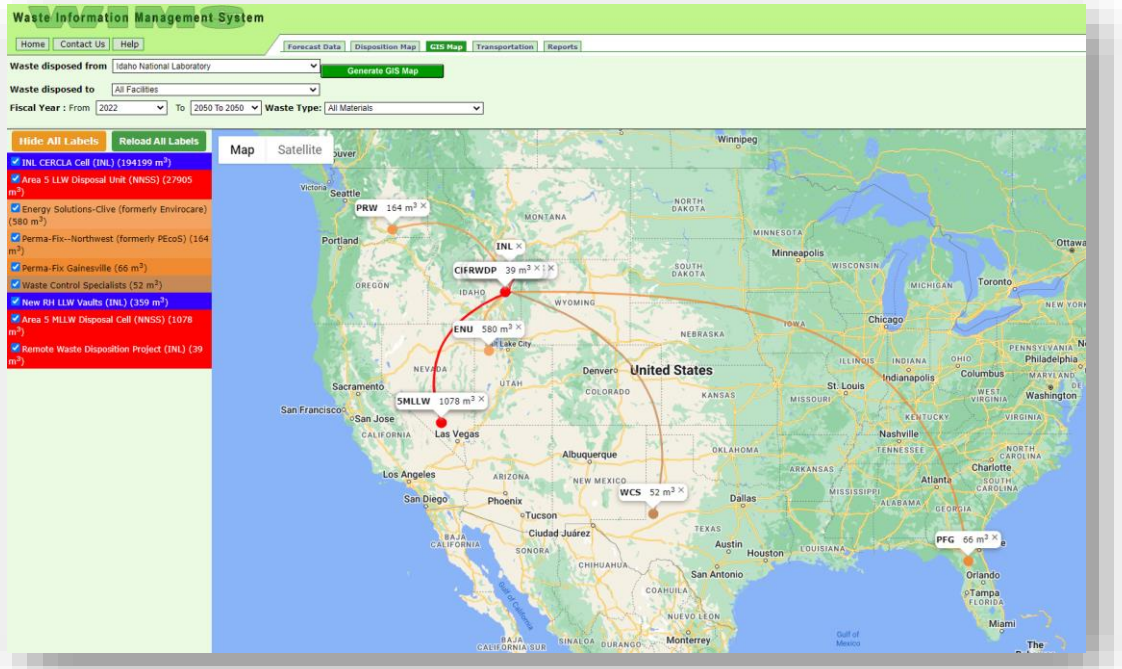
# Waste Information Management System (WIMS)

- Easy-to-use system to visualize and understand the forecasted DOE-EM waste streams & transportation information.
- Various modules of WIMS are Forecast Data, Disposition Map, Successor Stream Map, GIS Map, Transportation, Reports and Help.
- WIMS is deployed and available at https://emwims.org



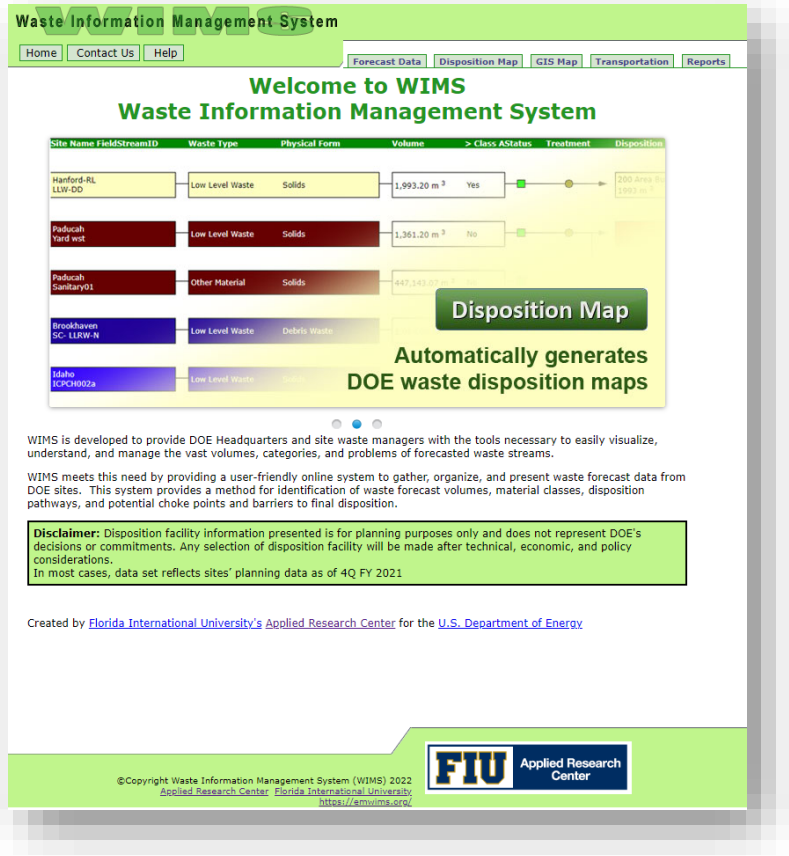
# Waste Information Management System (WIMS)

## Site Needs:

- Accurate estimates of the quantity and type of present and future radioactive waste streams is critical to the development of tools to integrate the complex-wide management of LLW/MLLW treatment and disposal. A complex-wide LLW and MLLW database and reporting system is needed to communicate this information to local and national stakeholders and governmental groups.

## Objectives:

- Provide a central web-based system to access waste forecast streams for sites across the DOE complex.
- Provide easy-to-use systems to view & download waste stream forecast information in various formats.
- Update waste stream forecast information annually.



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# Waste Information Management System (WIMS)

## 36 Supported Sites:

- Ames Laboratory
- Argonne National Laboratory
- Bettis Atomic Power Laboratory
- Brookhaven National Laboratory
- Energy Technology Engineering Center
- Fermi National Accelerator Laboratory
- Hanford Site-RL
- Hanford Site-RP
- Idaho National Laboratory
- Kansas City Plant
- Knolls Atomic Power Laboratory - Kesselring
- Knolls Atomic Power Laboratory - Schenectady
- Lawrence Berkeley National Laboratory
- Lawrence Livermore National Laboratory
- Los Alamos National Laboratory
- Naval Reactor Facility
- Nevada National Security Site
- NG Newport News
- Norfolk Naval Shipyard
- Nuclear Fuel Services, Inc. (cleanup site)
- Oak Ridge Reservation
- Paducah Gaseous Diffusion Plant
- Pantex Plant
- Pearl Harbor Naval Shipyard
- Pacific Northwest National Laboratory
- Portsmouth Gaseous Diffusion Plant
- Portsmouth Naval Shipyard
- Princeton Plasma Physics Laboratory
- Puget Sound Naval Shipyard
- Sandia National Laboratories - NM
- Savannah River Site
- Stanford Linear Accelerator Center
- Separations Process Research Unit
- Thomas Jefferson National Accelerator Facility
- Waste Isolation Pilot Plant
- West Valley Demonstration Project

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# Waste Information Management System (WIMS)

## 36 Disposition Facilities:

- 200 Area Burial Ground (HANF)
- 746-U Landfill(Paducah)
- Area 5  LLW Disposal Unit (NTS)
- Area 5 MLLW Disposal Cell (NTS)
- Area G (LLW disposal) (LANL) (New)
- Clean Harbors
- Commercial TBD
- E-Area Disposal (SRS)
- EMWMF Disposal Cell (ORR)
- Energy Solutions-Clive (formerly Envirocare)
- Energy Solutions-TN (formerly GTS Duratek)
- ERDF (HANF)
- Heritage Liverpool (Ohio) (New)
- Impact Services-TN
- INL CERCLA Cell (INL)
- Integrated Disposal Facility (HANF)
- New RH LLW Vaults (INL)
- Omega Waste Logistics
- OSWDF(Portsmouth)
- Paducah CERCLA
- Perma-Fix Gainesville
- Perma-Fix--Diversified Scientific Services, Inc.
- Perma-Fix--Northwest (formerly PEcoS)
- Perma-Fix/Materials & Energy Corp
- Remote Waste Disposition Project (INLS)
- River Metals
- RMW Trenches (MLLW/LLW) (HANF)
- RMW Trenches/IDF (HANF)
- RWMC (LLW disposal) (INL)
- Siemens
- Smokey Mountain Solutions
- To Be Determined
- Unitech
- US Ecology-Idaho
- Veolia
- Waste Control Specialists

# Waste Information Management System (WIMS)

## Forecast Period and Waste Type:


**Date Range**

- 2023 - Inventory
- 2023 to 2025
- 2026 to 2030
- 2031 to 2035
- 2036 to 2040
- 2041 to 2045
- 2046 to 2050
- 2050

**Waste Type**

- Low Level Waste
- Mixed Low Level Waste
- 11e(2) Byproduct Material
- Other Material
- Unknown

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# Subtask 1.1: WIMS System Administration - Database Management, Application Maintenance & Performance Tuning

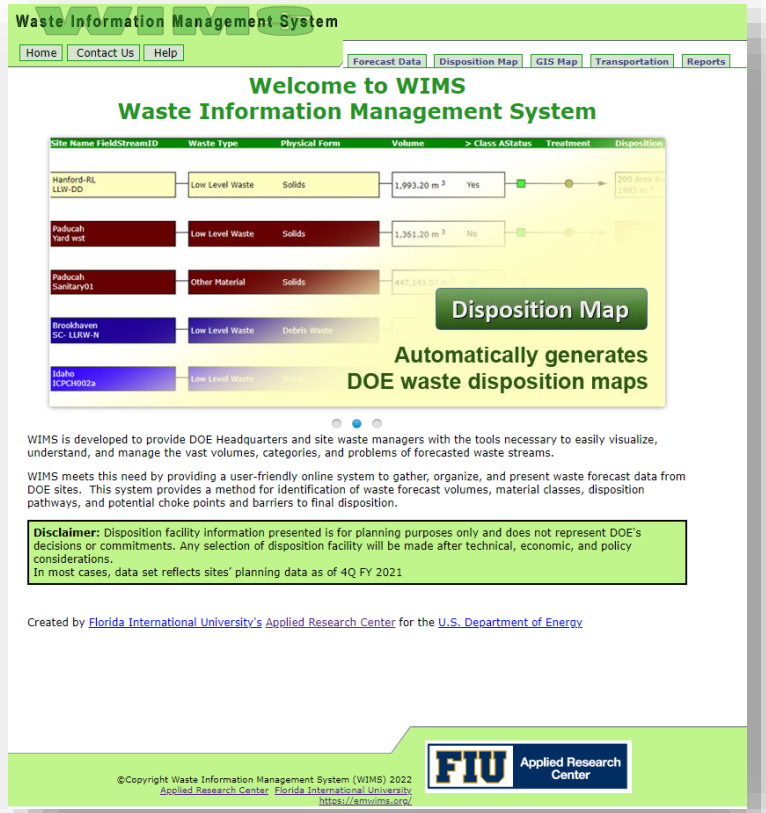
## Accomplishments:

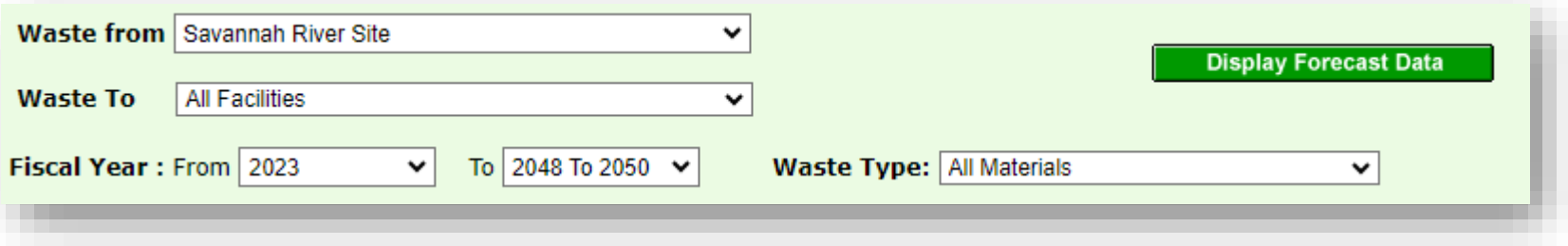
- Continue to perform day-to-day maintenance and administration to ensure consistent high level of performance of WIMS application.
- Updating patches and OS fixes, updating antivirus engines and definitions, updating drivers and assuring that the network is working properly.
- Hardware upgrades (memory, hard drives, video cards, routers, firewall, etc.).
- Updating backup scripts and backup repository hardware.
- Updated reporting server that supports WIMS Report module.

# Subtask 1.2: Waste Stream Annual Data Integration

## Accomplishments:

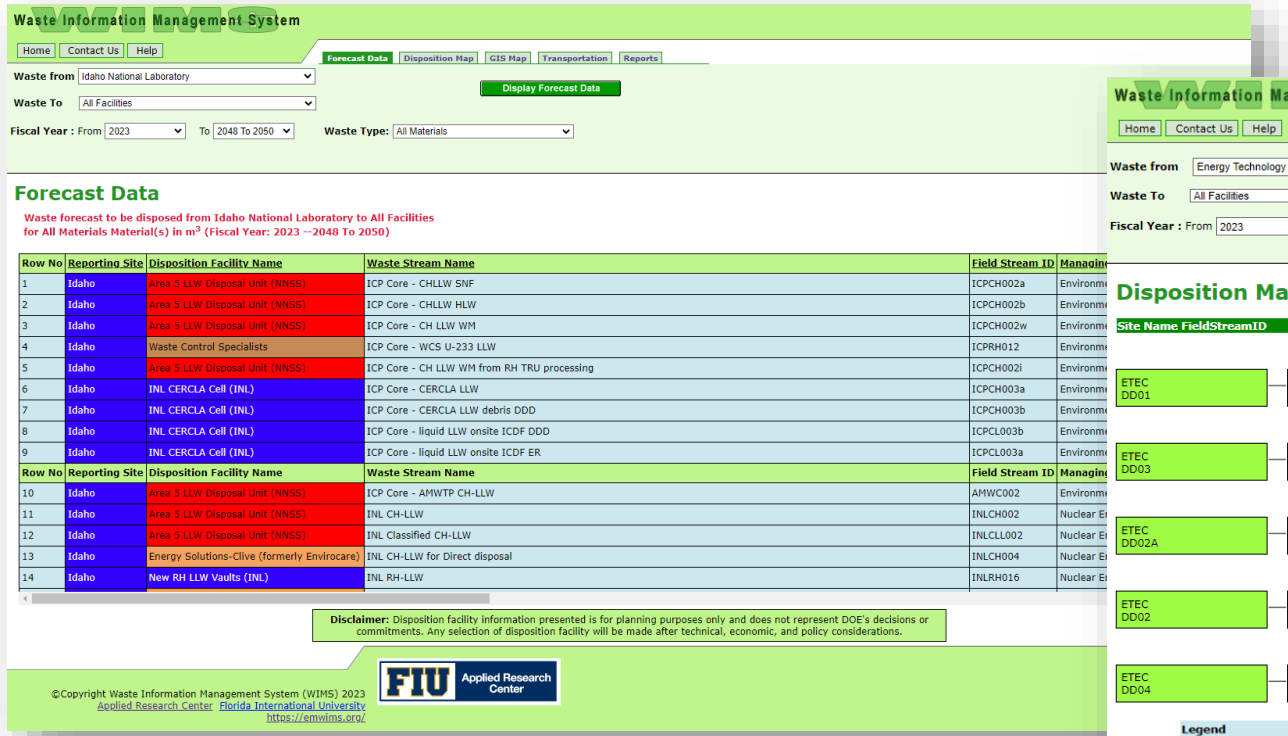
- FIU received the revised waste forecast data from DOE HQ and incorporated the data on the system.
- Completed integration of 2023 waste forecast and transportation data into WIMS system (Milestone 2022-P3-D5).
- Published 2023 Forecast Waste stream information and DOE was notified on May 5, 2023.
- Status: 6 waste types, 708 waste streams, 36 reporting sites and 36 disposition facilities.



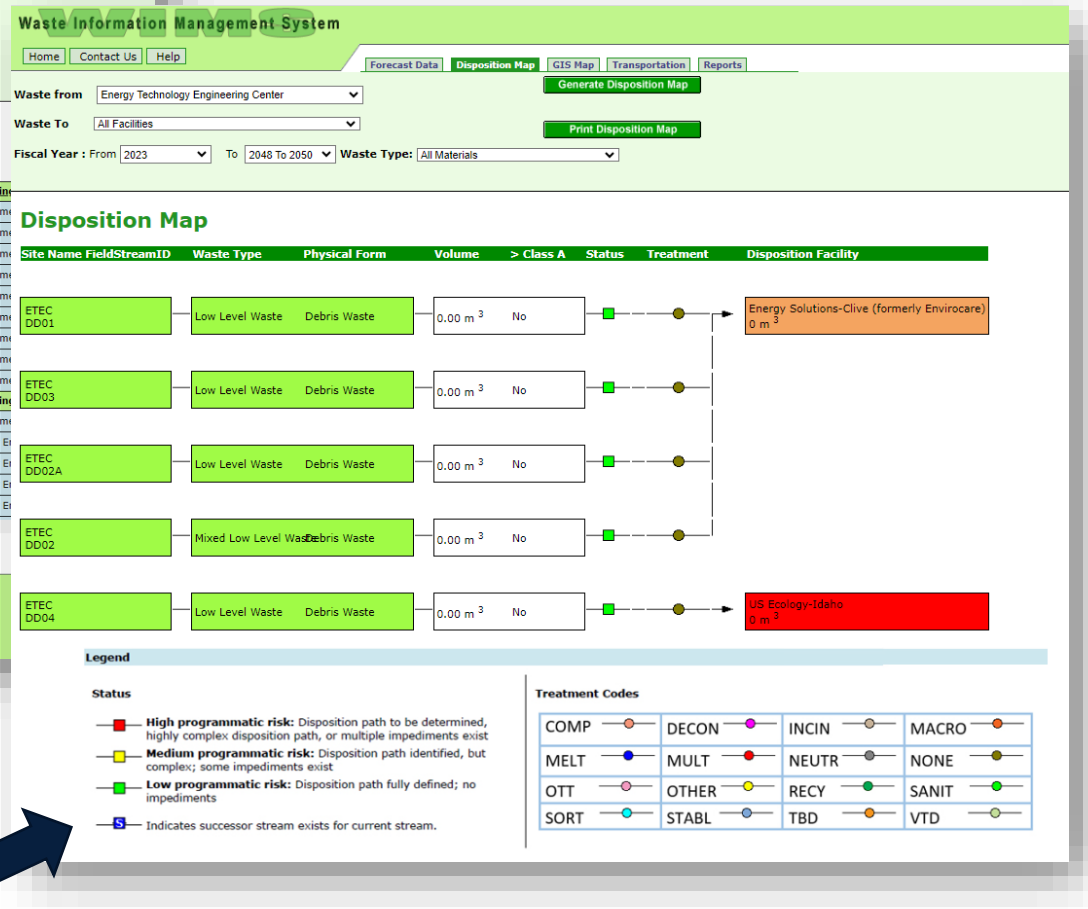



# Subtask 1.2: Waste Stream Annual Data Integration

## Accomplishments:




Forecast Data

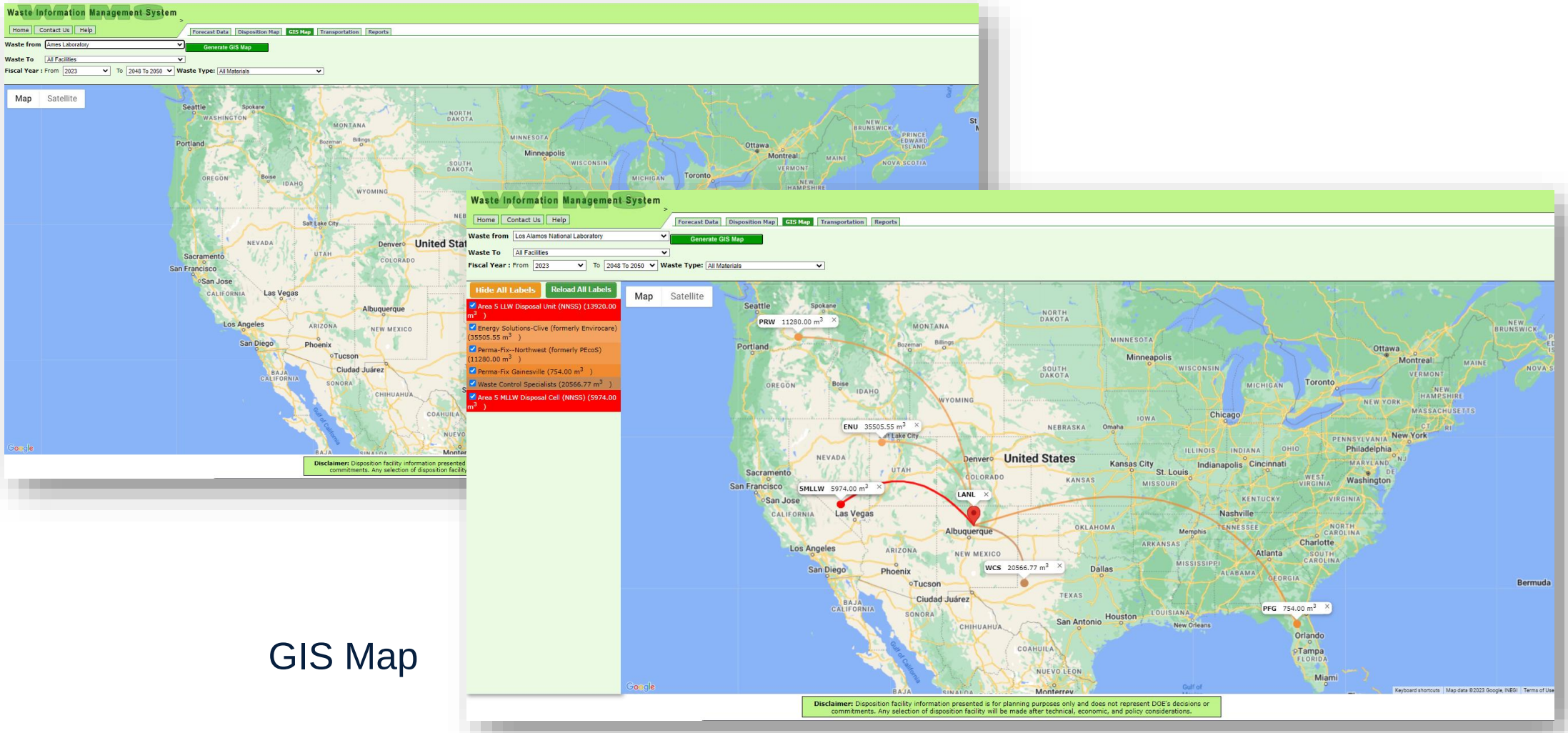



New Legend

Disposition Map

# Subtask 1.2: Waste Stream Annual Data Integration

## Accomplishments:

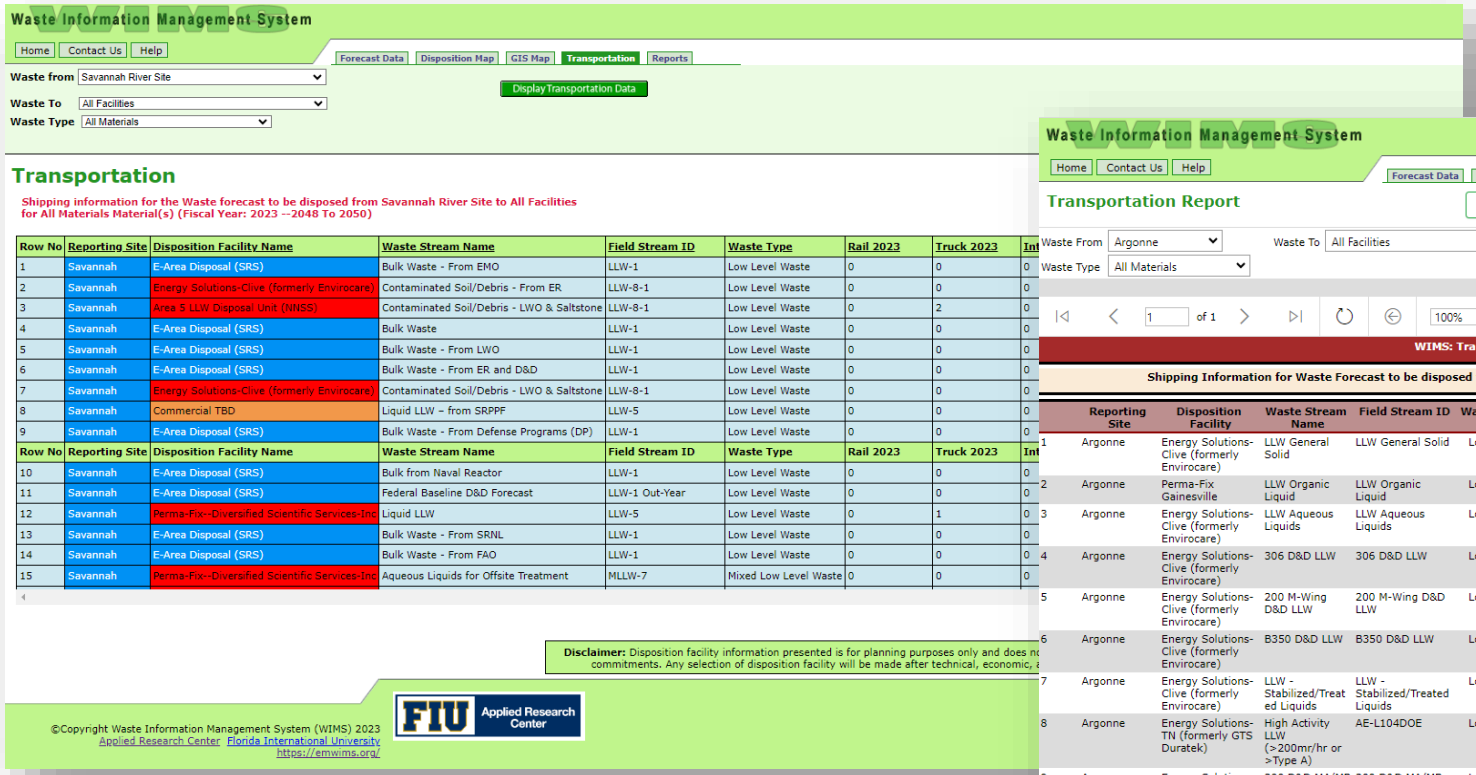



GIS Map

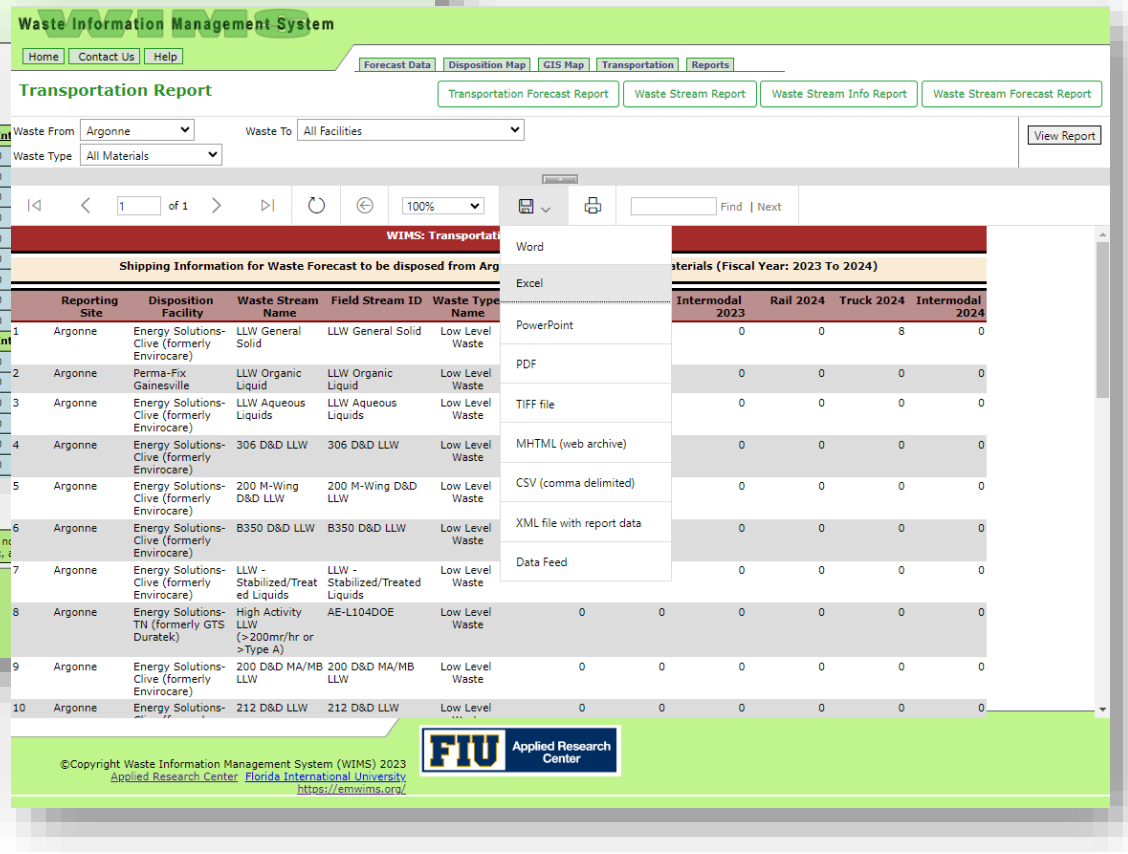
Uses Google Map API for enhanced user interaction

# Subtask 1.2: Waste Stream Annual Data Integration

## Accomplishments:




Transportation




Reports - Sample Transportation Report

# Subtask 1.2: Waste Stream Annual Data Integration

## Accomplishments:

- FIU presented WIMS research and accomplishments at 2023 Waste Management Symposia, March 2023


FIU team presenting WIMS poster at WM2023. From left to right, Walter Quintero, Himanshu Upadhyay and Douglas Tonkay (DOE HQ).

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# Subtask 1.5: Cyber Security of WIMS Infrastructure

## Description and Accomplishments:

- Cyber security of WIMS involves securing the network infrastructure that is deployed, secured and maintained in the FIU facility.
- This involves coordination between the FIU security team and DOE Fellows who learn cyber security skills while assisting staff do penetration testing and other tasks to test the overall security of the system at the application, database and infrastructure levels.
- Renewed and configured the yearly Secure Socket Layer (SSL) on WIMS website/server.

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# The Waste Information Management System (WIMS) Development, Maintenance and New Data Integration

## FIU Year 4 Projected Scope

- **Subtask 1.1: WIMS System Administration & Cyber Security - Database Management, Application Maintenance & Performance Tuning**
  - This subtask includes the day-to-day maintenance and administration of the application and the database servers.
  - Administrator will monitor the network and server traffic and performs updates necessary to optimize the application performance.
  - FIU will provide application and database security as well as help desk support to DOE site managers, HQ managers and other users who need assistance with WIMS.
  - Provide cyber security to WIMS infrastructure, application, database server and reporting server.
- **Subtask 1.2: Waste Stream Annual Data Integration**
  - Update WIMS modules – Forecast Data , Waste Stream and GIS map.
  - Update and publish reports.
  - Update and publish transportation module.

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# Task 2

## D&D Support to DOE EM for Technology Innovation, Development, Evaluation and Deployment

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# Subtask 2.1: Development of Uniform Testing Protocols and Standard Specifications for Fixative Technologies in Support of Complex-Wide D&D Activities

## Site Needs:

- A uniform, peer-reviewed, stakeholder endorsed test and evaluation methodology for D&D technologies, with a current emphasis on fixatives.
  - Define the operational requirement for the technology (What should it do and to what standard – characteristics and performance).
  - Develop uniform testing protocols so the D&D community can confirm it does, in fact, do it (also facilitates comparison).
- **Operationalize knowledge**, not just archive it.

## Objectives:

- Engage ASTM International's E10.03 Subcommittee on Radiological Protection for Decontamination and Decommissioning of Nuclear Facilities and Components to develop, ballot and promulgate standard specifications and uniform testing practices for fixative technologies intended to support D&D activities.

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# Subtask 2.1: Development of Uniform Testing Protocols and Standard Specifications for Fixative Technologies in Support of Complex-Wide D&D Activities

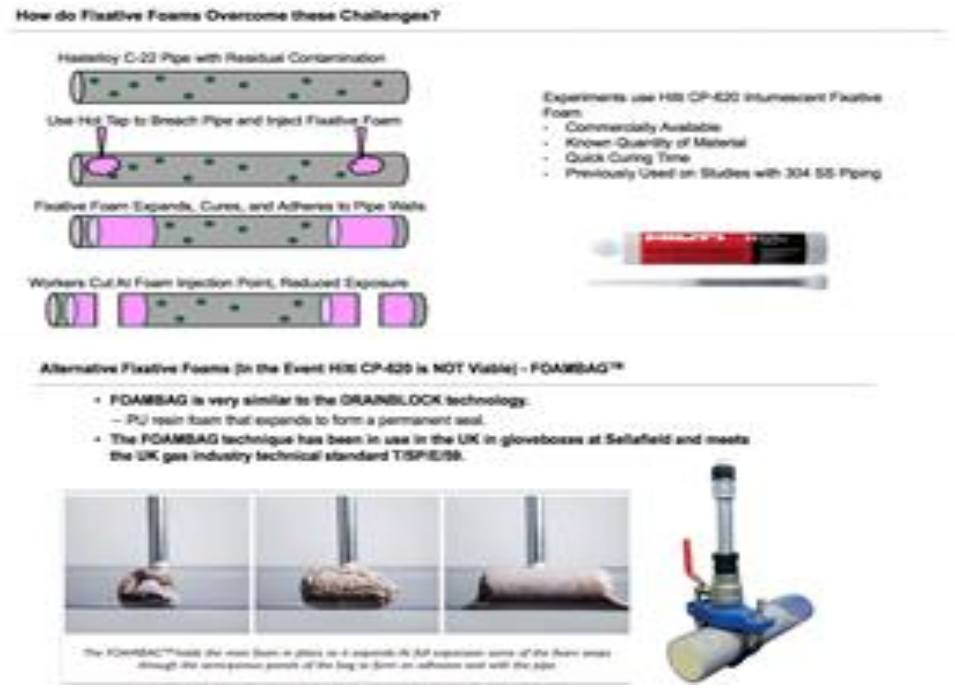
## Research Highlights & Accomplishments:

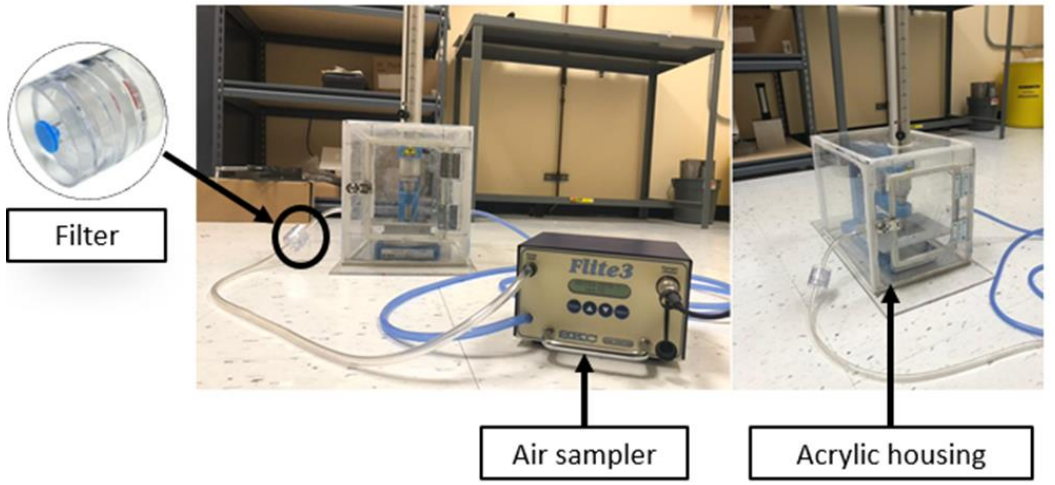
- ASTM E3104 (Decon Gels) and E3105 (Permanent Fixatives) were successfully balloted, approved, and renewed.
- Formal integration of ASTM standards related to fixative technology development, testing and evaluation is becoming mainstream (test plans, RFPs, peer-reviewed articles, etc.).
  - SRNL-STI-2023-00005, “Radiation Hardened Foam Cold Test Plan - Phase II: Foam Characterization Testing and Environmental Chamber Testing of FoamBag Fixative Foam”, 2023
    - **Supporting Foam Fixative Plug site deployment for F/H Labs**
  - Lee, E. H., et al., “Removable coatings: Thermal stability and decontamination of steel surfaces from 241Am,” Chemosphere, Vol 301, August 2022, 134680
  - FY 22 Minority Serving Institutions Partnership Program (MSIPP), RFP 000749

# Subtask 2.1: Development of Uniform Testing Protocols and Standard Specifications for Fixative Technologies in Support of Complex-Wide D&D Activities

## FIU Year 4 Projected Scope

- ASTM E 3191 (Foam Fixatives) updated and balloted
  - **Supporting Foam Fixative Plug site deployment for F/H Labs**
- ASTM Working Group established to codify experimental design developed in support of “certifying fixative technologies under impact stressors” into a formal testing practice



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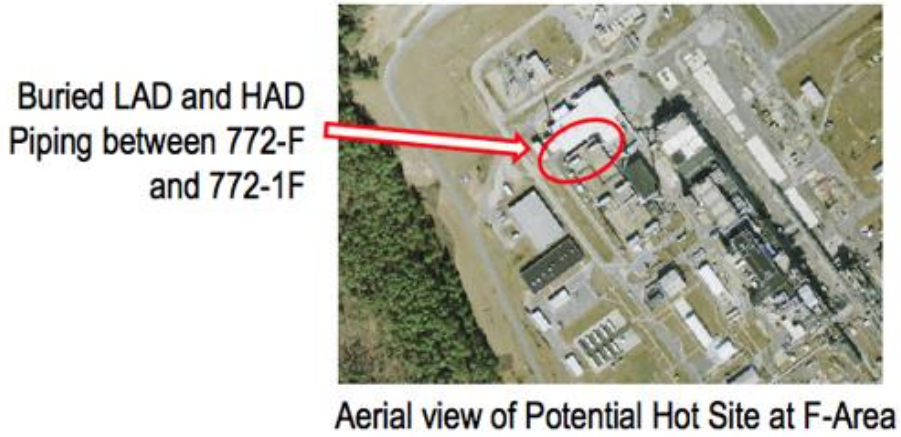
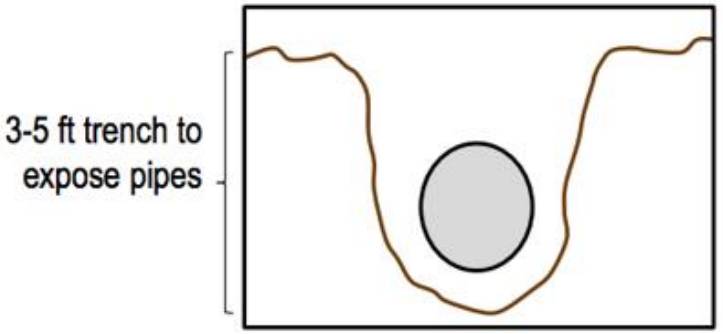
# Subtask 2.2: Test and Evaluation of Down-Selected Intumescent Foams/Foam Plug Technologies to Mitigate Contaminant Release during Nuclear Pipe Dismantling in Support of a Hot Demo at F/H Labs in FY25

## Site Needs:

- By FY '27, the F/H Laboratory Deactivation Project Team plans to remove all the buried LAD and HAD piping in the Courtyard between 772-F and 722-1F.
- The driver for removal is to prevent future release(s) to the environment from the buried, highly-contaminated piping.
- The intent is to remove the piping to within 1' of the respective building and then to cap both the 2 & 3-inch "core" pipe and the 3 & 4-inch "jacket" pipe.
- The piping is generally buried to a depth of 3-5 feet.
- Total length of piping to be removed is approximately 250 feet. Piping will be cut to 5' lengths so that it may be disposed to B-25.



Aerial view of Potential Hot Site at F-Area




# Subtask 2.2: Test and Evaluation of Down-Selected Intumescent Foams/Foam Plug Technologies to Mitigate Contaminant Release during Nuclear Pipe Dismantling in Support of a Hot Demo at F/H Labs in FY25

## Research Highlights & Accomplishments: Identify & Down-select Most Compatible Technology

### Hilti

- A two-component polyurethane (PU) intumescent foam that expands up to six times in volume upon application.
  - Meets ASTM E84 standard.
- Foam is applied through a dispenser and a mixer nozzle attachment.


### FoamBag™

- Expanding PU resin foam.
  - Used in the UK in gloveboxes at Sellafield & meets the UK gas industry technical standard T/SP/E/59.
- Injected into a semiporous bag via an injection tube which passes up through the standpipe assembly.

*The FOAMBAG™ holds the resin foam in place as it expands. At full expansion some of the foam seeps through the semi-porous panels of the bag to form an adhesive seal with the pipe*

# Research Highlights & Accomplishments: Technology Comparison to Support Down-selection

| | Curing Time | Max Curing Temp. | Average Plug Strength | Adhesion to Wetted Surface | Fire Retardant | Environmental Chamber | Headspace | Hot Tap Compatible |
|---|---|---|---|---|---|---|---|---|
| Hilti | 1-3 mins | 276°F | 7733 lbf | **888 lbf** | YES | PASS | PASS | **FAIL** |
| FoamBag | 15-45 mins | 277°F | 9684 lbf | **4741 lbf** | YES* | In progress (SRNL) | In progress (SRNL) | **PASS** |

*Fire retardant with addition of Exolit AP 750 additive

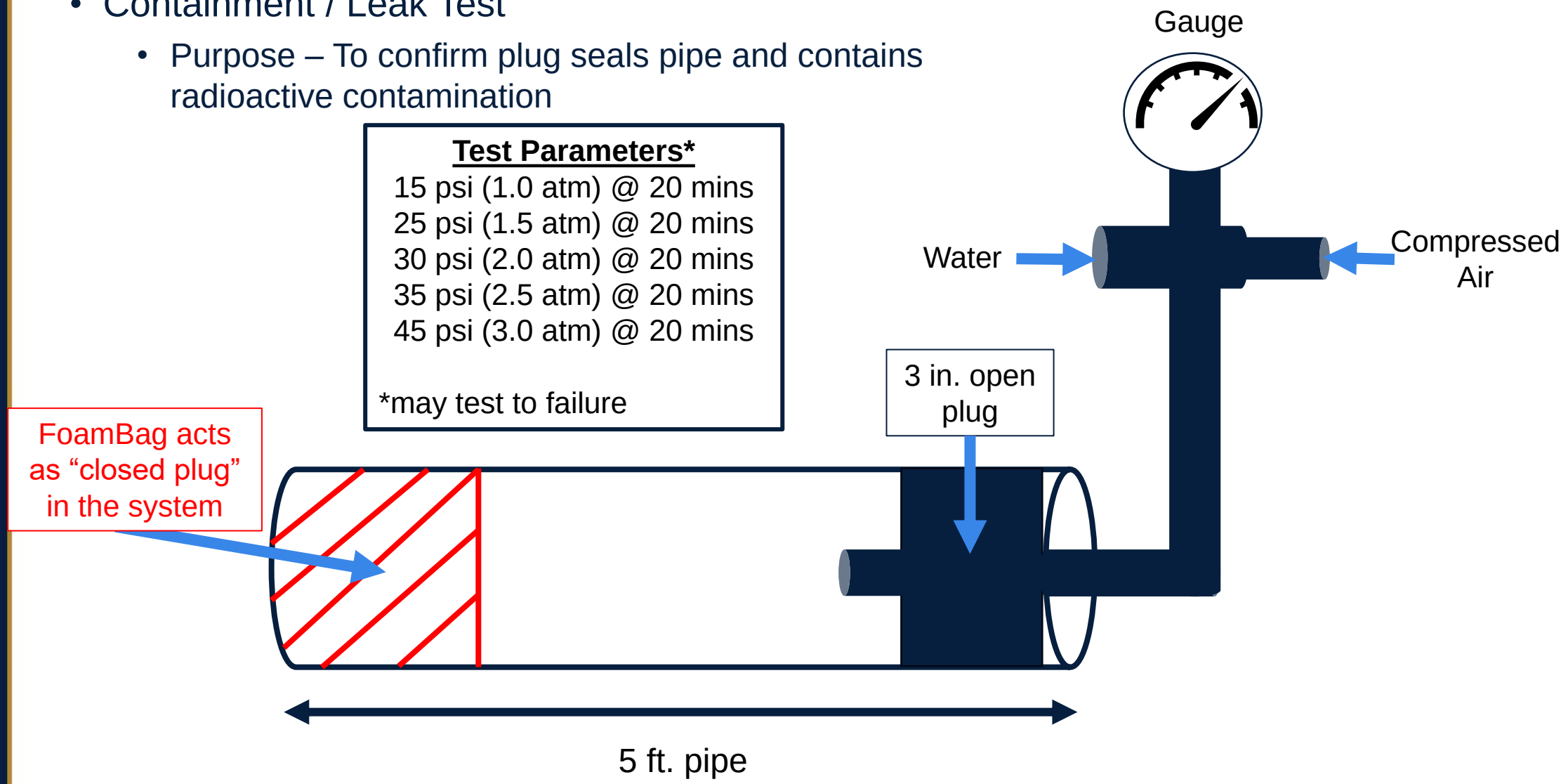
# FIU Year 4 Projected Scope

- Containment / Leak Test
  - Purpose – To confirm plug seals pipe and contains radioactive contamination

**Test Parameters***

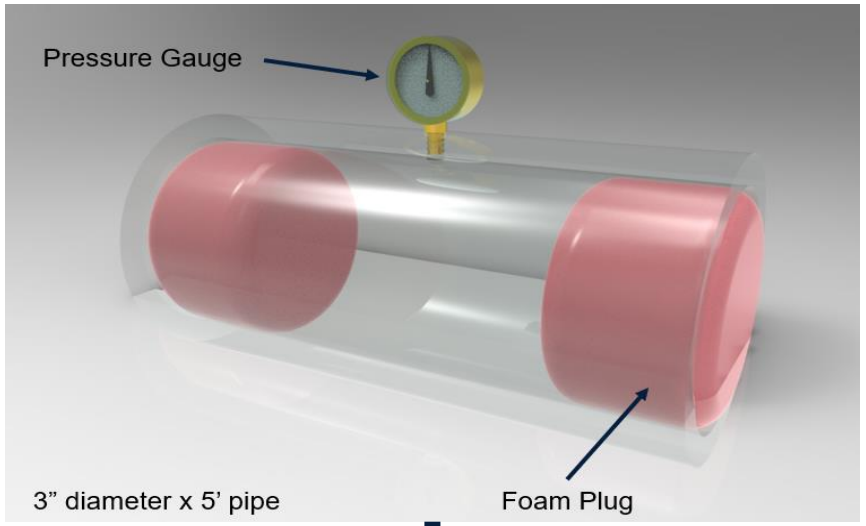
15 psi (1.0 atm) @ 20 mins
25 psi (1.5 atm) @ 20 mins
30 psi (2.0 atm) @ 20 mins
35 psi (2.5 atm) @ 20 mins
45 psi (3.0 atm) @ 20 mins

*may test to failure



# FIU Year 4 Projected Scope

- Confirm Internal Pipe Pressure Conforms to SRS Manual under the following conditions:
  - During curing process (potential heat generation up to 277°F for 5 mins.)
  - During cutting process (heat generation from mechanical and/or torch cutting methods)




- SRS Manual 1S LLW WAC section 5.3 identifies the **maximum** amount of **allowable pressure** within a pressurized container to be **1.5 atm** (22 psi).
- Pressure will be monitored for 24 hours.

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# Subtask 2.3: Certifying Fixative Technology Performance when Exposed to Impact Stressors Postulated in Contingency Scenarios Highlighted in Safety Basis Documents

## Site Needs:

- Outdated regulations, such as the DOE-HDBK-3010, outline factors for dealing with residual contamination, but fail to account for the positive impacts provided by fixative technologies in reducing ARF coefficients.
  - Results in inconsistent certification methodology for fixative technologies.
  - Produces varying Source Term calculations.
  - Fails to provide sufficient credit for improvements in state-of-the-art fixative technologies.
  - Key finding in the SRS 235F-PuFF research activity – after fixative deployment, site personnel could not take credit for fixatives in the safety basis calculations.
  - Potential to reduce cost due to a more accurate/lower Source Term.

## Objectives:

- Reevaluate ARF coefficients for powder contaminants under impact.
- Determine ARF coefficients for fixative materials under impact.
  - Fixative/Polymer State
- Integrate results to update DOE-HDBK-3010.

**FIXATIVE STATE**

- Reduces ARFs
- Reduces RFs

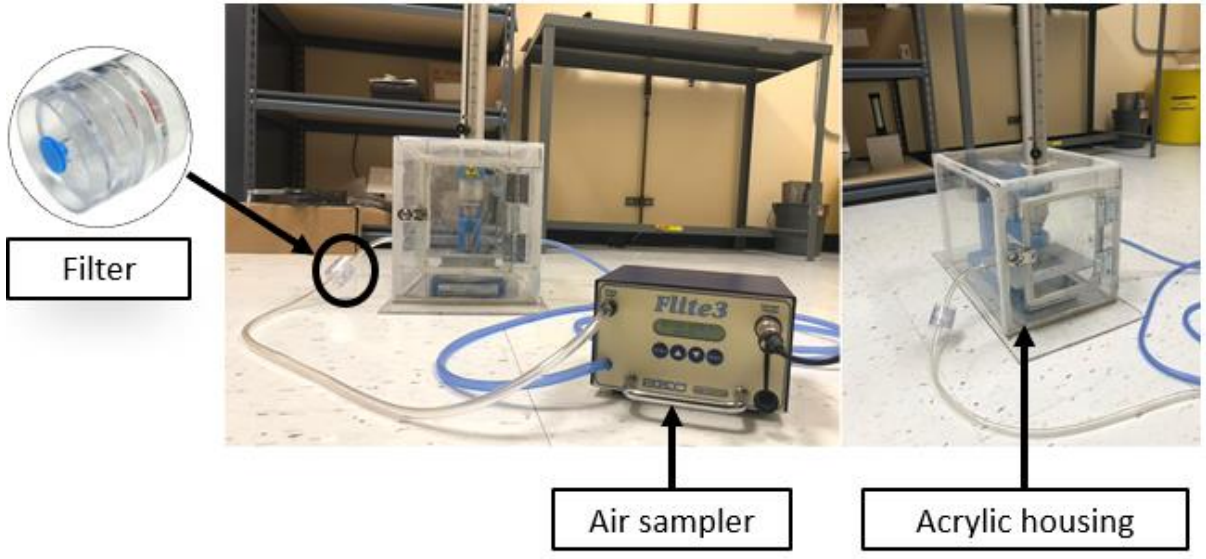
?

?

| Contaminant Form | Impact ARF |
|---|---|
| Gas / Vapor | 1.0 |
| **Powder** | **4e-4** |
| Liquid | 4e-5 |
| Metal / Solid | No significant airborne release is postulated for this accident configuration. |

High Risk

Low Risk



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# Subtask 2.3: Certifying Fixative Technology Performance when Exposed to Impact Stressors Postulated in Contingency Scenarios Highlighted in Safety Basis Documents

## Research Highlights & Accomplishments:

- ARF for loose powder contamination under impact produced an average ARF of 3.47e-04 – **reconfirmed the validity of the value presented in the DOE-HDBK-3010, 4e-04.**

| | Impact (in-lb) / (kg-cm) | Average Airborne Release Fraction |
|---|---|---|
| **Powder** | 320 / 368 | 2.23E-04 |
| | 240 / 276 | 1.08E-04 |
| | 200 / 230 | 1.05E-05 |
| | 160 / 184 | 6.32E-07 |
| **Total Average** | | **3.47E-04** |

- Applying fixative technologies significantly reduced ARFs under impact stressors.
  - **Supports the addition of a new designation: "Fixative / Polymer State"**

| Contaminant Form | Impact ARF |
|---|---|
| Gas / Vapor | 1.0 |
| **Powder** | **4e-4** |
| Liquid | 4e-5 |
| Metal / Solid | No significant airborne release is postulated for this accident configuration. |

High Risk

Low Risk

| | Impact (in-lb) / (kg-cm) | Average Airborne Release Fraction |
|---|---|---|
| **FD** | 320 / 368 | 5.55E-07 |
| | 240 / 276 | 6.78E-07 |
| | 200 / 230 | 8.34E-07 |
| | 160 / 184 | 3.33E-08 |
| **Total Average** | | **5.25E-07** |

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# Subtask 2.3: Certifying Fixative Technology Performance when Exposed to Impact Stressors Postulated in Contingency Scenarios Highlighted in Safety Basis Documents

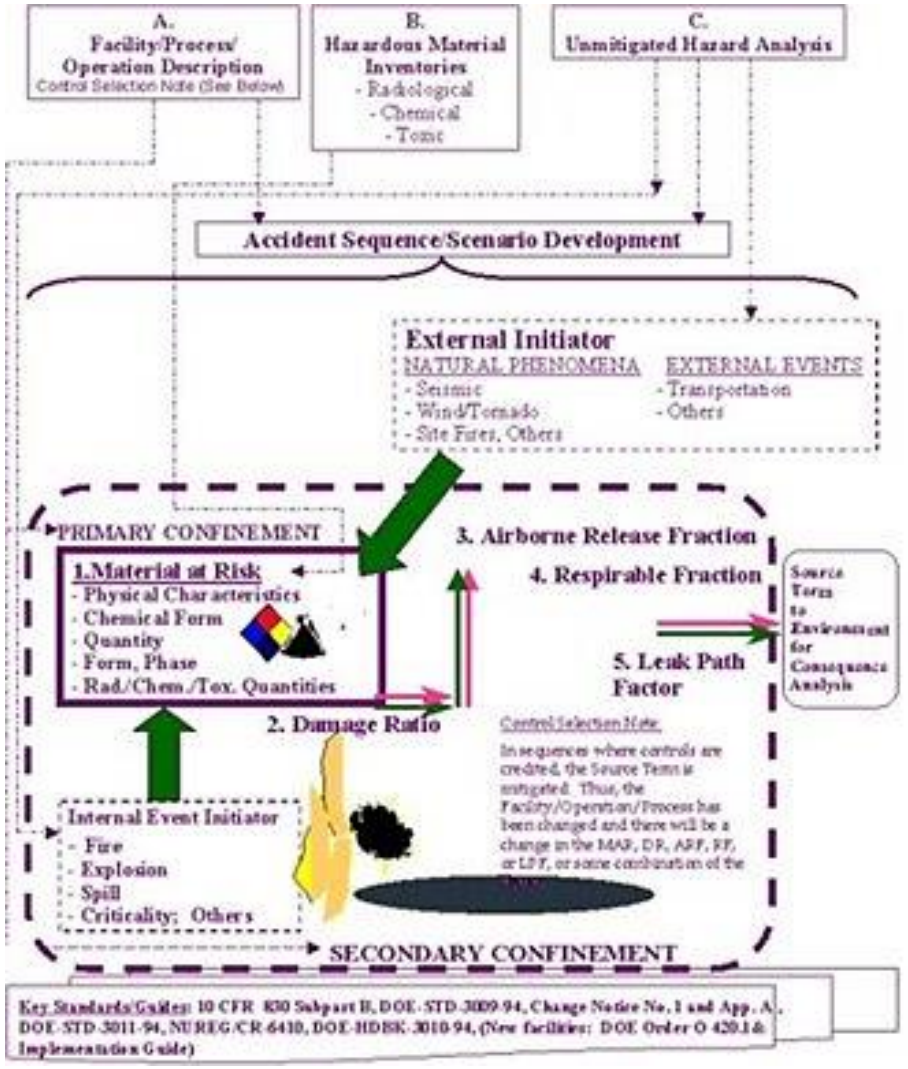
## FIU Year 4 Projected Scope

ASTM Testing Practice

- Draft ASTM Testing Practice and submit to E10.03 for review and publication

Standardize Methodologies for Direct Comparison of Fixative Technologies for Impact Stressors

Provide Empirical Data to Support Potential Update to DOE HDBK



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# Subtask 2.4: Multi-functional 3D Polymer Micro-Ribbons for Mercury Abatement (Discontinued)

## Site Needs:

- Development of novel technologies that support Hg remediation in water.
- Address the adsorption of various forms of Hg contaminants.
- Enable an easy, cost-effective method to recycle the used sorbent.

## Objectives:

- Design recyclable polydimethylsiloxane micro-ribbons (PDMS-MRs) to achieve $Hg^{2+}$ and $CH_3Hg^+$ abatement.
- Confirm application of PDMS-MRs for $Hg^{2+}$ remediation in water.
- Confirm application of PDMS-MRs for $CH_3Hg^+$ remediation in water.
- Synthesis of magnetic PDMS-MRs (mPDMS-MRs).
- Confirm the recycling of mPDMS-MRs in water.

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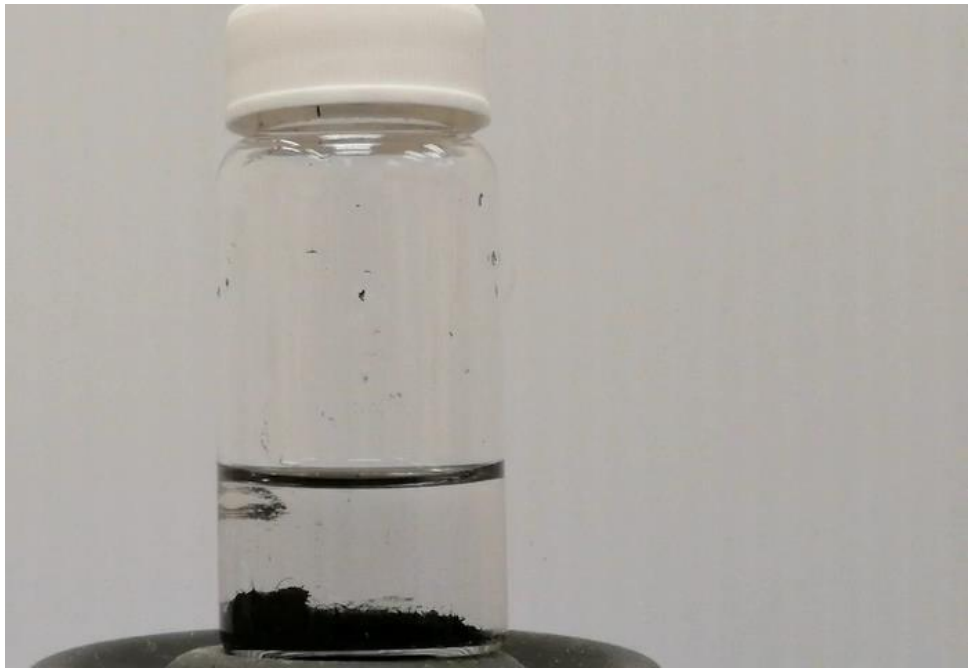
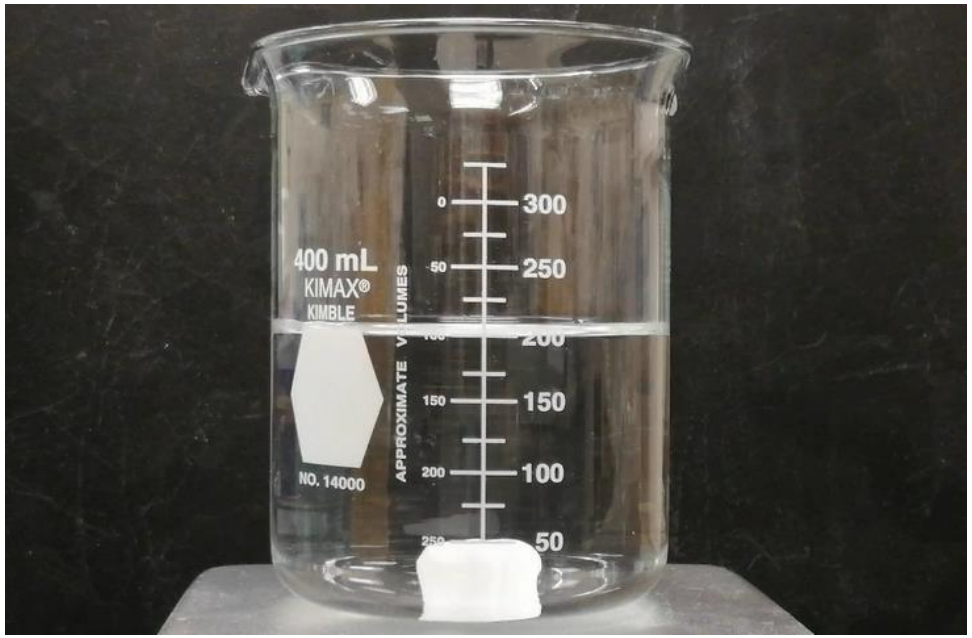
# Subtask 2.4: Multi-functional 3D Polymer Micro-Ribbons for Mercury Abatement (Discontinued)

## Research Highlights & Accomplishments:



Recycling m-PDMS-MRs from water



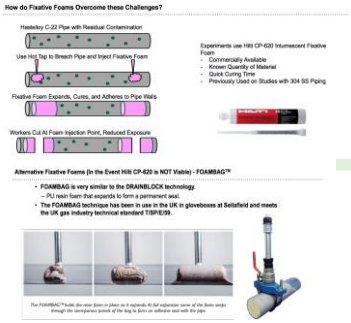
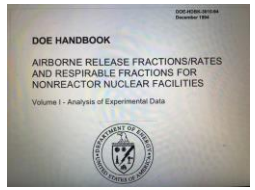

m-PDMS-MRs in Oil/Water separation

***Conclusion***:

1. The mPDMS-MRs demonstrated excellent capability for Hg remediation.
2. Cost effective method when compared to other technologies being investigated.
3. Recommend further investigation if correct resources/personnel can be identified.

# Technology Development and Deployment Road Map

## D&D Roadmap

| Activity | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|
| Foam Fixatives ISO F/H Labs Pipe Dismantling  | Completed Phase I Test Plan (T&E of Foam Technology 1) | Complete Phase II Test Plan (T&E of Foam Technology 2) | Complete Phase III Test Plan (Pressure / Leak Testing and Cold Demo of Hot Tap compatibility) | F/H Lab Site Deployment |
| DOE EM Complex-wide  | ASTM E3104 Updated ASTM E3105 Updated | ASTM E3104 Balloted and Approved ASTM E3105 Balloted and Approved | ASTM E 3191 (Foam Fixatives) updated and balloted | ASTM E 3191 Approval & Promulgation as Formal Standard |
|  | | Technical Progress Report | Final Technical Progress Report | Propose DOE-HDBK-3010 Update |
|  | Proof-of-Concept for Hg Remediation | Project Ended | | |

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# DOE EM Citations Referencing ASTM E10.03 Fixative Technology Standards and Impact Performance

- ASTM E10.03 standards have established a recognized, community-wide, uniform methodology for testing, evaluating, certifying and crediting fixative technologies for use in support of D&D activities and have been extensively cited. A few recent examples include:
  - SRNL-STI-2021-00115, “A Novel Approach to Mitigating the Potential Release of Radioisotopes Under Fire Conditions - Enhancing Fire Resiliency of Radiological Contamination Fixatives During Deactivation & Decommissioning Activities”, 2021.

    *Integrated into SRS 235-F PUFF Facility Work Plan for Incombustible Fixative site deployment
  - SRNL-STI-2023-00005, “Radiation Hardened Foam Cold Test Plan - Phase II: Foam Characterization Testing and Environmental Chamber Testing of FoamBag Fixative Foam”, 2023.

    *Supporting Foam Fixative Plug site deployment for F/H Labs
  - Lee, E. H., et al., “Removable coatings: Thermal stability and decontamination of steel surfaces from 241Am,” Chemosphere, Vol 301, August 2022, 134680.
  - FY 22 Minority Serving Institutions Partnership Program (MSIPP), RFP 000749
    - PA3: Incombustible fixatives and decontamination agents
    - RN3: R&D leading to the development of these fixatives and agents for a nuclear facility. Also, the development of testing protocols to demonstrate their acceptance.
    - C3: Meets ASTM standard from E10.03. Protocols should be applicable to various DOE facilities

- Certifying Fixative Technology Performance Under Impact Stressors
  - Technical Progress Report, “Certifying Fixative Technologies – Impact” – submitted for upload to OSTI.
  - Technical Progress Report submitted as Peer-reviewed manuscript, “Determination of Airborne Release Fractions from Loose Powder Contamination under Impact Stress” – submitted to the Nuclear Technology Journal, Aug 2023.

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# Task 3

# D&D Knowledge Management Information Tool (KM-IT)

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

| | |
|---|---|
| **Subtask 3.4** | Content Management |
| **Subtask 3.5** | Marketing and Outreach |
| **Subtask 3.6** | D&D KM-IT System Administration |
| **Subtask 3.7** | Cyber Security of D&D KM-IT Infrastructure |
| **Subtask 3.8** | KM-IT Tech Talks |

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

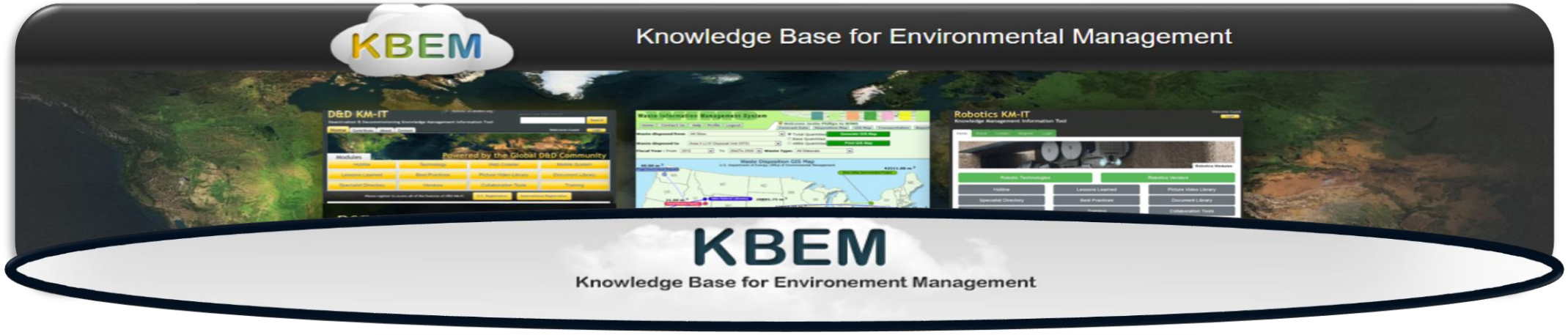
## Site Needs:

- To prevent the loss of the collective knowledge from the aging workforce, the need to collect, retain and disseminate knowledge in an organized and structured way through the development and maintenance of a universally available and usable knowledge management system for DOE-EM.

## Objectives:

- Knowledge management (KM) is a modern approach & discipline being used within EM to capture knowledge. Objectives for KM-IT are to attain the long-term active use, operation, and continued growth of the knowledge from across the DOE global community and capture within the KM-IT system, resulting in enhanced worker safety, improved operational efficiencies, improved communication & knowledge among stakeholders, and the cross-generational transfer of knowledge to the future workforce.

# Knowledge Base for Environmental Management



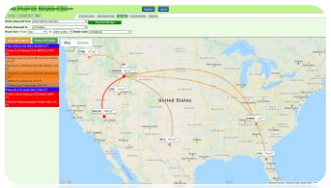

DND KM-IT
dndkm.org

WIMS
emwims.org

DOE FELLOWS
fellows.fiu.edu

DOE RESEARCH
doeresearch.fiu.edu

Robotics KM-IT
rkmit.org



# Knowledge Base for Environmental Management

# KM-IT Modules

- D&D Hotline
- Technology Module
- Vendor Module
- D&D Research
- Mobile applications
- Lessons Learned
- Document Library
- Pictures/videos
- Search tools
- Training
- Specialists
- Best Practices

https://www.dndkm.org/

# Subtask 3.4: Content Management

## Accomplishments:

- Publishing D&D technologies, vendors, lessons learned, best practices, D&D news, conferences and other content to KM-IT
- Perform QA/QC of existing content in the system with assistance of DOE Fellows
- 33 technologies were published on this platform in this fiscal year, bringing the total technologies published to 1577


Portable Fume Extractor

Robotic Welders

Anti-Contamination “Blu” Suit

# Subtask 3.4: Content Management

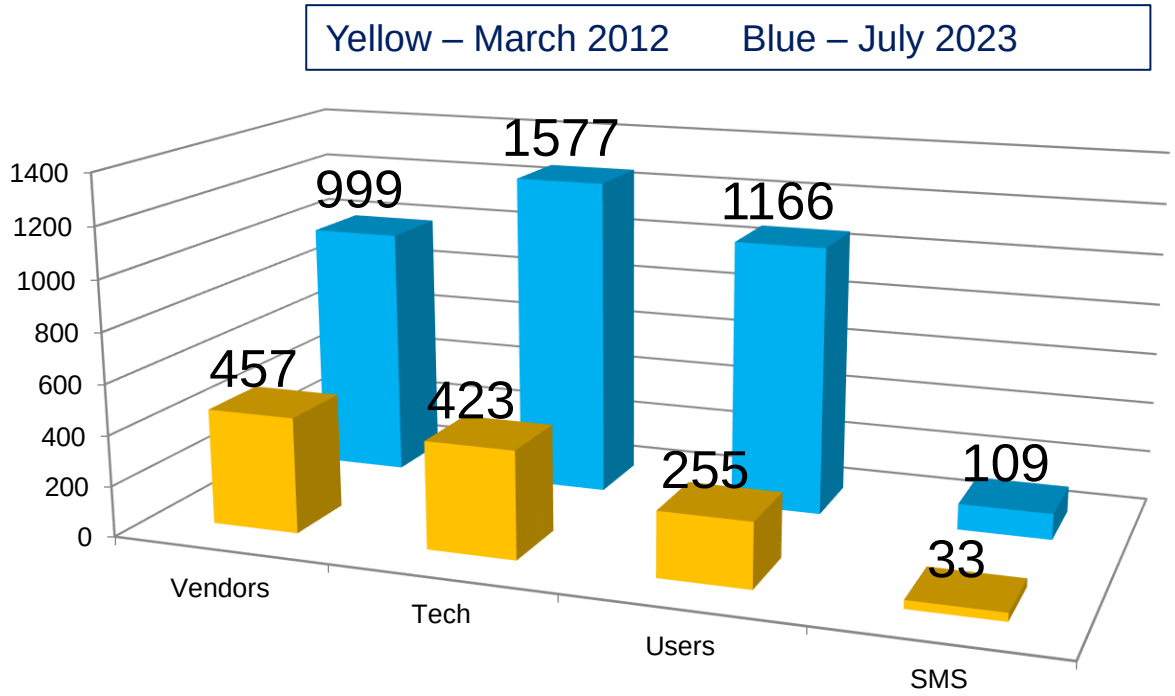
## Accomplishments:

- 41 news articles published on the news module
- 23 event posted under the training module
- Currently updating legacy videos on the Video & Picture module from Adobe Flash to .mp4 and uploading them on YouTube because modern browsers stopped supporting Flash

# Subtask 3.4: Content Management

## Description and Accomplishments:

- D&D KM-IT web analytics to track usage metrics.
- 1577 D&D technologies
- 1166 registered users
- 999 D&D vendors
- 109 subject matter specialists




Growth from March 2012 to July 2023

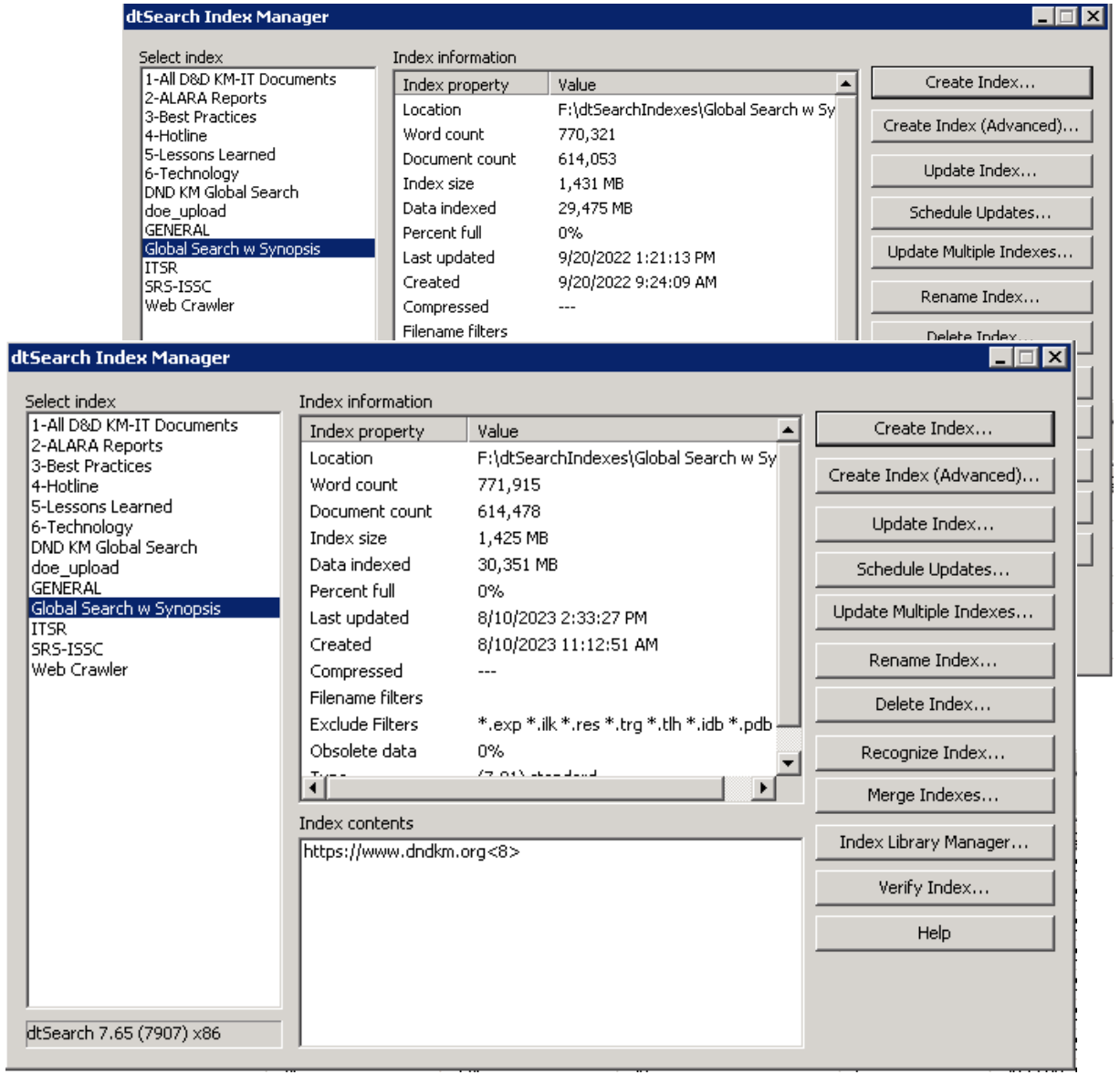
<u>Fully searchable resources – Original sources no longer available</u>

- 169 ALARA Center reports archived (Hanford and SRS)
- 231 Innovative Technology Summary Reports archived

# Subtask 3.4: Content Management

## Accomplishments:

- Search KM-IT – This feature involves search index optimization.
  - Search process crawls through D&D KM-IT system and stores key information about each document so that when users perform a search, the information can be retrieved in real time.
  - The index is built using word, pdf, html and other readable documents stored in the system.
  - The search index is updated manually after any significant changes to the D&D KM-IT (6-8 times per year).
  - Since last year, the D&D KM-IT has added 425 files (html, pdf and doc).



# Subtask 3.4: Content Management

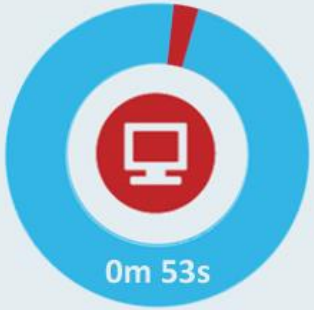
## Aug 2022 - Jul 2023 DND KM-IT WEB ANALYTIC DATA

### TOTAL PAGEVIEWS
**30,641**

SESSIONS **17,150**

UNIQUE USER VISITS **16,328**

AVG. TIME ON SITE




TRAFFIC TYPE


### TOP 5 DEMOGRAPHICS


### USERS


### TOP QUERIES (Clicks)

acm-r ail american atc **avatar** barrier calculator coat denuke dyneema **elite** excel gammacam gasoline giraff gripper hglove **iii** inc isocs **manual** military modiks niton nuclear oxy parts pdf polymeric poxy radiation resrad **robot** **rotobec** scaffolding scansort schilling services sheet shirt **specs** **systems** torch training vasteras versaball xlt

### BROWSERS


### MODULE DESTINATION


Source: Google Analytics (GA)

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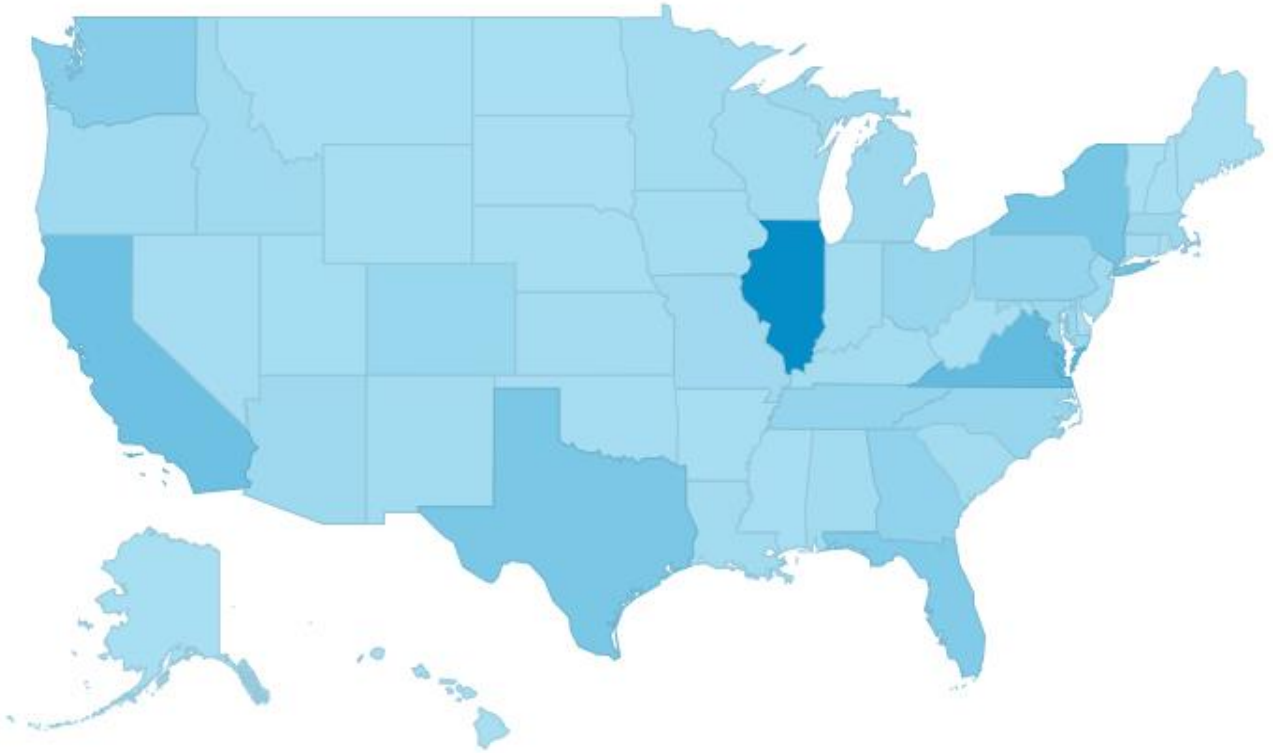
# Subtask 3.4: Content Management

## Description and Accomplishments:

- KM-IT visited by every state of the union in the last 12 months
- Top 5 states include:
  - Illinois – 19.17%
  - Virginia – 8.28%
  - California – 7.07%
  - New York – 5.98%
  - Texas– 5.59%

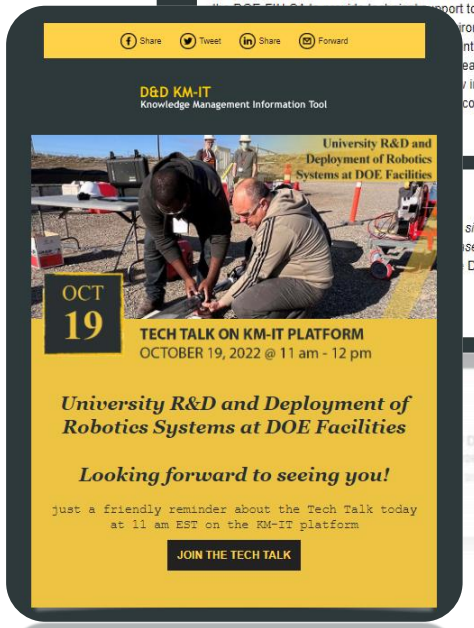


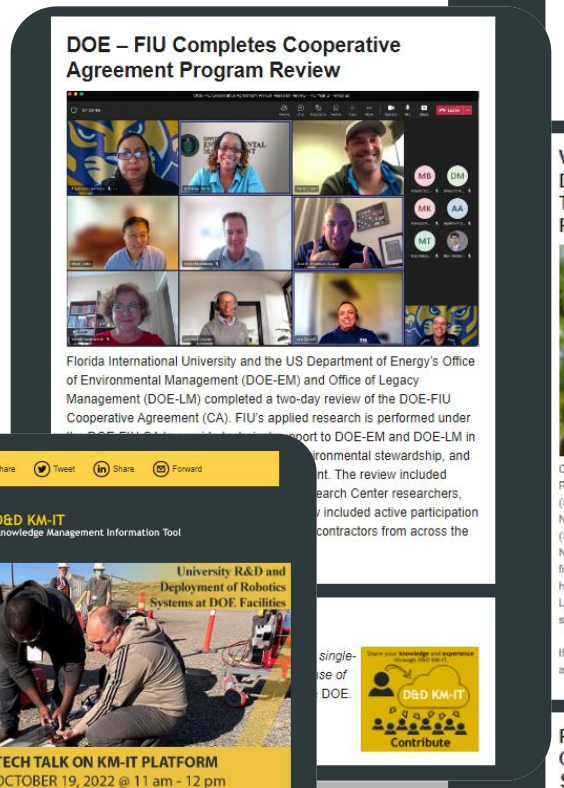
# Subtask 3.5: Marketing and Outreach

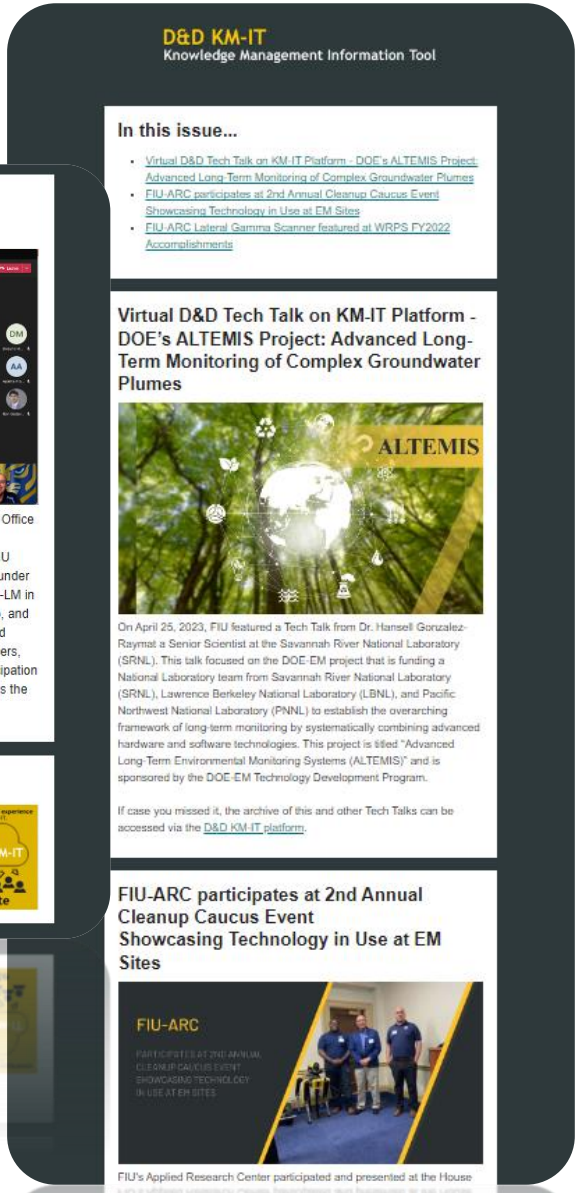
## Accomplishments:

- Reaching out to sites/national labs to increase KM-IT user involvement
- Development of newsletters, post cards and factsheets
- Other marketing and outreach to introduce the system to SME who may not be aware of its features and capabilities





# Subtask 3.5: Marketing and Outreach

## Accomplishments:

- Participation at workshops and conferences such as Waste Management
  - FIU ARC Booth
  - Presented KM-IT poster at WM2023



Dr. Himanshu Upadhyay (FIU), Nancy Bushman (DOE) and Walter Quintero (FIU) in front of the D&D KM-IT poster at WM2023.

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# Subtask 3.6: D&D KM-IT System Administration

## Description and Accomplishments:

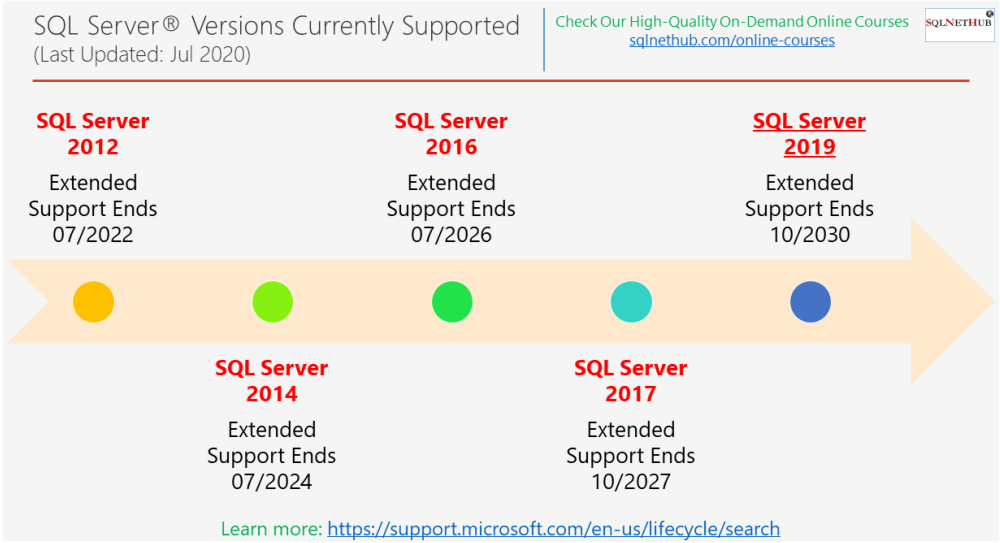
- D&D KM-IT System Administration is an ongoing task, which involves day-to-day administration of servers that house the KM-IT databases and web applications.
- This task includes updating patches and OS fixes, updating antivirus engines and definitions, updating drivers and assuring that the network is working properly.
- Under this task, hardware upgrades are also conducted (memory, hard drives, video cards, routers, firewall, etc.).
- Other administrative task consist of network access control of staff and DOE Fellows (including remote network access).
- This task also supports creating development environments for other subtasks, data and application backups.


Virtualized Server Architecture

# Subtask 3.6: D&D KM-IT System Administration

## Description, Process and Accomplishment:

- This task involves migration/backup of the existing databases and KM-IT modules to latest .NET Framework.
- Created a development environment for the application and database server
- Testing application before moving to production on staging servers
- This constant administration improve performance, security, stability and long-term support of the system




Microsoft® .NET Framework

# Subtask 3.7: Cyber Security of D&D KM-IT Infrastructure

## Description and Accomplishments:

- Cyber security of D&D KM-IT involves securing the network infrastructure maintained in the FIU facility.
- Updating of Secure Socket Layer (SSL) for dndkm.org domain.
- Maintaining and optimizing firewall rules.
- Regularly performed penetration testing on network, KM-IT database and application servers.
- Trained DOE Fellows in DOE-EM Cybersecurity lab on advanced security tools commonly used in the industry.

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# Subtask 3.8: KM-IT Tech Talks

## Accomplishments:

- Conducted D&D related Tech Talk every quarter on the D&D KM-IT platform.
- Collaborated with National Laboratories and/or DOE sites to identify and present technical topics of interest to the community.
- Tech Talks are conducted virtually using an online meeting platform that can be accessed via KM-IT
- Promoted Tech Talks via newsletters, website, emails and flyers developed by FIU.
- Conducted 4 Tech Talks (https://www.dndkm.org/TechTalk)
  - October 19, 2022
    University R&D and Deployment of Robotics Systems at DOE Facilities
  - January 24, 2023
    International Perspective on Decommissioning with focus on 3D hazard aware digital and robotics technology-based transformation
  - April 25, 2023
    DOE's ALTEMIS Project: Advanced Long-Term Monitoring of Complex Groundwater Plumes
  - July 18, 2023
    AI/ML Research support for Advance Long-Term Environmental Monitoring Systems (ALTEMIS)

# Subtask 3.8: KM-IT Tech Talks

## Accomplishments:

### October 19, 2022
### University R&D and Deployment of Robotics Systems at DOE Facilities

Collaborator:
Florida International University Robotics Team

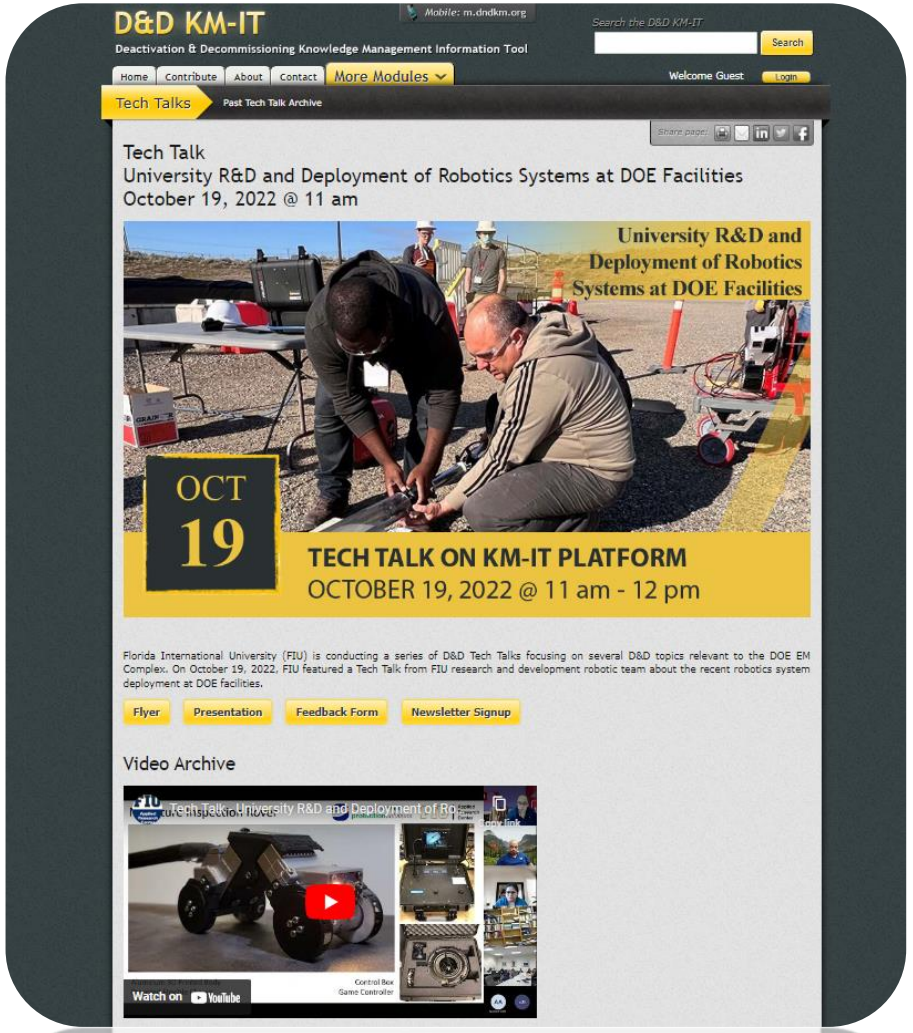
Speakers:

Dr. Leonel Lagos

FIU-ARC Director of Research
Florida International University

Anthony Abrahao

Research Scientish
Florida International University



# Subtask 3.8: KM-IT Tech Talks

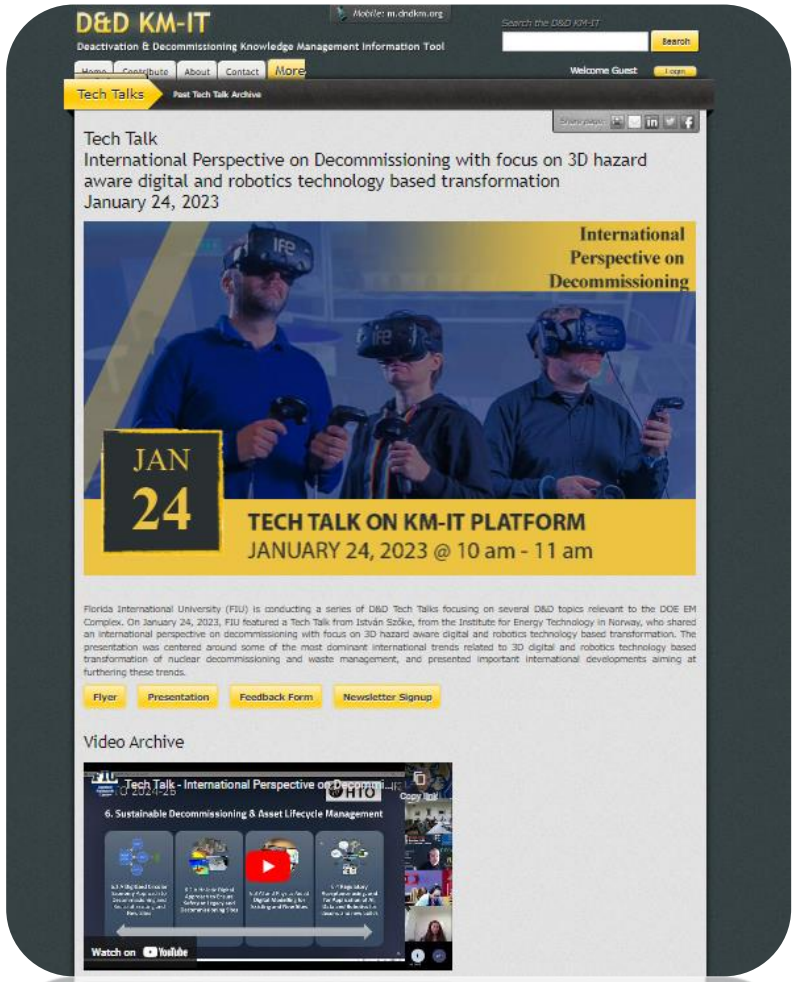
## Accomplishments:

**January 24, 2023**
**International Perspective on Decommissioning with focus on 3D hazard aware digital and robotics technology based**

Collaborator:
Institute for Energy Technology in Norway

International Speaker:
István Szőke, PhD

Principal Scientist, Research Manager
Applied Physics Head of Research
DECOM Cluster



# Subtask 3.8: KM-IT Tech Talks

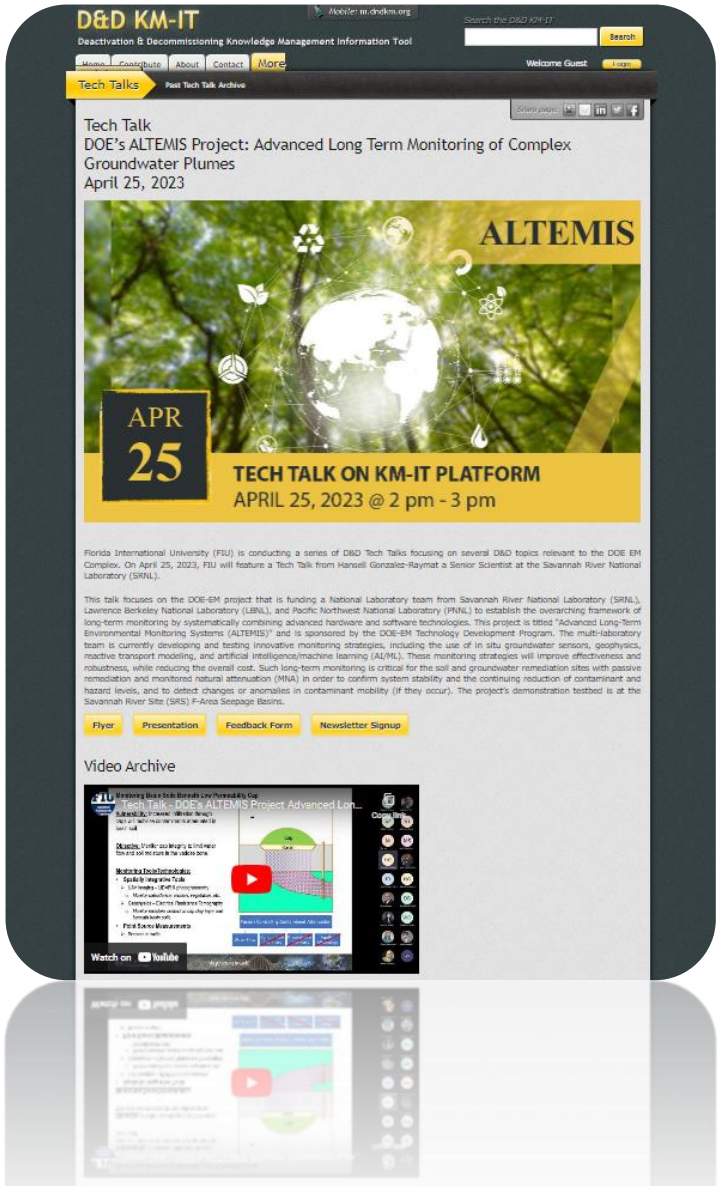
## Accomplishments:

**April 25, 2023**
**DOE's ALTEMIS Project: Advanced Long-Term Monitoring of Complex Groundwater Plumes**

Collaborator:
Savannah River National Laboratory (SRNL)

Speaker:
Hansell Gonzalez-Raymat

Senior Scientist at the
Savannah River
National Laboratory (SRNL)



# Subtask 3.8: KM-IT Tech Talks

## Accomplishments:

**July 18, 2023**
**AI/ML Research support for Advance Long-Term Environmental Monitoring Systems (ALTEMIS)**

Collaborator:
Idaho National Laboratory (INL)

Speaker:
Jayesh Soni

Postdoctoral Associate at the
FIU's Applied Research Center

# Subtask 3.8: KM-IT Tech Talks

## Next Tech Talk:

**SAVE THE DATE!**

**October 17, 2023**

Topic:
To be finalized

Speaker:
Paul Dixon

# D&D KNOWLEDGE MANAGEMENT INFORMATION TOOL (KM-IT) (HQ, SRNL, INL, ANL)

## FIU Year 4 Projected Scope

- **Subtask 3.4: Content Management**
  - Publishing D&D technologies, vendors, D&D technologies, lessons learned, best practices, D&D news, conferences and other content to KM-IT
  - Perform QA/QC of existing content in the system with assistance of DOE Fellows
- **Subtask 3.5: Marketing and Outreach**
  - Reaching out to sites/national labs to increase KM-IT user involvement
  - Participation at workshops and conferences such as Waste Management and engagement with other agencies such as the IAEA.
  - Introduce the system to SME who may not be aware of its features and capabilities
  - Development of newsletters, post cards, factsheets and other print material to promote KM-IT

# D&D KNOWLEDGE MANAGEMENT INFORMATION TOOL (KM-IT) (HQ, SRNL, INL, ANL)

## FIU Year 4 Projected Scope

- **Subtask 3.6: D&D KM-IT System Administration & Cyber Security**
  - D&D KM-IT System Administration is an ongoing task which involves day-to-day administration of servers that house the KM-IT databases and web applications.
  - This task includes updating patches and OS fixes, updating antivirus engines and definitions, updating drivers and assuring that the network (firewall, routers and switches) is working properly.
  - Securing the network by conducting routine cyber security tasks to test the network's vulnerability.
  - Coordination between the FIU security team and DOE Fellows who learn cybersecurity skills while assisting staff do penetration testing and other tasks to test the overall security of the system at the application, database and infrastructure levels.
- **Subtask 3.8: KM-IT Tech Talks**
  - Conduct D&D related Tech Talk every quarter on the D&D KM-IT platform.
  - Collaborate with National Laboratories and/or DOE sites to identify and present technical topics of interest to the community.
  - Tech Talks will be performed virtually using an online meeting platform (KM-IT)
  - Promote Tech Talks via newsletters, website, emails and flyers developed by FIU.

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# Artificial Intelligence Support to DOE-EM

## Advanced Automated Machine Learning System (AAMLS) Transition to DOE-EM

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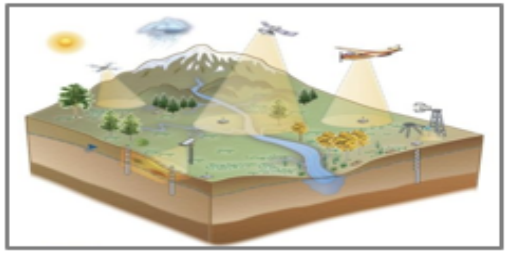
# Advanced Automated Machine Learning System (AAMLS)

## ARTIFICIAL INTELLIGENCE / MACHINE LEARNING

### APPLICATION DOMAIN



SENSOR / IMAGERY DATA FROM DOE-EM SITES

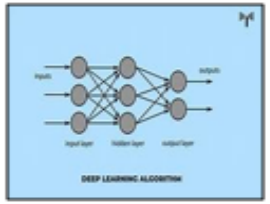
### AI / ML TECHNOLOGY

TensorFlow

Keras

python

APACHE Spark




AI / ML FRAMEWORKS AND ALGORITHMS

### OPERATIONALISE AI / ML MODEL


DATABASE / MACHINE LEARNING SERVERS / BIG DATA CLUSTER

IT INFRASTRUCTURE AND APPLICATIONS

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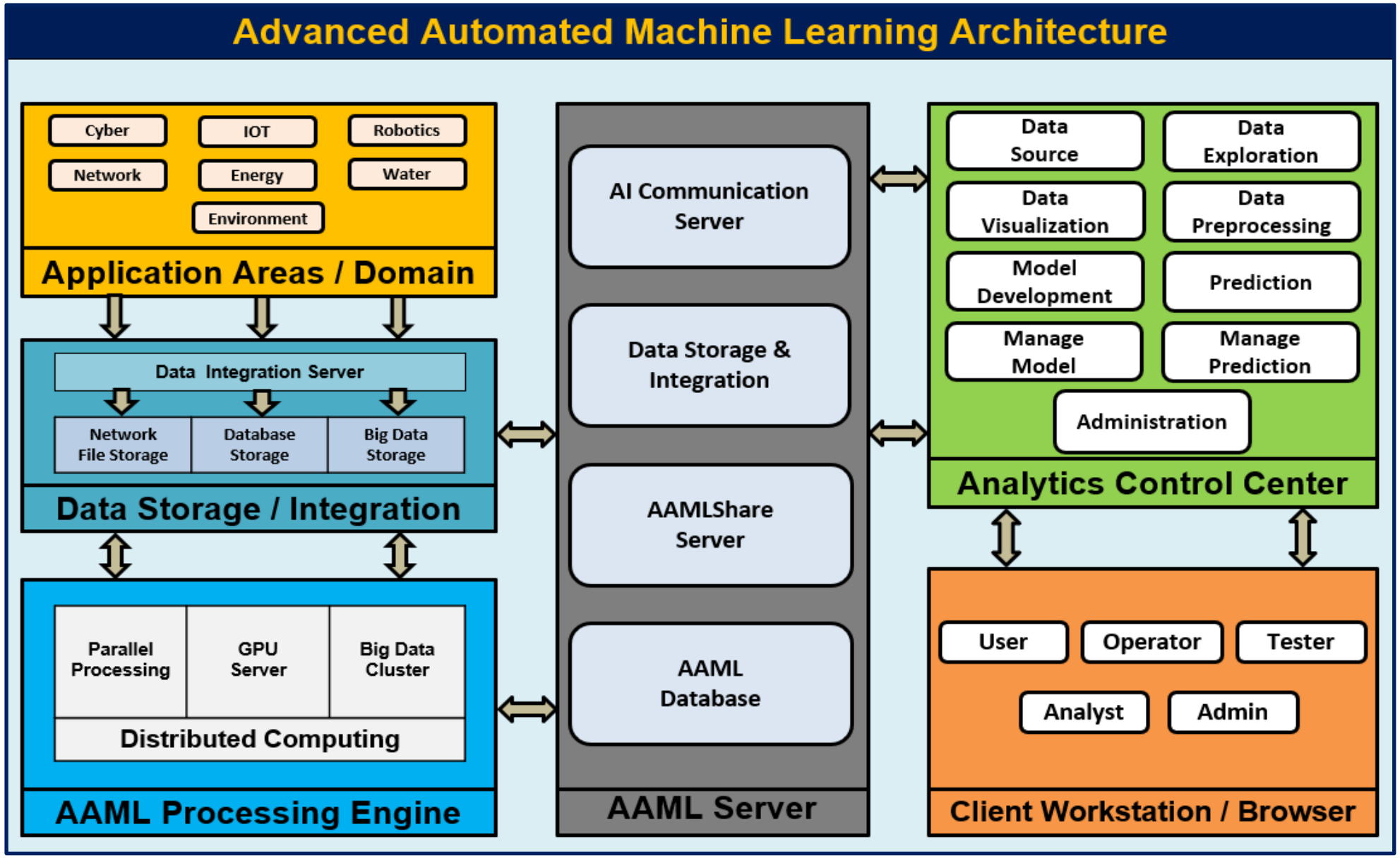
# Advanced Automated Machine Learning System (AAMLS)



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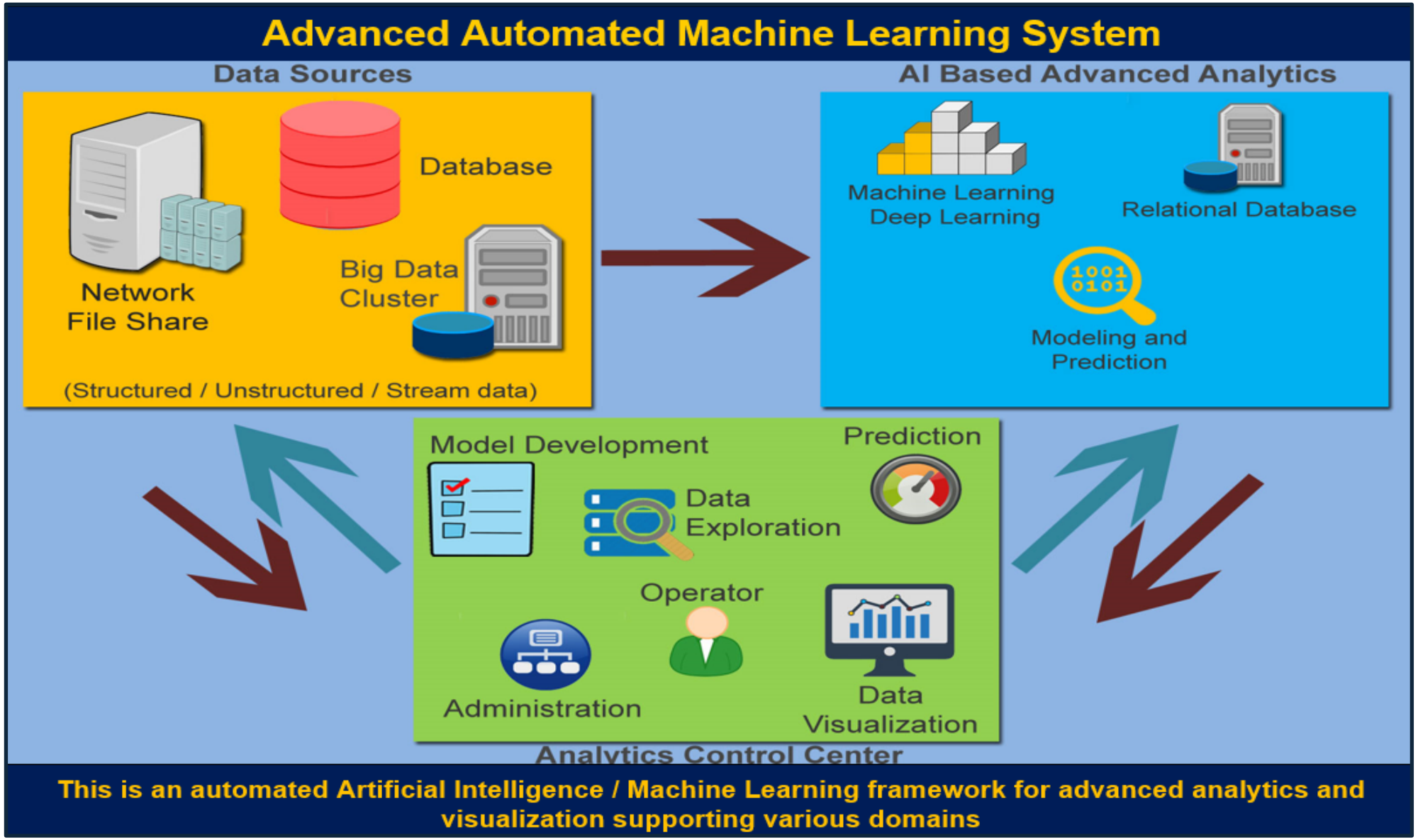
# Advanced Automated Machine Learning System (AAMLS)



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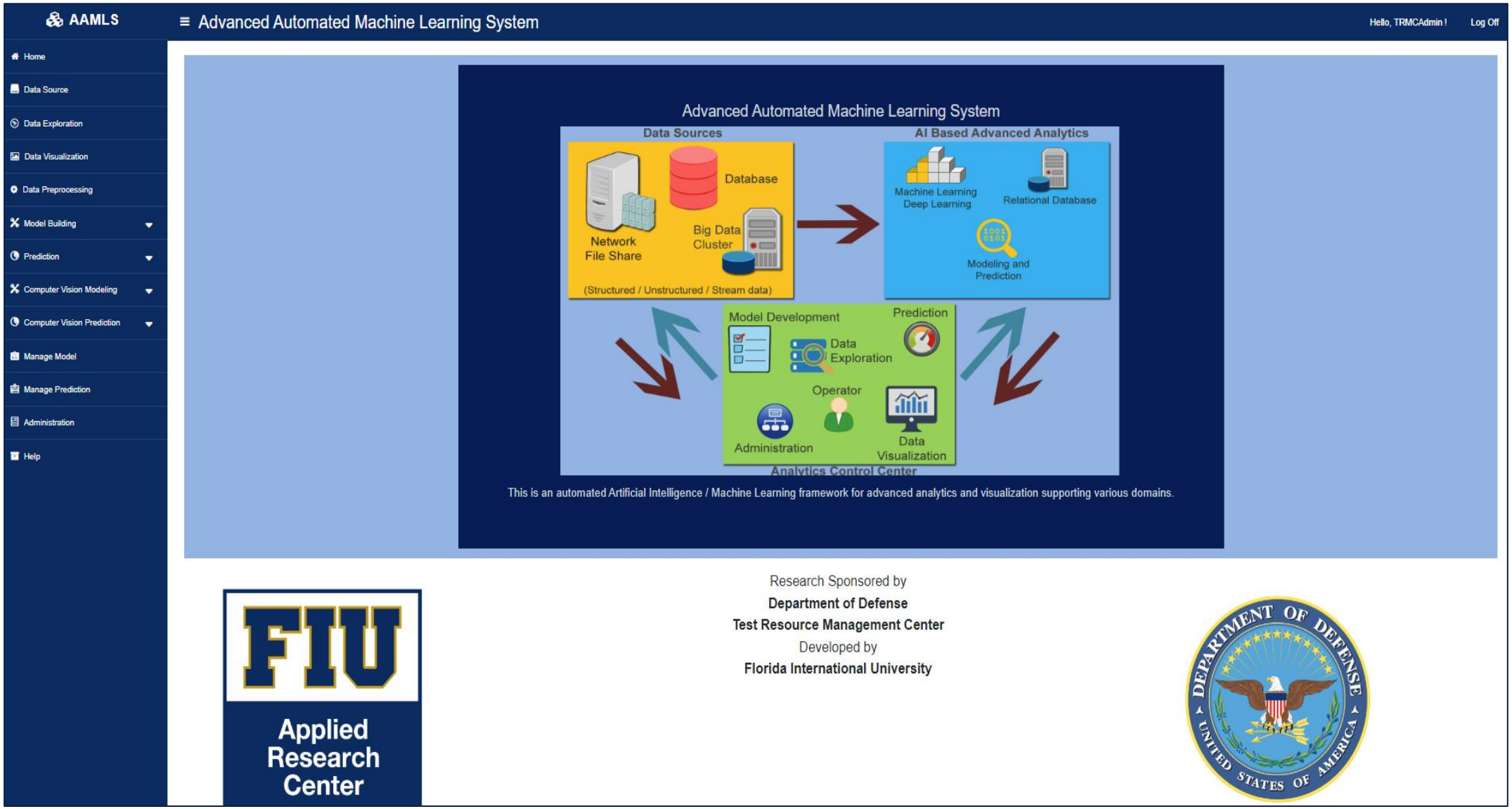
# Advanced Automated Machine Learning System (AAMLS)

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Research Sponsored by
**Department of Defense**
**Test Resource Management Center**
Developed by
**Florida International University**

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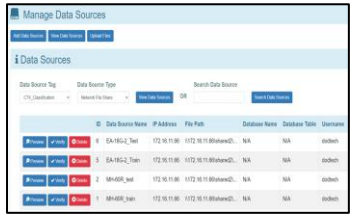
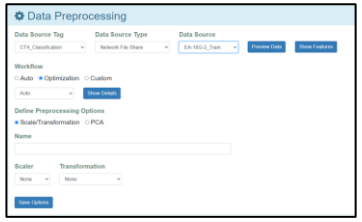
# Advanced Automated Machine Learning System (AAMLS)

## FIU Year 3 Research Highlights:

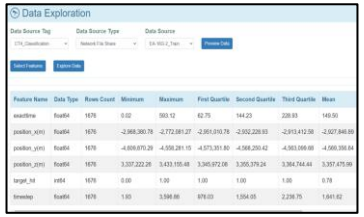
Data Source (1)



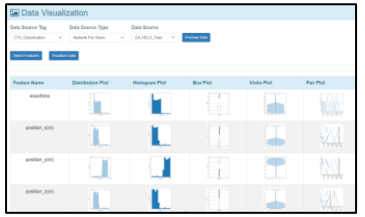

Pre-Processing (2)



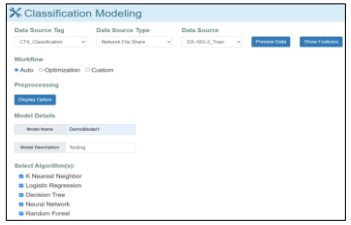

Data Exploration (3)




Data Visualization (4)

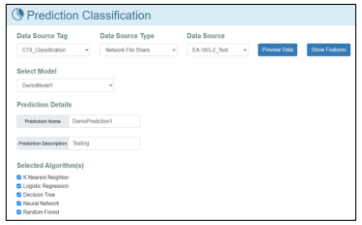



Model Building (5)




Model Validation (6)

Prediction (7)




Prediction Results (8)

# AAMLS Workflow

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# Advanced Automated Machine Learning System (AAMLS)

- Automation of Machine Learning model development and prediction in few steps
- Application can be used with minimal machine learning knowledge
- Dynamic connectivity to existing data sources in network file share, database and big data cluster
- Explore and visualize datasets prior to building model and prediction
- Access to the historical model and prediction results

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# Task 7

## AI for EM Problem Set (Soil & GW):

### Exploratory Data Analysis and Machine Learning Model for Hexavalent Chromium [Cr (VI)] Concentration in 100-H Area (PNNL)

# Task 7: AI for EM Problem Set (Soil & GW): Exploratory Data Analysis and Machine Learning Model for Hexavalent Chromium [Cr (VI)] Concentration in 100-H Area

| | |
|---|---|
| **Subtask 7.3** | Algorithm Development for Spatiotemporal Relationship Identification |
| **Subtask 7.4** | Publishing AI/ML models on AAML System (NEW) |

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# Task 7: AI for EM Problem Set (Soil & GW): Exploratory Data Analysis and Machine Learning Model for Hexavalent Chromium [Cr (VI)] Concentration in 100-H Area

**Site Needs:**

- Subsurface Chromium transport temporal and spatial relationships identification using Artificial Intelligence and Machine Learning.

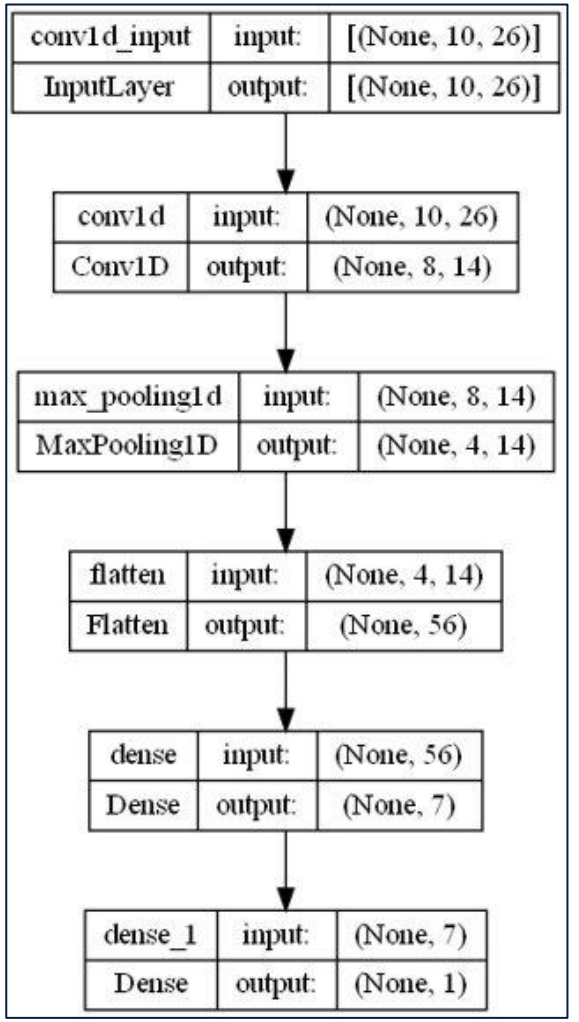
**Objectives:**

- Develop Artificial Intelligence and Machine Learning algorithm for spatiotemporal relationship exploration.
- Perform exploratory data analysis using state-of-the-art statistical methods.
- Explain historical contaminant transport through model interpretation.

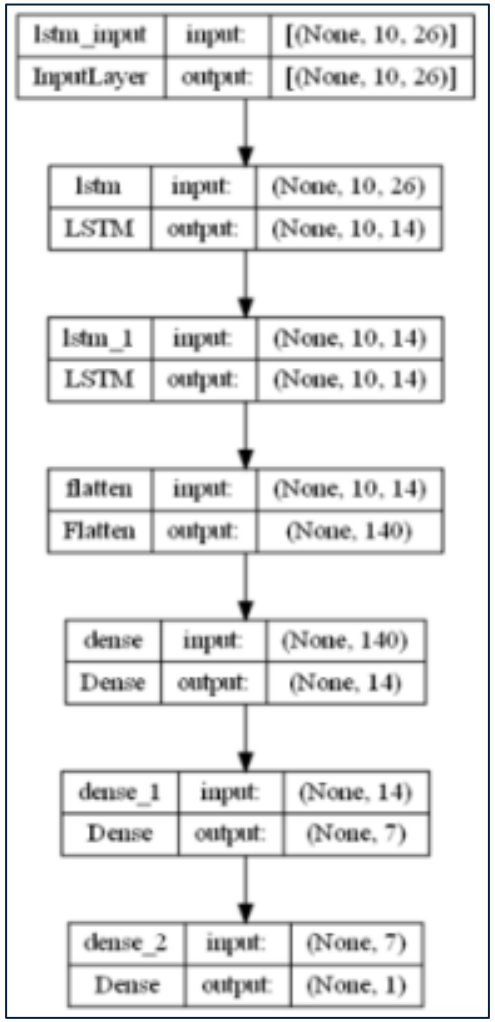
# Subtask 7.3: Algorithm Development for Spatiotemporal Relationship Identification

## FIU Year 3 Research Highlights:

- FIU team researched different algorithms to build ML/DL models to predict Hexavalent Chromium contamination concentration using historical Wells datasets.
- A 1-Dimensional Convolutional Neural Network (CNN) and LSTM-DENSE algorithms are employed to build models.




CNN model architecture targeting well 199-D4-98.




LSTM-DENSE model architecture targeting well 199-D4-98.

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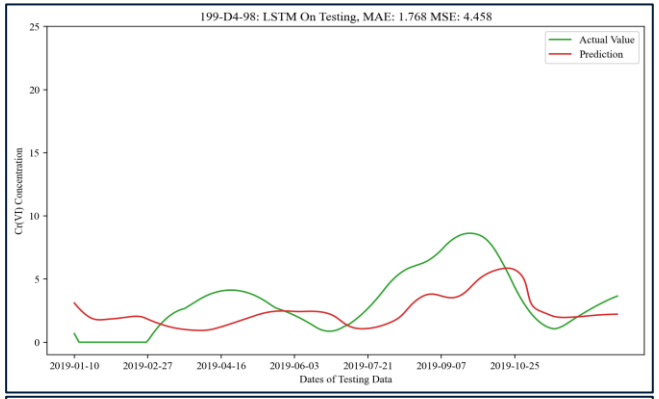
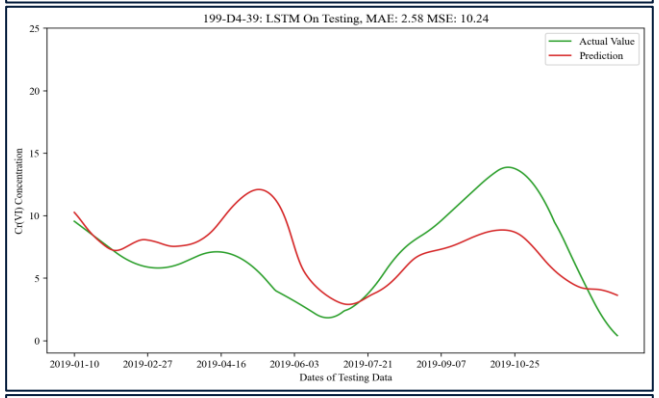
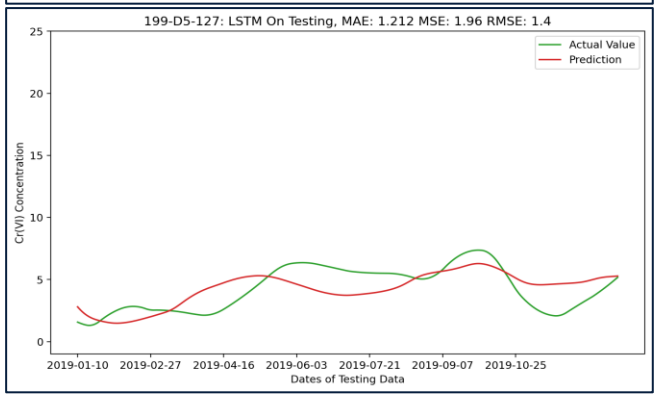
# Subtask 7.3: Algorithm Development for Spatiotemporal Relationship Identification

## FIU Year 3 Research Highlights:

- Developed ML/DL model for prediction of chromium contaminant concentration based on historical data using LSTM-DENSE algorithm.
- Timeseries dataset for the chosen well with contaminant concentration was used to train the model and algorithm was executed 10 times to identify the best model with the desired metrics used for further analysis.
- Targeted wells 199-D4-98, 199-D4-39, and 199-D5-127 prediction performance for contaminant concentration are shown on the right.



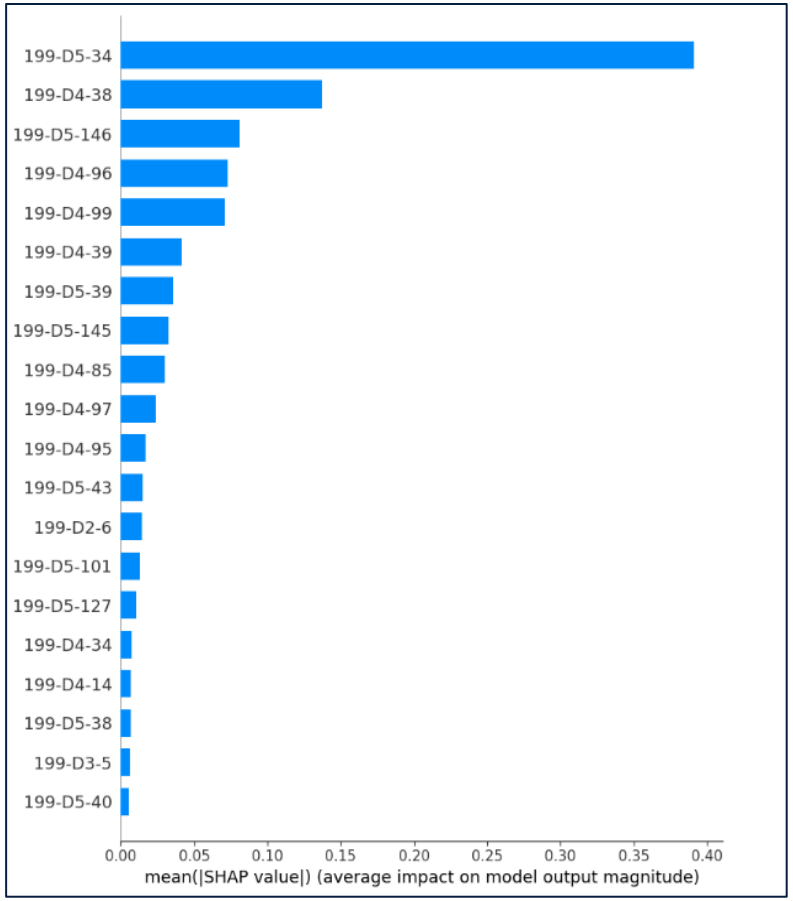



# Subtask 7.3: Algorithm Development for Spatiotemporal Relationship Identification

## FIU Year 3 Research Highlights:

- Extraction of well contributions towards contaminant concentration using feature importance evaluation on the LSTM-DENSE models using SHAP (shapely additive explanations) was built into analysis pipeline.

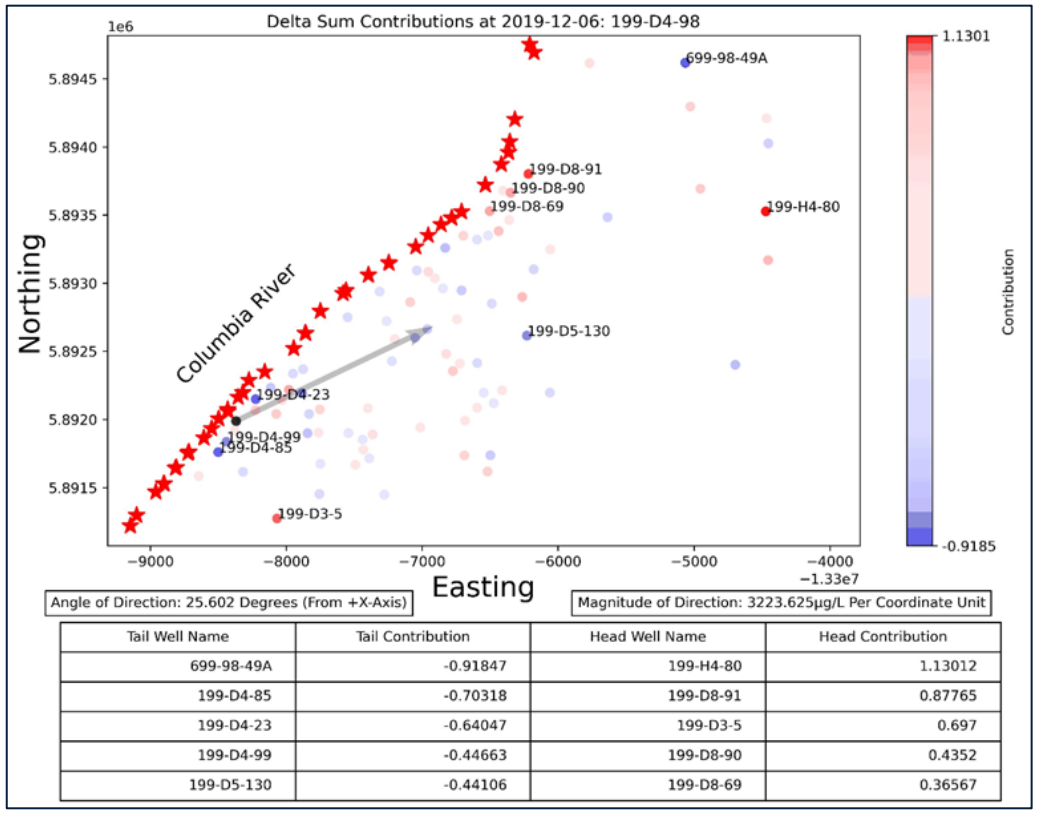



**Cumulative contributions of feature wells on target well for the constitution of final predicted contaminant concentration value.**

# Subtask 7.3: Algorithm Development for Spatiotemporal Relationship Identification

## FIU Year 3 Research Highlights:

- Mapped contributions of feature wells to spatial-temporal visualization illustrating directivity and distribution of contaminant concentration relative to target well.
- Generated plots are snapshots of concentration profile for a given day within the inspected testing window.
- Contribution values mapped are the contribution change from the previous day, or a derivation of the series of contributions throughout the test window.



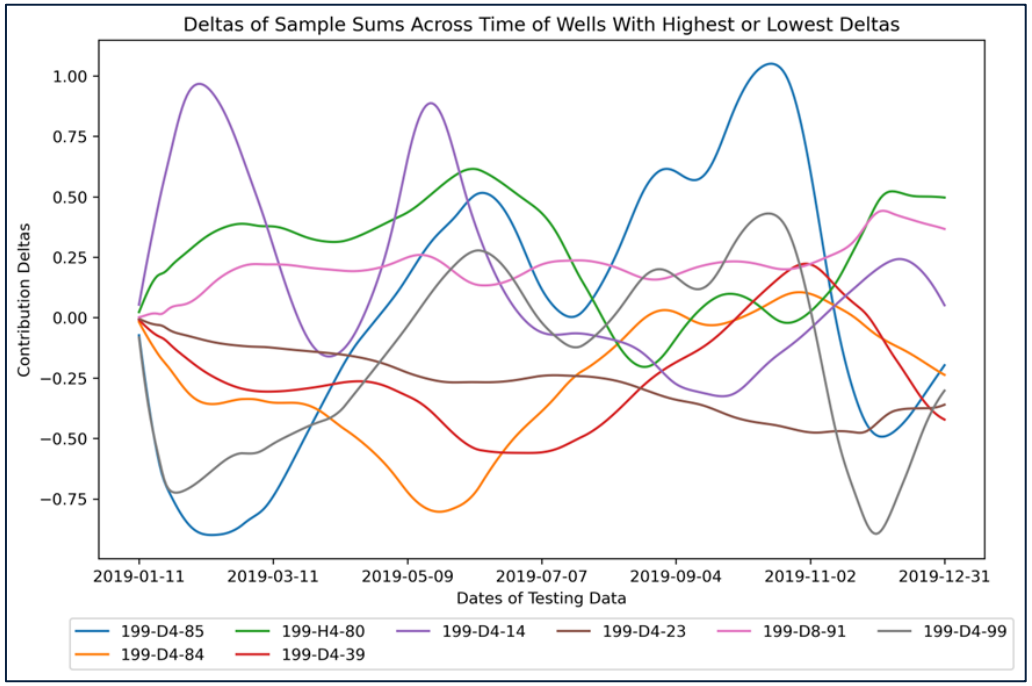

| Tail Well Name | Tail Contribution | Head Well Name | Head Contribution |
|---|---|---|---|
| 699-98-49A | -0.91847 | 199-H4-80 | 1.13012 |
| 199-D4-85 | -0.70318 | 199-D8-91 | 0.87765 |
| 199-D4-23 | -0.64047 | 199-D3-5 | 0.697 |
| 199-D4-99 | -0.44663 | 199-D8-90 | 0.4352 |
| 199-D5-130 | -0.44106 | 199-D8-69 | 0.36567 |

**Example snapshot of spatiotemporal visualization for target well 199-D4-98 for the December 6th, 2019, dataset**

# Subtask 7.3: Algorithm Development for Spatiotemporal Relationship Identification

## FIU Year 3 Research Highlights:

- Analyzed individual well contribution change with respect to time to determine which wells have highest contribution variance throughout the year and how those changes impact the predictions.



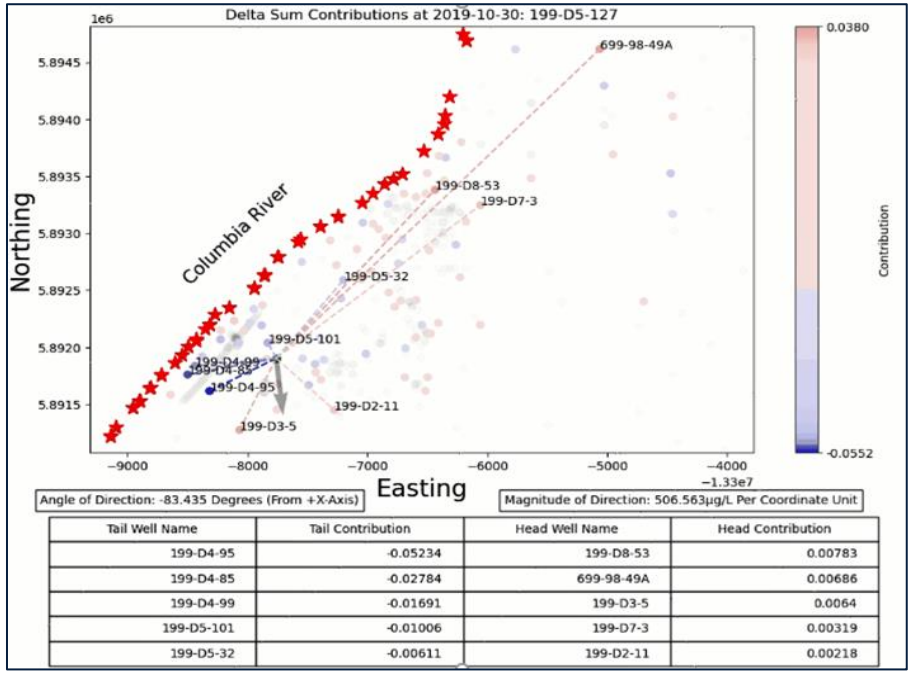

**Shows the 10 top feature wells (with 199-D4-98 as a target for the model) that have exhibited highest daily change (negative or positive) throughout the year.**

**Highest fluctuation does not always mean the well had the highest overall contribution, but it may explain trends in prediction**

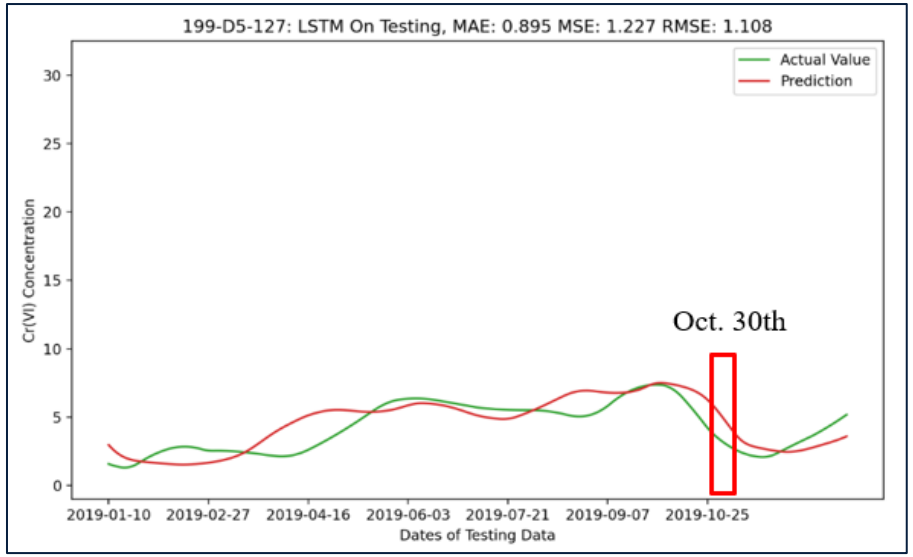
# Subtask 7.3: Algorithm Development for Spatiotemporal Relationship Identification

## FIU Year 3 Research Highlights:

- The contribution balance at a given date helped to explain the prediction trend (tangent) at the same date.
- As an example, results shown on the right, depicts:
  - Change in concentration over time (for target well 199-D5-127).
  - Spatial-temporal visualization around the date interval exhibiting prediction trend.
- As far as the model is concerned, the change in concentration on October 30th is majority-caused by negatively contributing wells 199-D4-95, 199-D4-85, and 199-D4-99.




| Tail Well Name | Tail Contribution | Head Well Name | Head Contribution |
|---|---|---|---|
| 199-D4-95 | -0.05234 | 199-D8-53 | 0.00783 |
| 199-D4-85 | -0.02784 | 699-98-49A | 0.00686 |
| 199-D4-99 | -0.01691 | 199-D3-5 | 0.0064 |
| 199-D5-101 | -0.01006 | 199-D7-3 | 0.00319 |
| 199-D5-32 | -0.00611 | 199-D2-11 | 0.00218 |



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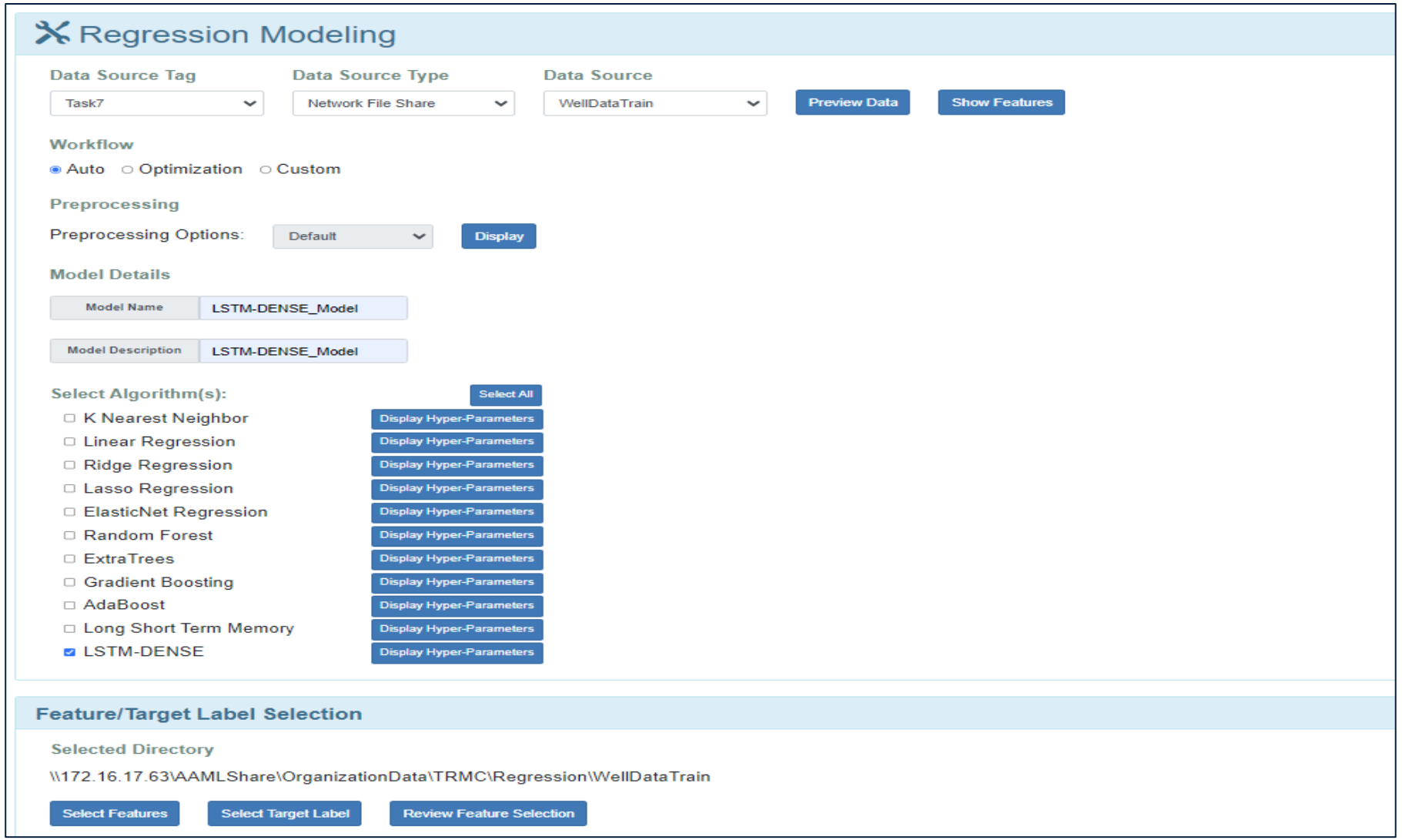
# Subtask 7.4: Publishing AI/ML models on AAML System (NEW)

## FIU Year 3 Research Highlights:




**AAMLS - Model Building**

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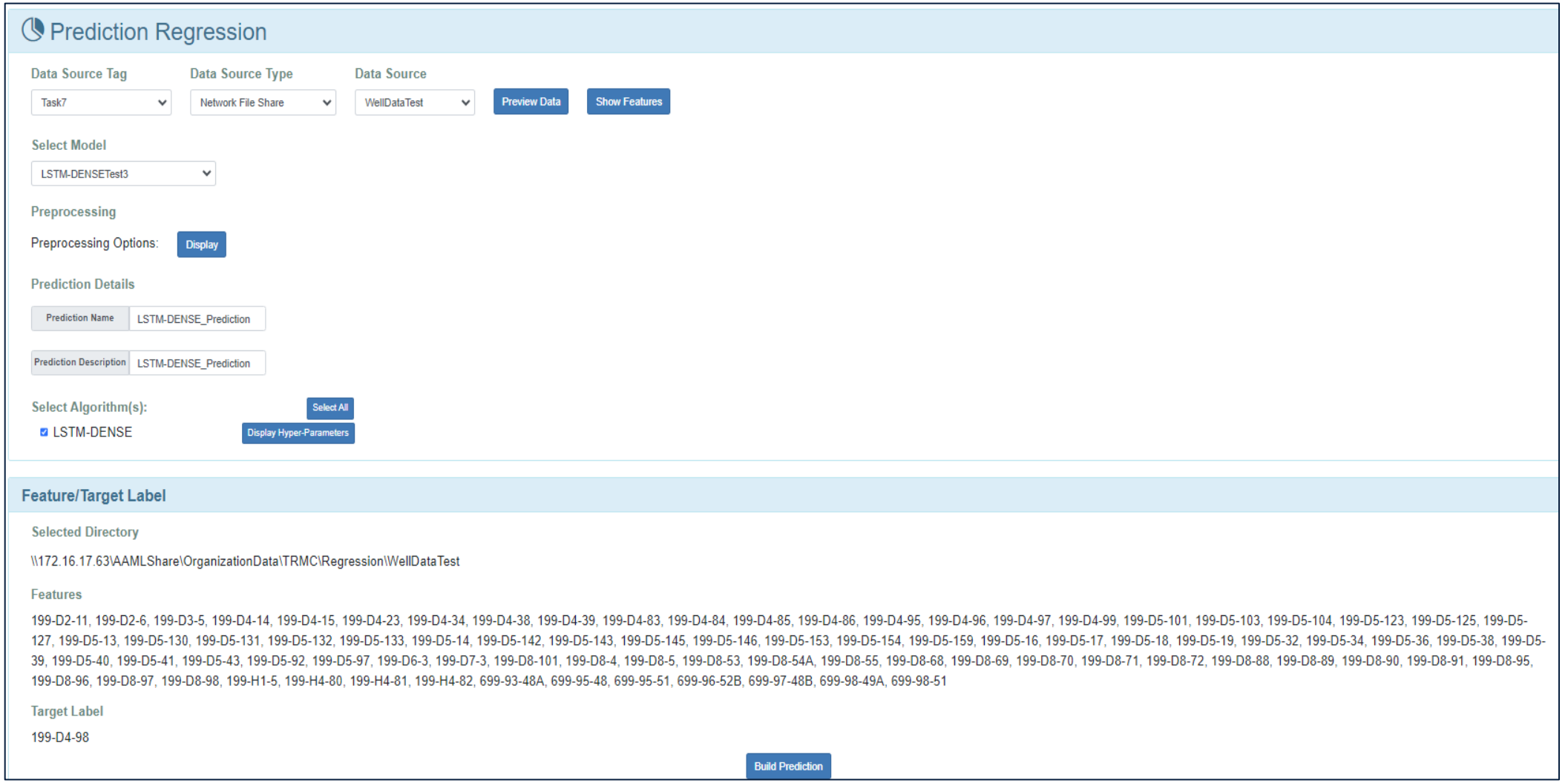
# Subtask 7.4: Publishing AI/ML models on AAML System (NEW)

## FIU Year 3 Research Highlights:




**AAMLS - Prediction**

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# Subtask 7.4: Publishing AI/ML models on AAML System (NEW)

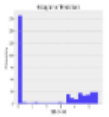
## FIU Year 3 Research Highlights:

### Predictions

Data Source Tag: Task7 | Data Source Type: Network File Share | ML Problem: Regression | View Predictions | OR | Search Prediction | Search Predictions

| | Test Name | Description | Preprocessing | Status | Username | Label(s) | Inserted On | |
|---|---|---|---|---|---|---|---|---|
| View Features / View Results | Test9 | Prediction | Show Options | Completed | TRMCAdmin | 199-D4-98 | 5/31/2023 8:28:42 PM | Delete |
| View Features / View Results | Test8 | Prediction | Show Options | Completed | TRMCAdmin | 199-D4-98 | 5/31/2023 8:22:35 PM | Delete |
| View Features / View Results | Test5 | Prediction | Show Options | Completed | TRMCAdmin | 199-D4-98 | 5/31/2023 8:16:16 PM | Delete |
| View Features / View Results | Task7WellData_Prediction | Prediction | Show Options | Completed | TRMCAdmin | 199-D4-98 | 5/31/2023 8:04:15 PM | Delete |
| View Features / View Results | Predtest | Prediction | Show Options | Completed | TRMCAdmin | 199-D4-98 | 5/31/2023 7:55:16 PM | Delete |
| View Features / View Results | Test4 | Prediction | Show Options | Completed | TRMCAdmin | 199-D4-98 | 5/31/2023 5:17:52 PM | Delete |
| View Features / View Results | Test3 | Regression | Show Options | Completed | TRMCAdmin | 199-D4-98 | 5/31/2023 5:06:03 PM | Delete |
| View Features / View Results | Test2 | Prediction | Show Options | Completed | TRMCAdmin | 199-D4-98 | 5/31/2023 4:39:42 PM | Delete |
| View Features / View Results | Auto_WellPred | Regression | Show Options | InProgress | TRMCAdmin | 199-D4-98 | 5/31/2023 2:03:36 PM | Delete |

### Prediction Results

| Test Result | Algorithm Name | Hyper-Parameters | Algorithm Group | Status | Frequency | TimePlot |
|---|---|---|---|---|---|---|
| View Test Result | LSTM-DENSE | View Parameters | Regression | Success |  |  |

**AAMLS - Manage Prediction**

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# Task 7: AI for EM Problem Set (Soil & GW): Exploratory Data Analysis and Machine Learning Model for Hexavalent Chromium [Cr (VI)] Concentration in 100-H Area

## FIU Year 4 Projected Scope

- Achieve more consistent accurate prediction performance with current pipeline with the inclusion of more well characteristics other than contaminant concentration.
- Other well characteristics from the sensor data such as specific conductance and/or Ph of water will be explored. Characteristics could also include spatial coordinates of the well and/or water depth level for indication or river stage.
- This work would involve pre-processing features from simple values into vector representations, the addition of another dimension to  input data.
- Explore the use of generative models to create a pipeline that can predict contaminant concentration at a given coordinate point, as opposed to a well.
- These algorithms would include Generative Adversarial Networks (GANs), Variational Autoencoders (VAEs), and SMOTER (Synthetic Minority Over-sampling Technique for Regression).
- Continue to deploy the implemented models on the AAML System.
    - Deep Learning Models will be deployed on the AAML System for automating the contaminant concentration predictions.

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# Task 8

**AI for EM Problem Set (Soil and Groundwater)**

- Data analysis and visualization of sensor data from the wells at the SRS F-Area using machine learning (LBNL, SRNL)

# Task 8: AI for EM Problem Set (Soil & GW):Data analysis and visualization of sensor data from the wells at the SRS F-Area using machine learning

**Subtask 8.6** Publishing AI/ML models on AAML System (NEW)

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# Task 8: AI for EM Problem Set (Soil and Groundwater) - Data analysis and visualization of sensor data from the wells at the SRS F-Area using machine learning (LBNL, SRNL)

## Site Needs:

- Develop machine learning tools to automate the monitoring and forecasting of contaminant transport dynamics at the Savannah River Site (SRS) F-Area to support DOE-EM's goal for long time monitoring of contaminated groundwater sites.

## Objectives:

- Develop data exploration tools for understanding the spatial and temporal distribution of the F-Area dataset.
- Develop a spatial interpolation approach for estimating a plume.
- Examine proxy variables at the site.
- Development of the AI/ML based system to perform predictive analytics.

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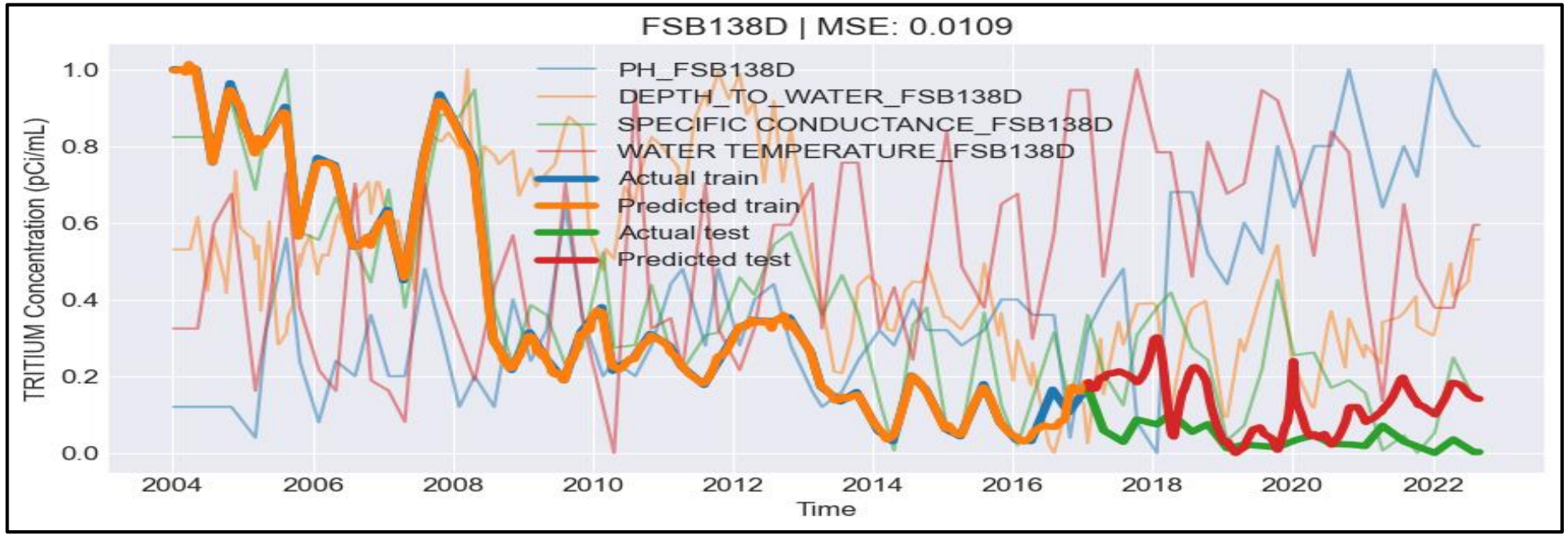
# Subtask 8.6: Publishing AI/ML models on AAML System (NEW)

## Research Highlights & Accomplishments:

- Developed Deep Learning based LSTM model for predicting contaminant concentrations. The following four insitu variables are used as feature vectors: (pH, specific conductance, water temperature and water table).
- Below Figure demonstrate the predictive capability of the model for FSB138D well. Thin lines shows the input variables whereas the thick line shows the target predictor tritium.



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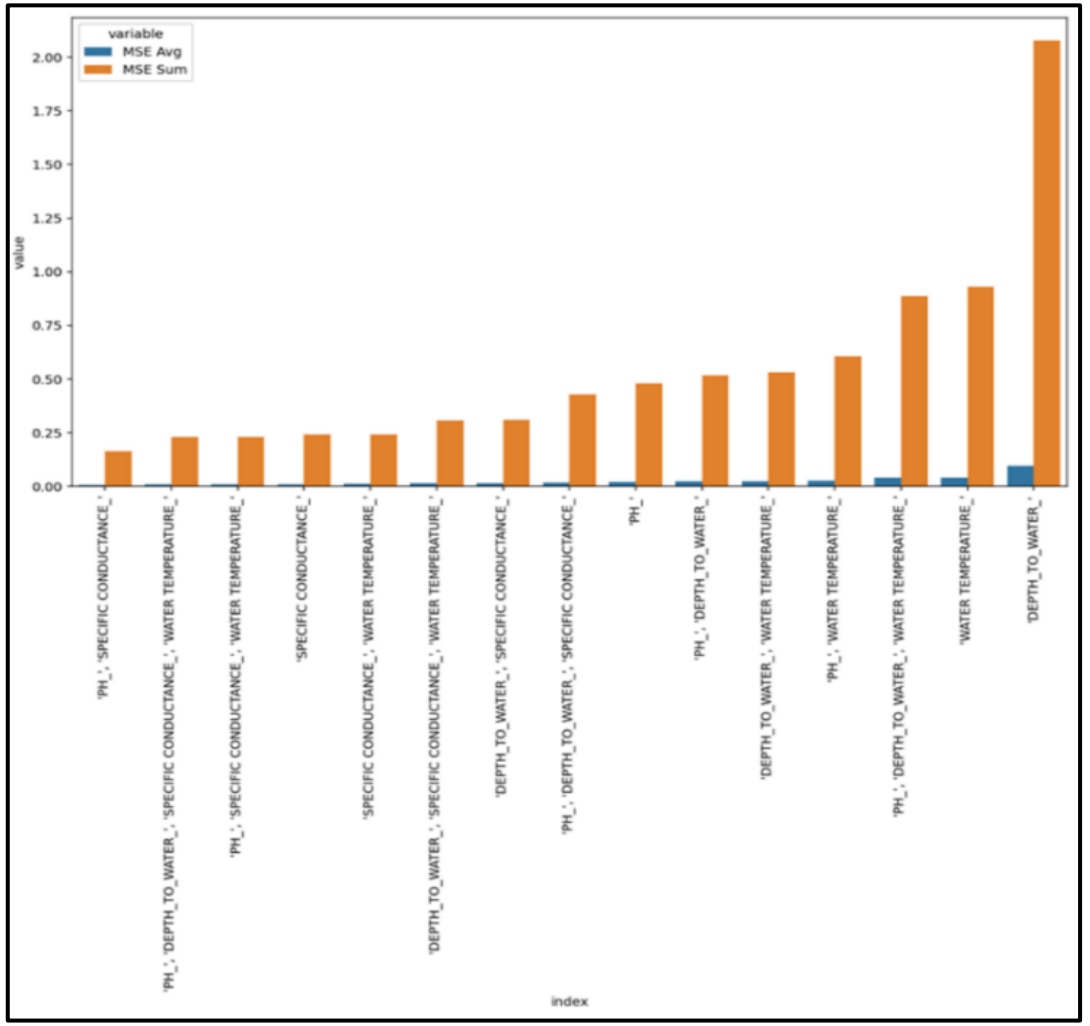
# Subtask 8.6: Publishing AI/ML models on AAML System (NEW)

## Research Highlights & Accomplishments:

- To test the importance of each input variable on the output prediction, FIU team developed a model on the powerset of the 4 input parameters.
- To compare the performance of each experiment, the MSE of all 22 well predictions was aggregated using both the average and sum, although these two metrics show the same trend.
- From this analysis, specific conductance is shown to be the most important individual input to the model as it appears in the top 7 of the 15 experiments.
- The results are as shown in the graph mentioned in the right side.



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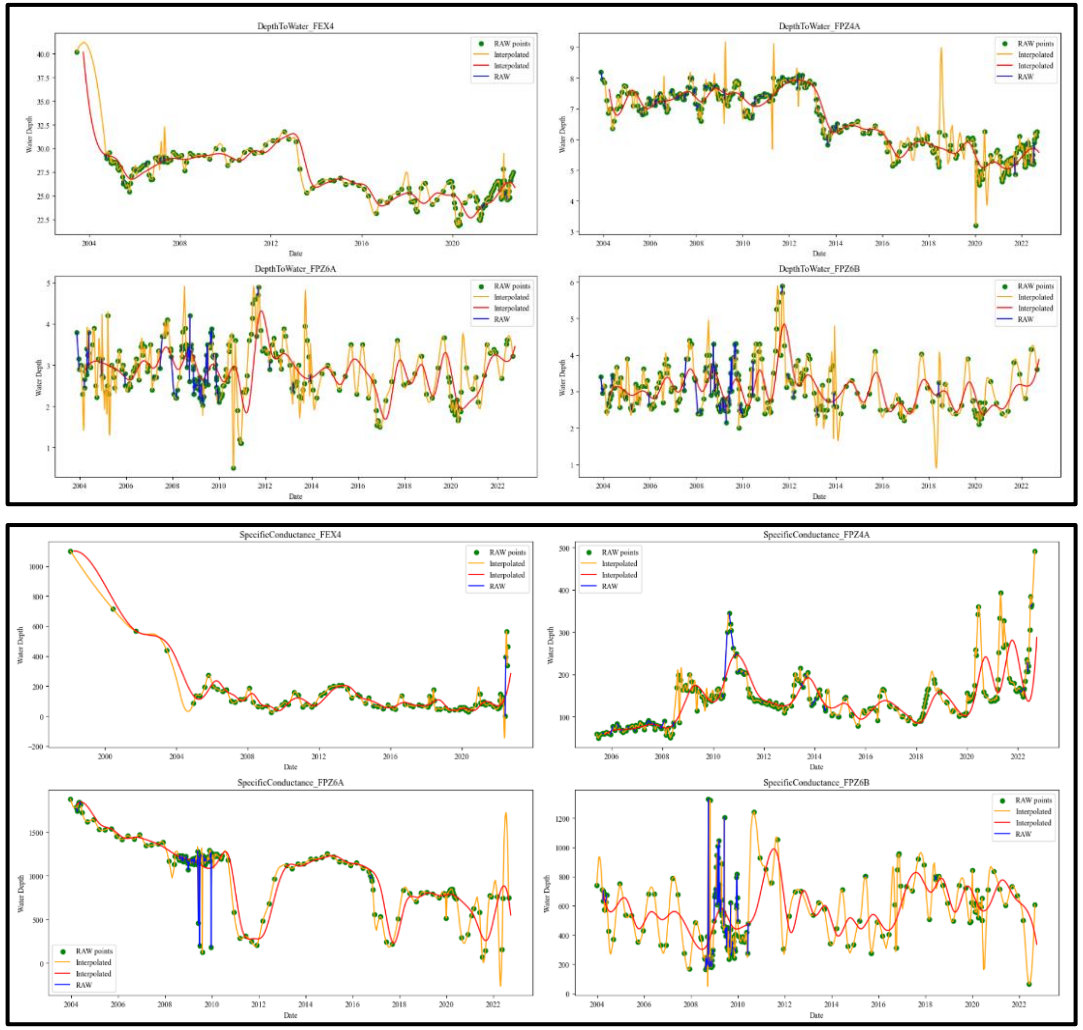
# Subtask 8.6: Publishing AI/ML models on AAML System (NEW)

## Research Highlights & Accomplishments:

- A pilot Python Script for Downloading In-Situ Data from HydroVu API as developed.
- The Python script carries out three primary functions to retrieve data from the HydroVu API and store it in the FIU-ALTEMISAI database.
- This script uses pyodbc to connect to a database and retrieve the last recorded time step for each well. It then fetches data from the HydroVu API, saves it to a temporary folder, and formats it into a master_json list.
- Finally, it inserts the data from the master_json list into the FIU-ALTEMISAI database using an SQL INSERT statement and commits the changes. Figure shows samples time series for Depth to Water and Specific Conductance.



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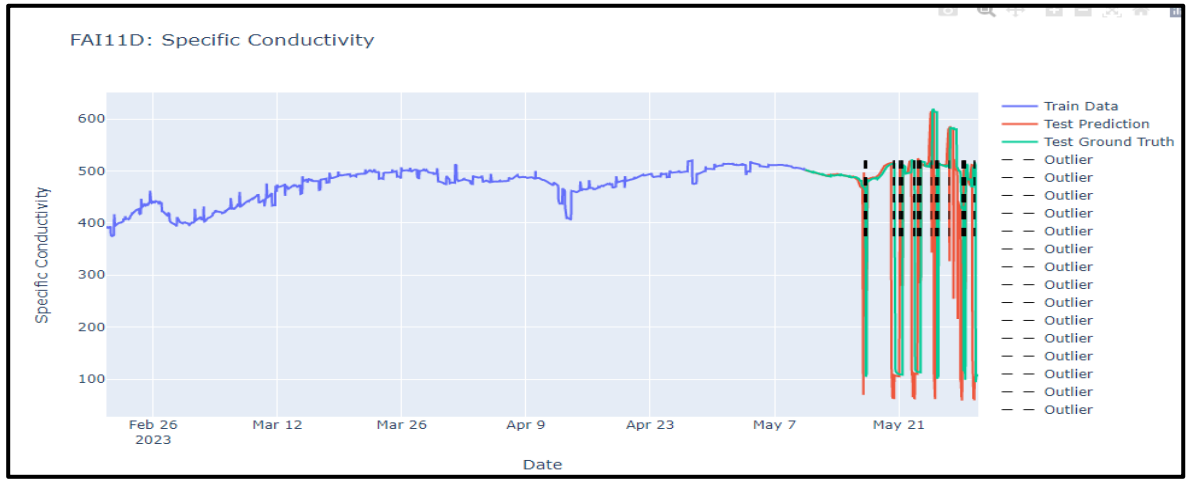
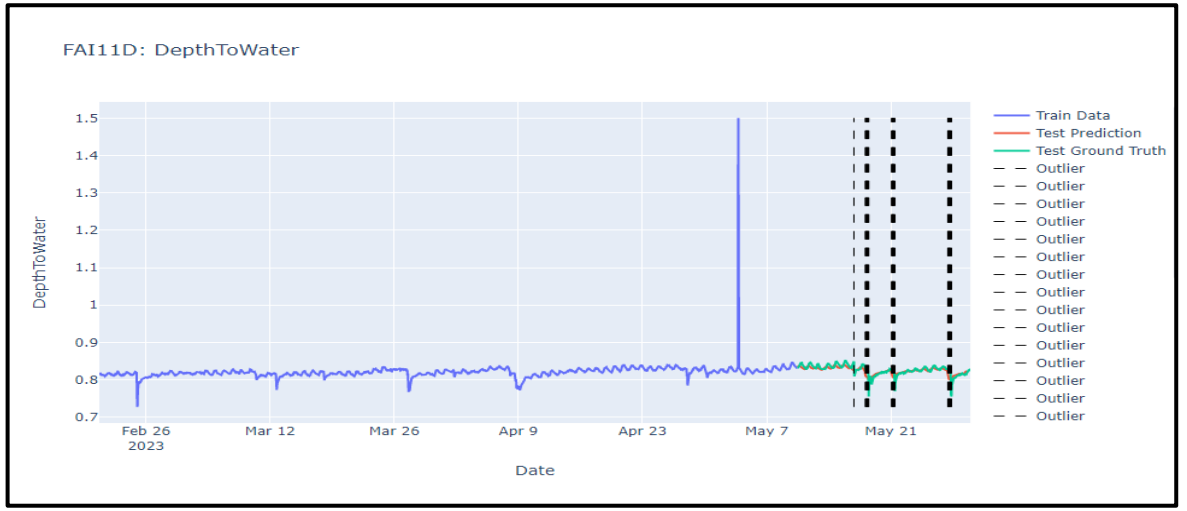
# Subtask 8.6: Publishing AI/ML models on AAML System (NEW)

## Research Highlights & Accomplishments:

- Figure shows the visual representation of the time series data for Specific Conductivity and DepthToWater respectively, along with the LSTM model's predictions and the detection of outliers.
- The red line represents the LSTM model's predictions for the Specific Conductivity values during the testing phase.
- The black dotted line in the figure represents the outliers.



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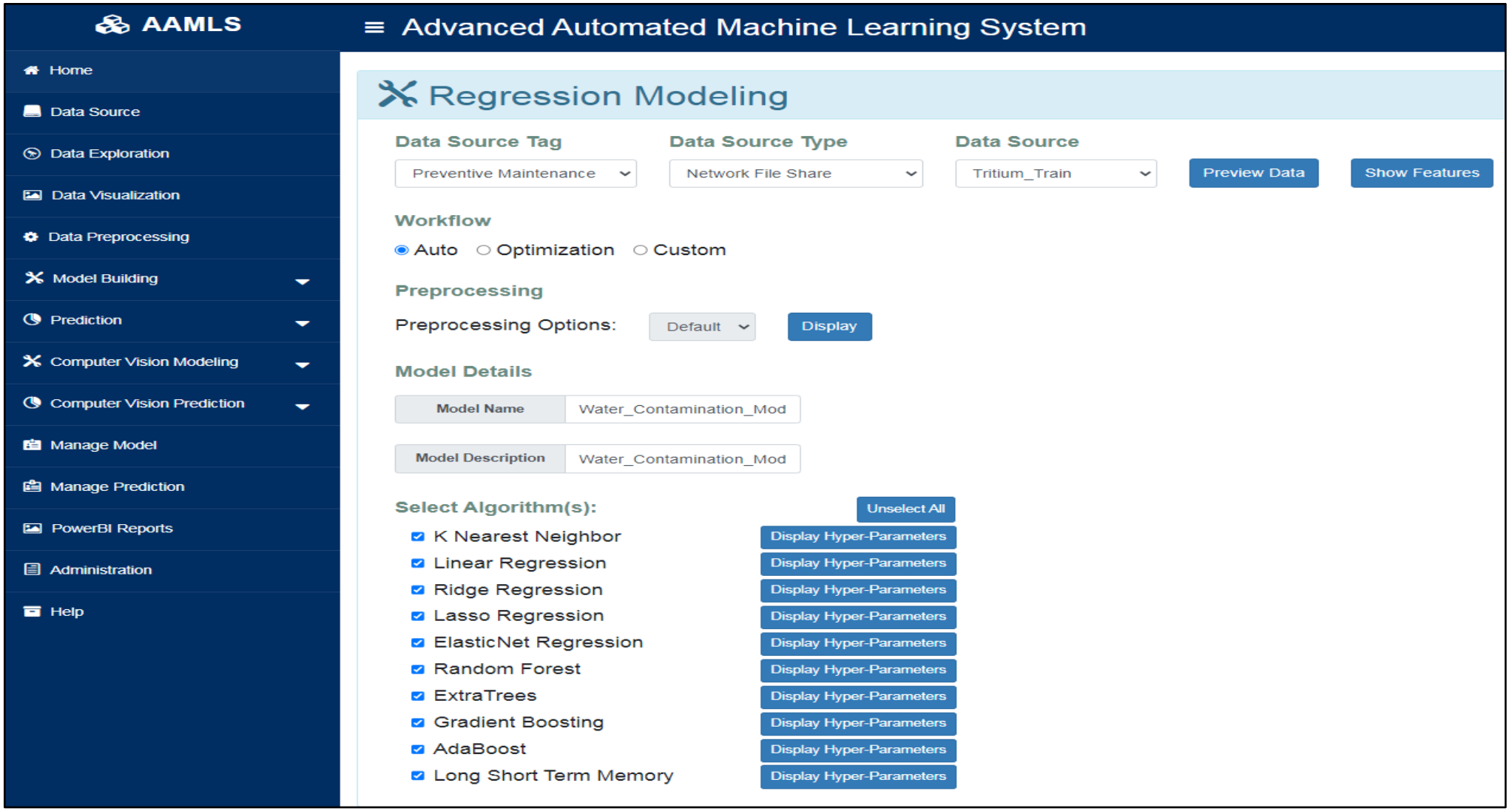
# Subtask 8.6: Publishing AI/ML models on AAML System (NEW)

## Research Highlights & Accomplishments:




**AAMLS - Model Building**

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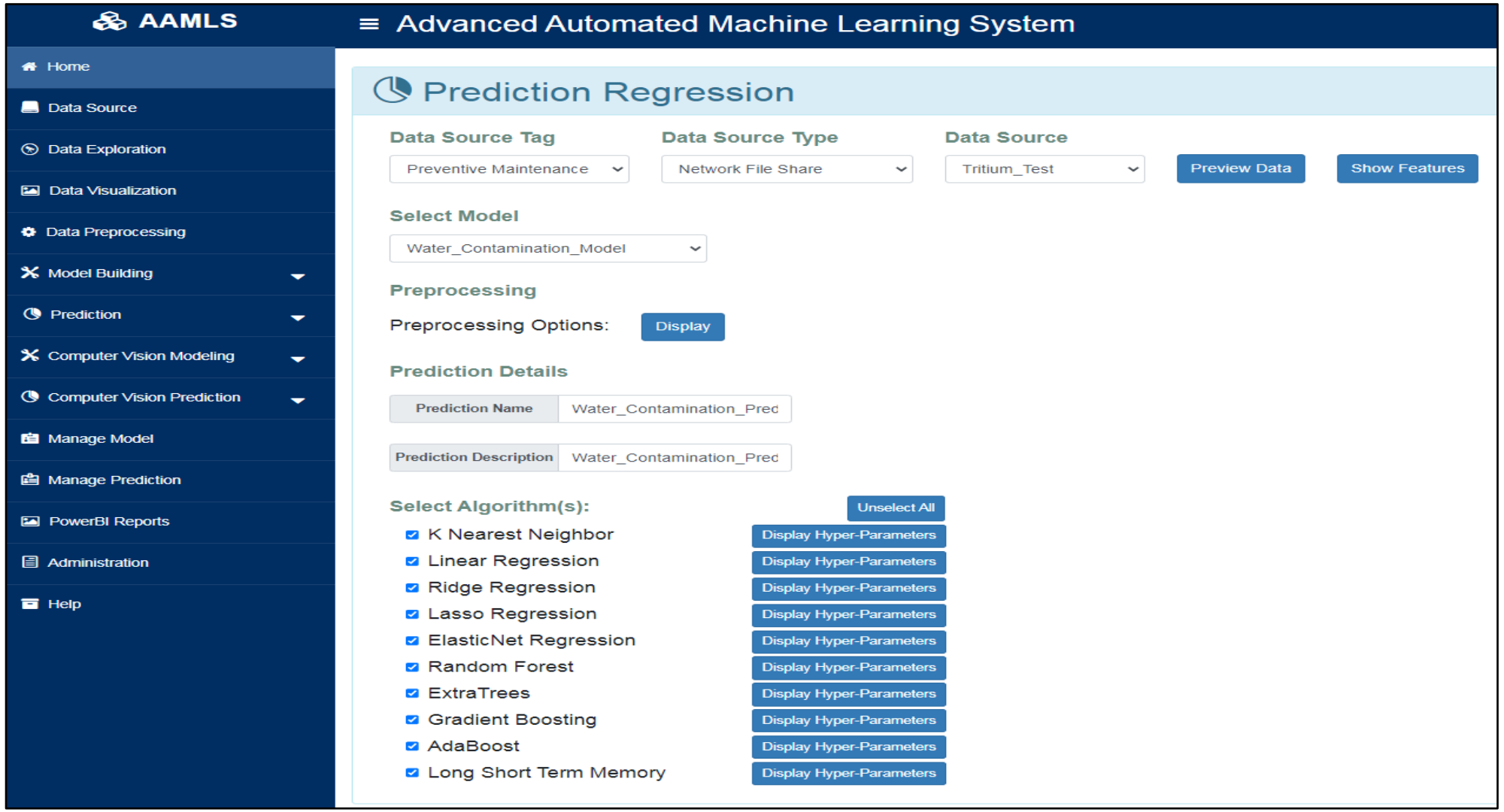
# Subtask 8.6: Publishing AI/ML models on AAML System (NEW)

## Research Highlights & Accomplishments:




**AAMLS - Prediction**

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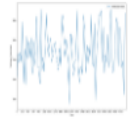
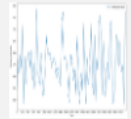
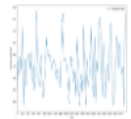
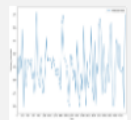
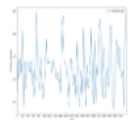
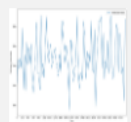
# Subtask 8.6: Publishing AI/ML models on AAML System (NEW)

## Research Highlights & Accomplishments:

Prediction Results

| Test Result | Algorithm Name | Hyper-Parameters | Algorithm Group | Status | Frequency | TimePlot |
|---|---|---|---|---|---|---|
| View Test Result | K Nearest Neighbor | View Parameters | Regression | Success |  |  |
| View Test Result | Linear Regression | View Parameters | Regression | Success |  |  |
| View Test Result | Ridge Regression | View Parameters | Regression | Success |  |  |
| View Test Result | Lasso Regression | View Parameters | Regression | Success |  |  |
| View Test Result | ElasticNet Regression | View Parameters | Regression | Success |  |  |
| View Test Result | Random Forest | View Parameters | Regression | Success |  |  |

**AAMLS - Prediction Results**

# FIU Year 4 Projected Scope

- Research and implement advanced deep learning models for time series data:
  - Develop a transformer model for learning temporal and spatial features from in-situ real-time sensor data of various analytes from the SRS site. The model's self-attention mechanism can assign significance to different sensor readings, capturing short-term fluctuations and long-term dependencies. This empowers the model to discern temporal dynamics, detect patterns, trends, and anomalies in real-time sensor data.
  - Develop an AutoEncoder model for effectively capturing both temporal and spatial dependencies of various analytes from the SRS site. The model is trained to reconstruct normal sensor data, effectively learning a compressed representation of the input. This approach holds promise for anomaly detection in real-time sensor data, providing a valuable research for early warning systems, fault detection, and maintenance optimization.
- Continue to deploy the implemented models on the AAML System.
  - Deep Learning Models will be deployed on the AAML System for automating the contaminant concentration predictions.

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# Task 9

## AI for EM Problem Set (Waste Processing):

### Nuclear Waste Identification and Classification using Deep learning (SRNL)

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# Task 9 - AI for EM Problem Set (Waste Processing): Nuclear Waste Identification and Classification using Deep learning

| | |
|---|---|
| **Subtask 9.1** | Algorithm & Model Development to Identify and Classify Nuclear Waste |
| **Subtask 9.2** | Transition Previously Trained Deep Learning Models to the Advance Automated Machine Learning (AAML) System |

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# Task 9 - AI for EM Problem Set (Waste Processing): Nuclear Waste Identification and Classification using Deep learning

## Site Needs:

- To understand and identify the presence of nuclear waste within multiple, different, environments in real time.
- Be able efficiently develop and use deep learning models to facilitate any operation that requires computer vision.

## Objectives:

- Research and explore the development of different deep learning solutions.
  - There are different algorithms that aim to solve the problem, each with their own advantages and disadvantages.
- Deploy developed models  for the integration with ROS2 code.
  - Once the models identify and classify an object, it might be of interest to forward those results to a robot or a similar system.
- Deploy developed models on the AAML System.

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# Subtask 9.1: Algorithm and Model Development to Identify and Classify Nuclear Waste (NEW)

## FIU Year 3 Research Highlights:

- **Implemented YOLOv7 model for Object Detection.**
  - The model is designed to detect objects in real time using a CPU.
  - For a given object, the model predicts the object's class, bounding box, and its confidence on the prediction.
  - It reaches a high mAP on the test set. The shortcoming of this algorithmic method is that it requires labeled data to learn how to detect objects, since it learns from bounding box. It is difficult to learn how to detect thin and/or long objects where the background is most of the box.


**Example of the predictions results for a given image**

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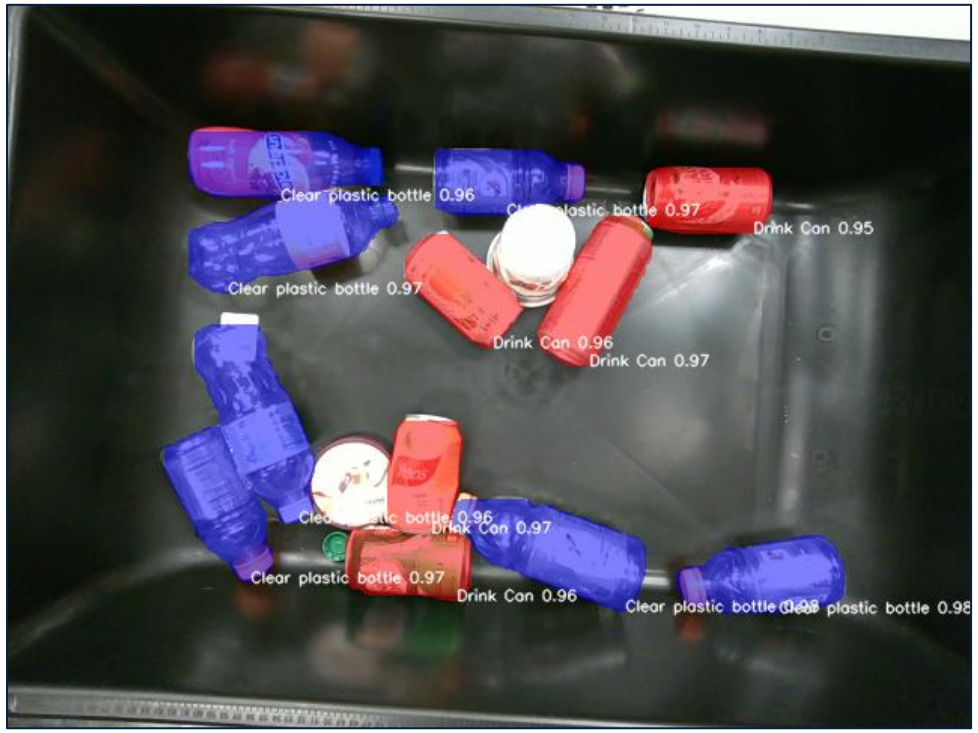
# Subtask 9.1: Algorithm and Model Development to Identify and Classify Nuclear Waste (NEW)

## FIU Year 3 Research Highlights:

- **Implemented YOLOv7 model for Instance Segmentation.**
  - The model is designed to detect objects in real time using a CPU, though it is slower than the Object Detection version.
  - For a given object, the model predicts the object's class, segmentation mask, and its confidence on the prediction.
  - The shortcomings of this model is that it requires labeled data to learn how to detect objects and it can detect thin and/or long objects better than the previous version.




**Example of the predictions results for a given image**

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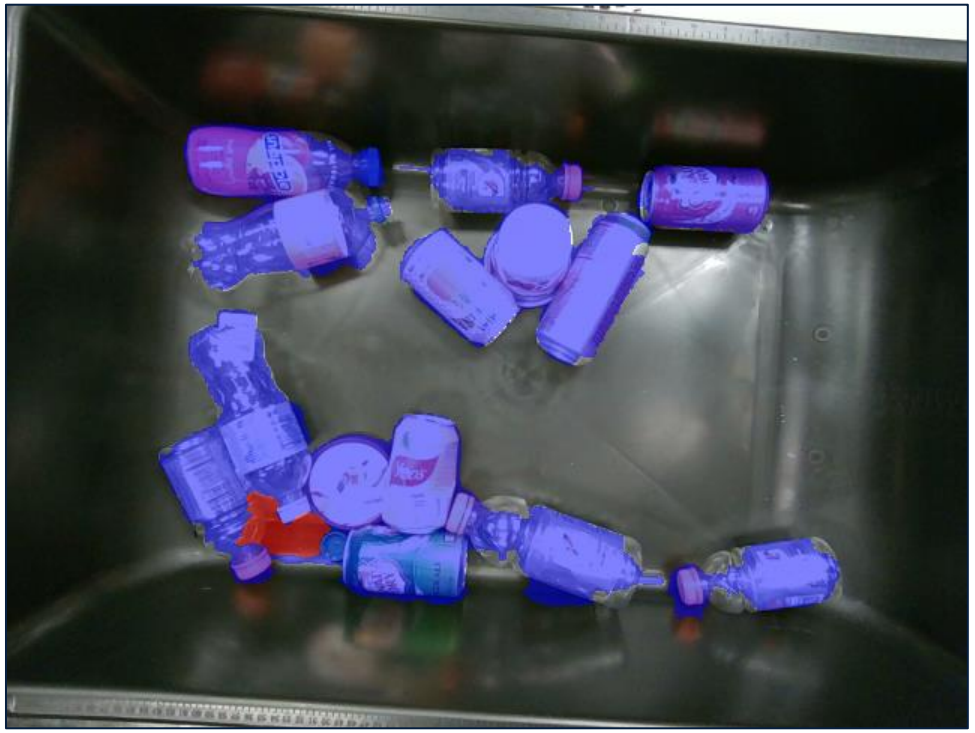
# Subtask 9.1: Algorithm and Model Development to Identify and Classify Nuclear Waste (NEW)

## FIU Year 3 Research Highlights:

- **Implemented STEGO model for Unsupervised Semantic Segmentation.**
  - The model is not designed to detect objects in real time using a CPU. However, by keeping a sufficiently small image size, it is possible to reach real-time inference speeds.
  - For a given image, the model predicts a set of clusters and the segmentation mask for each cluster.
  - It does not require labeled data to learn how to detect the clusters.
  - Sometimes it is unfeasible to convert the cluster masks into a polygon format because a cluster can contain one or more objects.



**Example of the predictions results for a given image where blue marks the object and red marks empty space within the object.**

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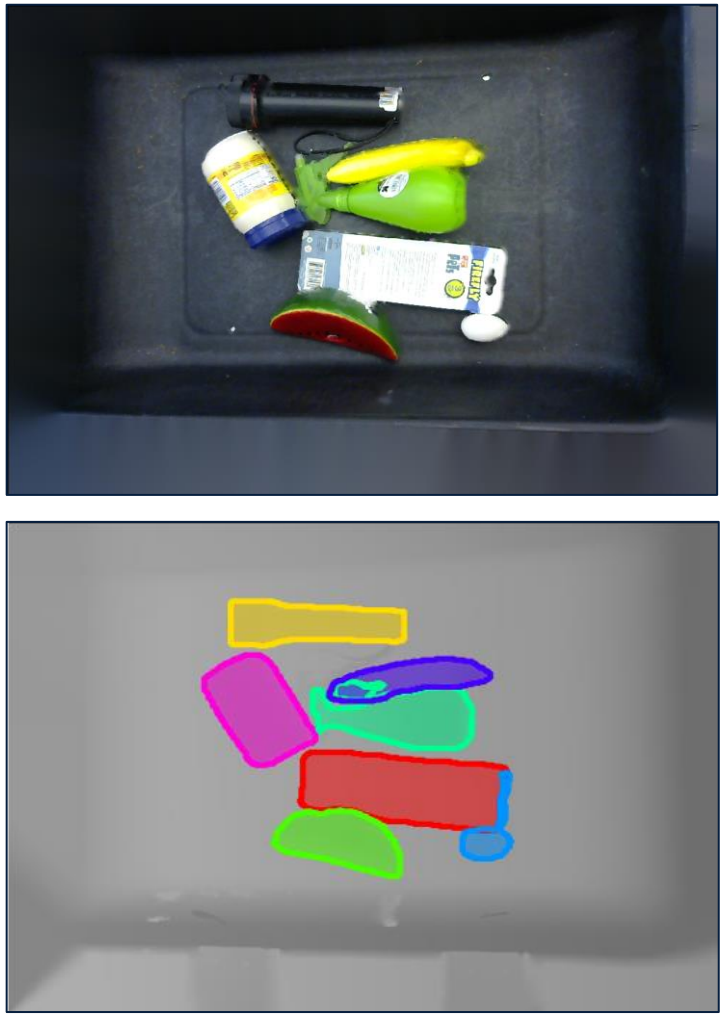
# Subtask 9.1: Algorithm and Model Development to Identify and Classify Nuclear Waste (NEW)

## FIU Year 3 Research Highlights:

- **Implemented Mask RCNN model for Disparity Image Segmentation.**
  - This model is not designed to detect objects in real time using a CPU. However, by keeping a sufficiently small image size, it is possible to reach real-time inference speeds.
  - For a given disparity image, the model predicts an object's segmentation mask and its confidence that it is a foreground object.
  - It does not require labeled data to learn how to detect the clusters. But it can only detect foreground vs background objects.
  - Predictions are not accurate for the nested objects.



**Example of the predictions results for a given disparity image. The top image is used for comparison purposes only.**

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# Subtask 9.2: Transition Previously Trained Deep Learning Models to the Advance Automated Machine Learning (AAML) System (NEW)

## FIU Year 3 Research Highlights:

- **Implemented Anomaly Detection Models (Wall Crack Detection).**
  - Added a custom model with good performance on detecting cracks on walls.
  - Implemented the ability to customize the models with different number of layers, activation functions, etc., to enhance the performance of the model on new data.
- **Implemented Object Detection Models.**
  - Added YOLOv3 model that has high performance and low latency when predicting.
  - Implemented the ability to customize the model's confidence and IoU thresholds. Also implemented transfer learning to reduce training time while maintaining a high performance.

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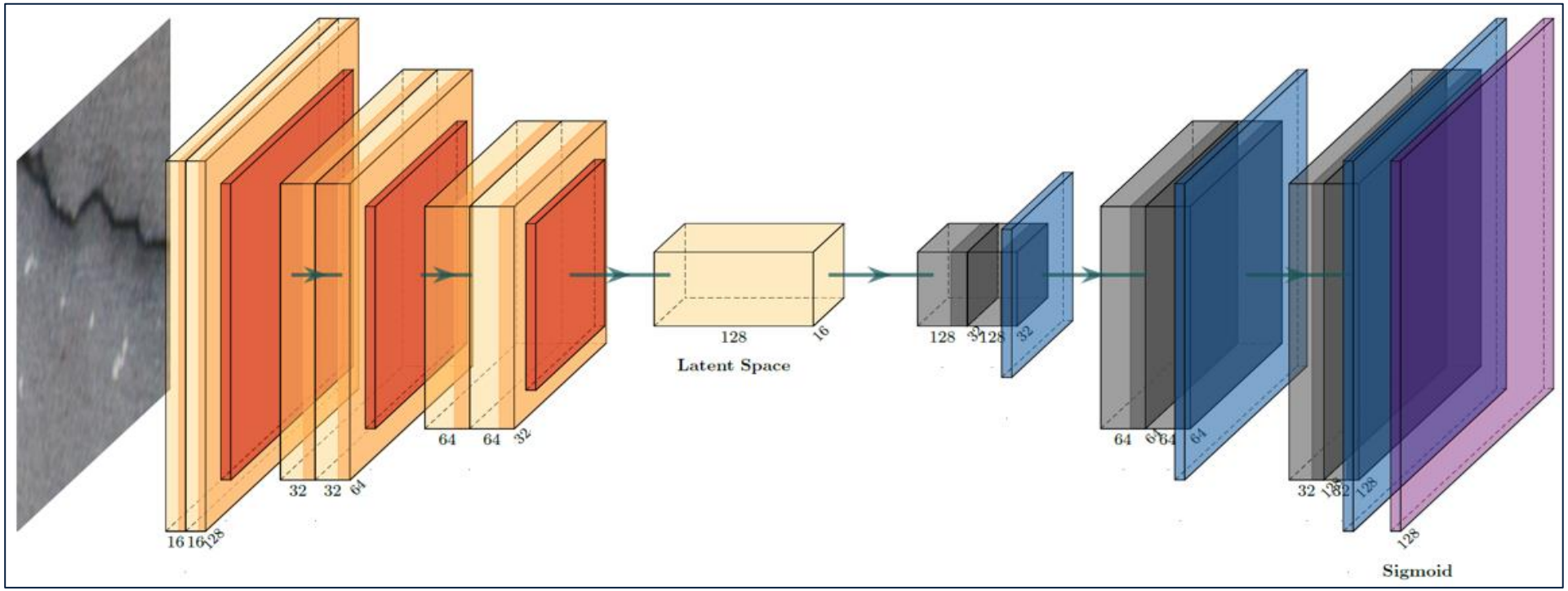
# Subtask 9.2: Transition Previously Trained Deep Learning Models to the Advance Automated Machine Learning (AAML) System (NEW)

## FIU Year 3 Research Highlights:

- The models developed as part of the Task 6 in the previous year (2022) are deployed on the AAML System.




**Convolutional AutoEncoder (CAE) Deep Learning Architecture**

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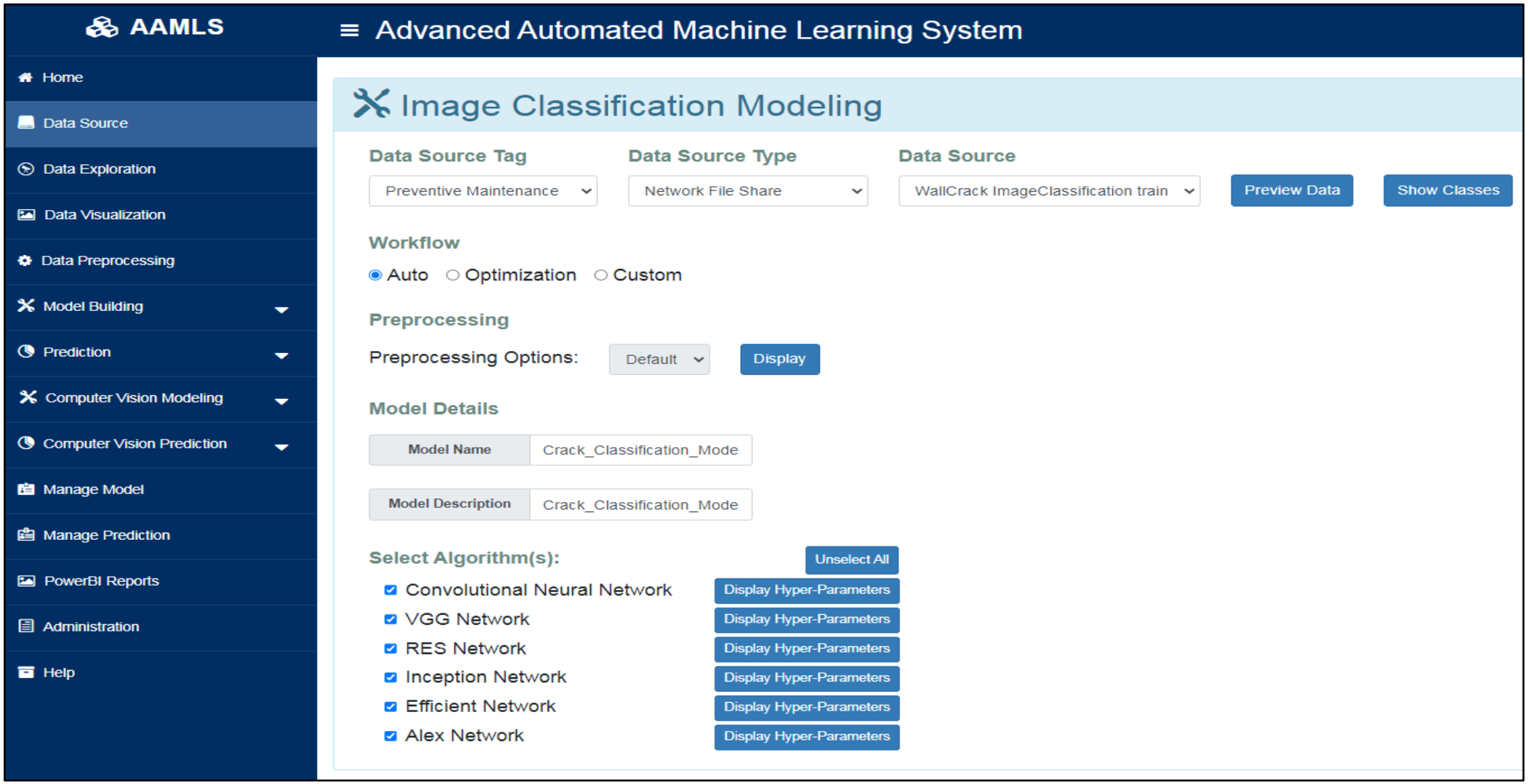
# Subtask 9.2: Transition Previously Trained Deep Learning Models to the Advance Automated Machine Learning (AAML) System (NEW)

## FIU Year 3 Research Highlights:




**AAMLS - Computer Vision Modeling - Classification**

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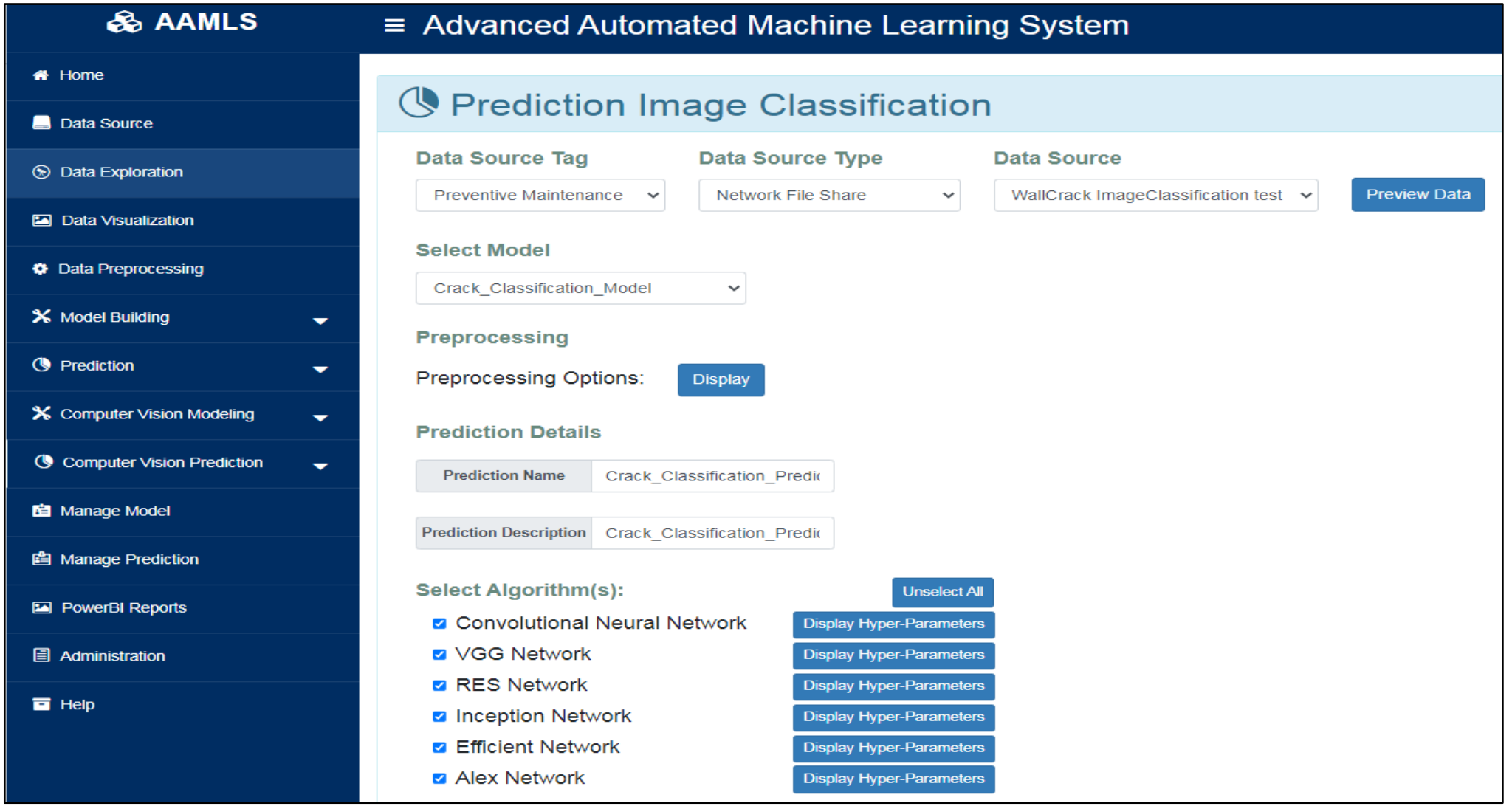
# Subtask 9.2: Transition Previously Trained Deep Learning Models to the Advance Automated Machine Learning (AAML) System (NEW)

## FIU Year 3 Research Highlights:




AAMLS - Computer Vision Prediction - Classification

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# Subtask 9.2: Transition Previously Trained Deep Learning Models to the Advance Automated Machine Learning (AAML) System (NEW)

## FIU Year 3 Research Highlights:

Prediction Results

| Test Result | Algorithm Name | Hyper-Parameters | Algorithm Group | Status | Distribution | Frequency |
|---|---|---|---|---|---|---|
| View Test Result | Convolutional Neural Network | View Parameters | Image Classification | Success | | |
| View Test Result | VGG Network | View Parameters | Image Classification | Success | | |
| View Test Result | RES Network | View Parameters | Image Classification | Success | | |
| View Test Result | Inception Network | View Parameters | Image Classification | Success | | |
| View Test Result | Efficient Network | View Parameters | Image Classification | Success | | |
| View Test Result | Alex Network | View Parameters | Image Classification | Success | | |

Algorithm Name: Convolutional Neural Network  Download Results

| Predicted | Filename | Image |
|---|---|---|
| CrackedWalls | data\00242.jpg | |
| SmoothWalls | data\00356.jpg | |
| CrackedWalls | data\00480.jpg | |

**AAMLS - Computer Vision Prediction Results – Classification**

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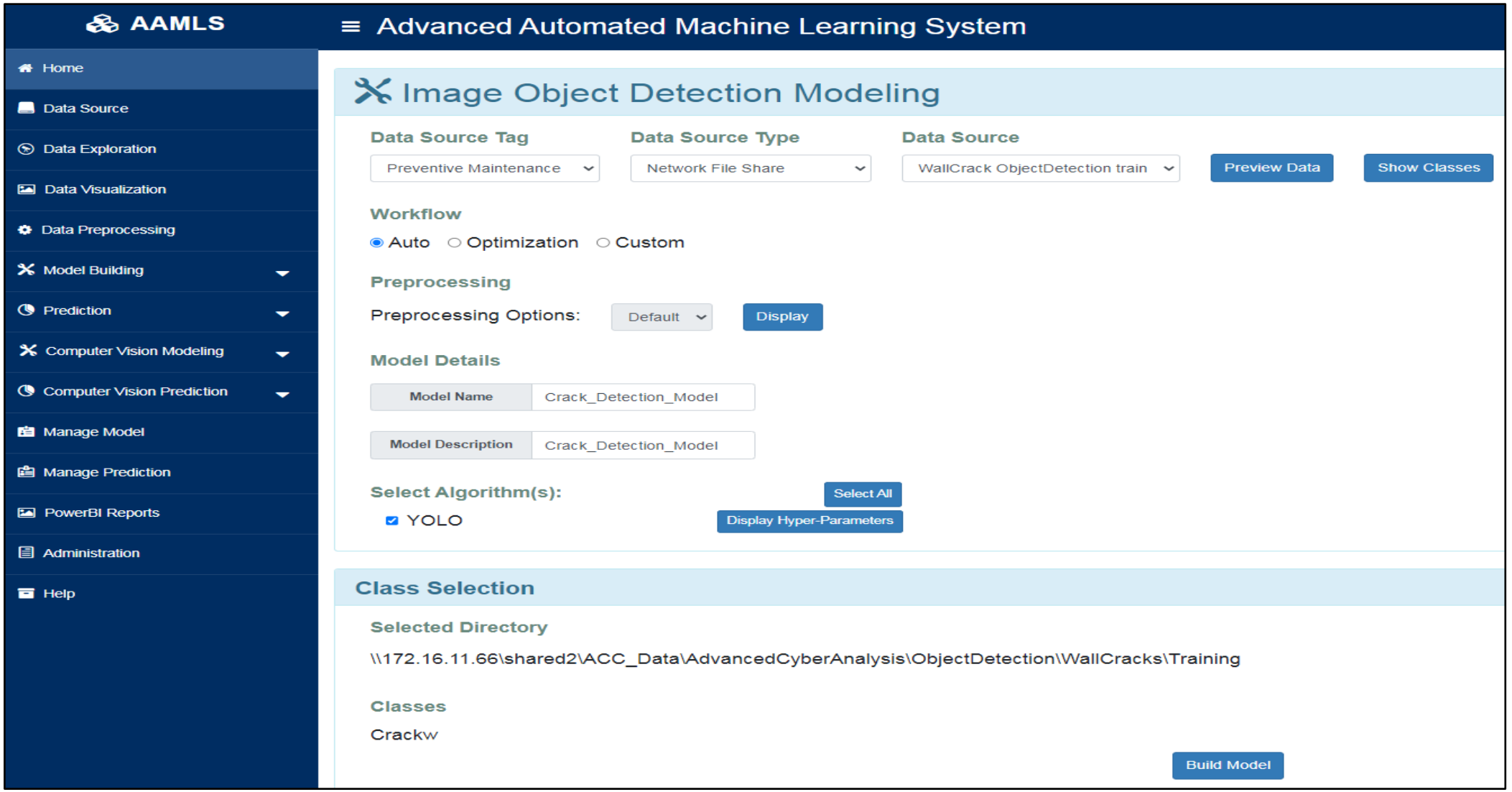
# Subtask 9.2: Transition Previously Trained Deep Learning Models to the Advance Automated Machine Learning (AAML) System (NEW)

## FIU Year 3 Research Highlights:




**AAMLS - Computer Vision Modeling - Object Detection**

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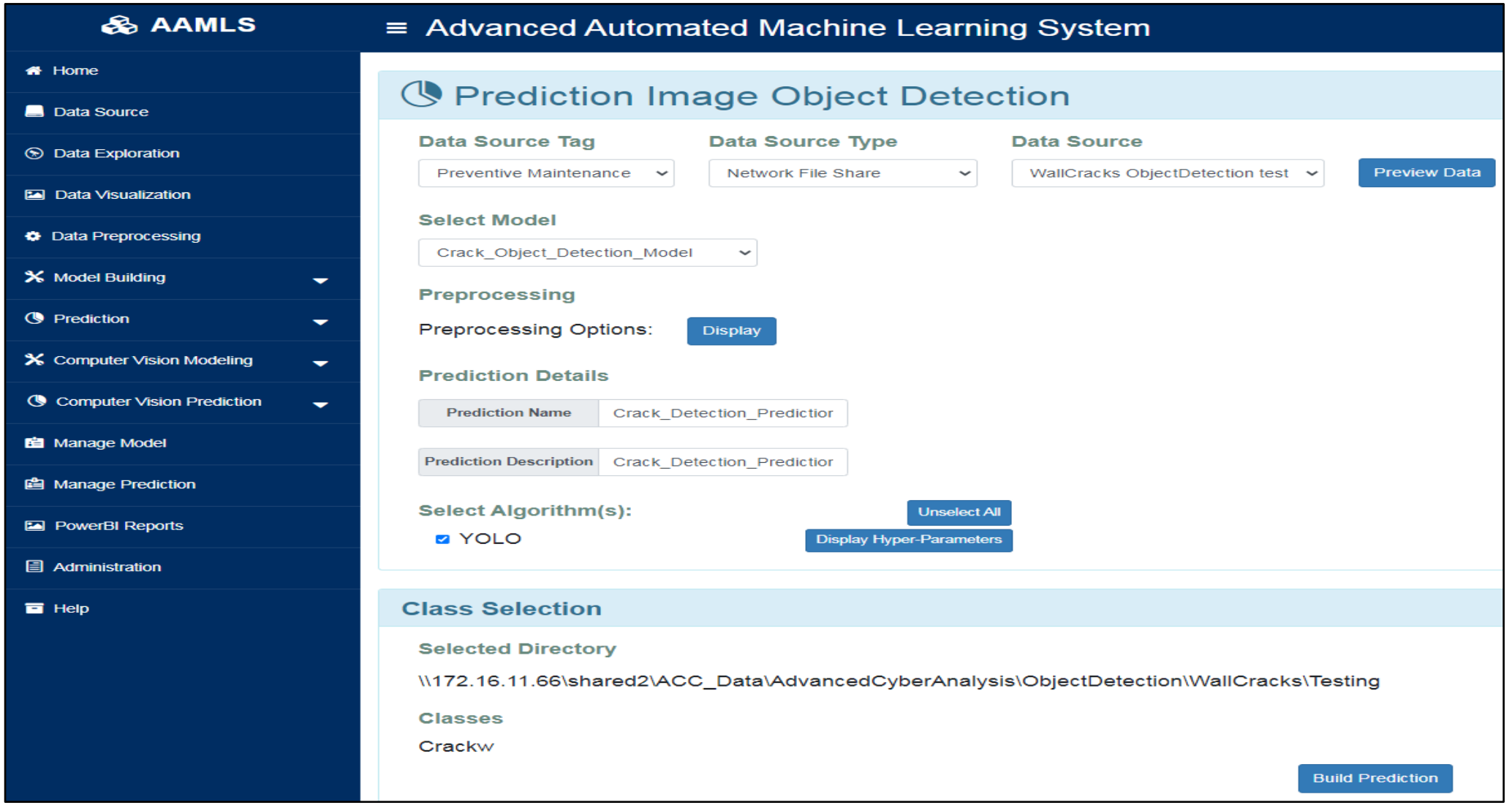
# Subtask 9.2: Transition Previously Trained Deep Learning Models to the Advance Automated Machine Learning (AAML) System (NEW)

## FIU Year 3 Research Highlights:




AAMLS - Computer Vision Prediction - Object Detection

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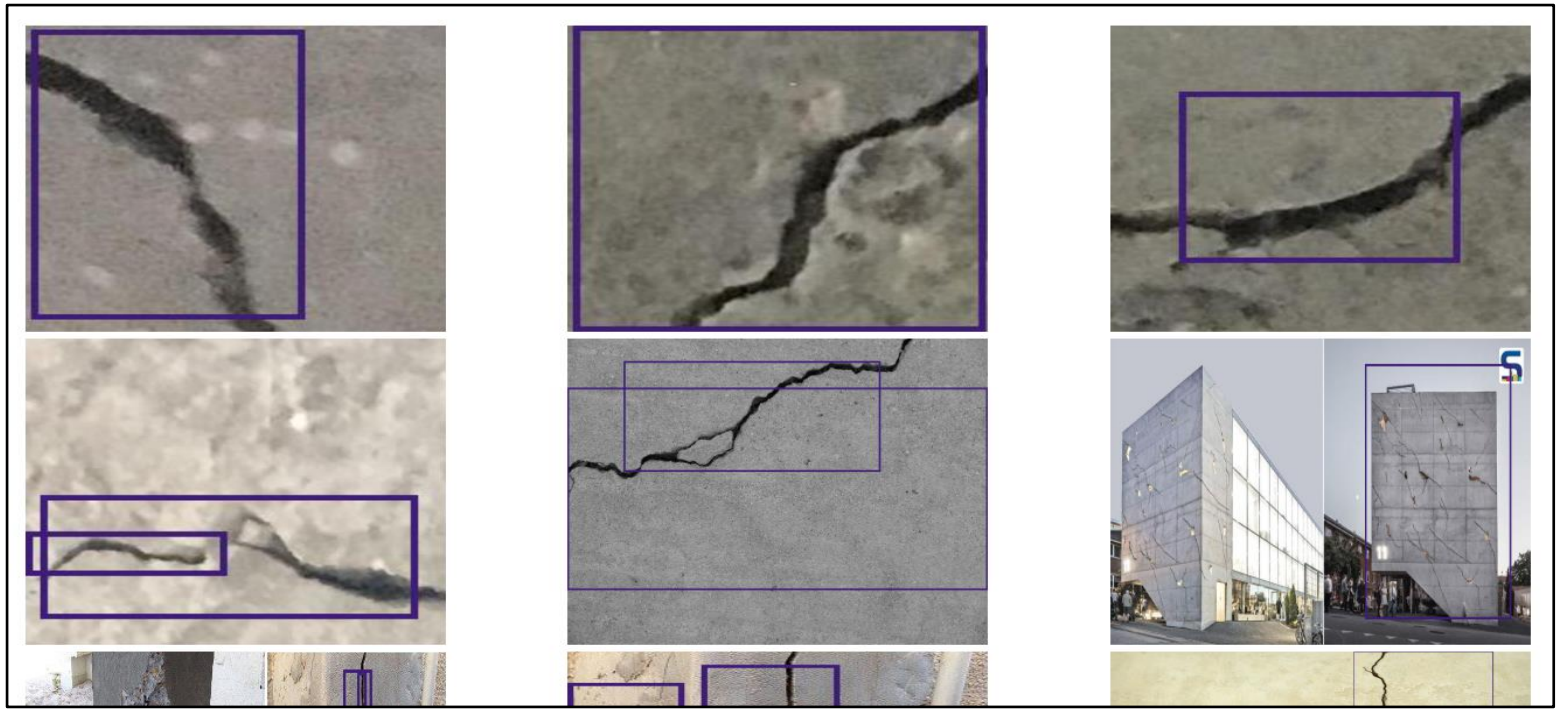
# Subtask 9.2: Transition Previously Trained Deep Learning Models to the Advance Automated Machine Learning (AAML) System (NEW)

## FIU Year 3 Research Highlights:

Prediction Results

| Test Result | Algorithm Name | Hyper-Parameters | Algorithm Group | Status |
|---|---|---|---|---|
| View Test Result | YOLO | View Parameters | Image Object Detection | Success |



**AAMLS - Computer Vision Prediction Results - Object Detection**

# Task 9 - AI for EM Problem Set (Waste Processing): Nuclear Waste Identification and Classification using Deep learning

## FIU Year 4 Projected Scope

- Research and implement an object detection algorithm with the following properties:
  - Does not require labeled data to learn to detect a new object.
  - Has the ability to choose which objects to detect, not just every foreground object.
  - Has real-time or close to real-time inference speeds.
- Continue to deploy the implemented models on the AAML System.

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# Awards & Recognition

## Accomplishments:

**February 28, 2023**

**ASME Best Oral Paper/Presentation Award at the WM2022 Conference, for Paper # 22045.**

“Mobile Platform for Structural Health Monitoring Using Convolutional Neural Network”.

Conference : **WM2023 Symposia, Pheonix, Arizona**

Team Members: **Himanshu Upadhyay, Santosh Joshi, Roger Boza, Leonel Lagos, Walter Quintero**

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# DOE EM IT/AI Deployment Roadmap

| | Technology | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|
| HQ All Sites |  WIMS | Site Deployment ✓ | | | | | |
| HQ, SRNL, ANL, PNNL |  KM-IT | Site Deployment ✓ | | | | | |
| PNNL | AI Soil & Ground Water | Data Exploration/ Visualization | Algorithm Development | Algorithm Optimization & Analysis | AI System Development & Integration | In-house Deployment | Site Deployment |
| LBNL, SRNL | AI Soil & Ground Water | Data Exploration & Visualization | Algorithm Development | Algorithm Optimization & Analysis | AI System Development & Integration | In-house Deployment | Site Deployment |
| SRNL | AI Waste Process | | | | Algorithm Development | Algorithm Optimization & Analysis | In-house Deployment |

# DOE EM IT/AI Deployment Roadmap

| | | |
|---|---|---|
| HQ<br>All Sites |  | WIMS |
| HQ, SRNL,<br>ANL, PNNL |  | KM-IT |
| PNNL | AI Soil & Ground Water | |
| LBNL,<br>SRNL | AI Soil & Ground Water | |
| SRNL | AI Waste Process | |

- WIMS - Web application deployed at https://emwims.org - Used by DOE sites, disposition facilities and DOE HQ
- KM-IT - Web application deployed at https://www.dndkm.org - Used by DOE sites/facilities, National Laboratories, DOE HQ and D&D community
- AI PNNL (Soil & Ground Water) - AI Models will be deployed on AAMLS to be used by PNNL
- AI SRNL (Soil & Ground Water) - AI Models will be deployed on AAMLS to be used by LBNL, SRNL
- AI Waste Process (SRNL) - Site deployment

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# DOE-FIU Cooperative Agreement

# Upcoming Events Announcement

# DOE Fellows Poster Exhibition

# DOE Fellows Induction Ceremony


Thank You. Questions?