SCHOOL OF ENERGY RESOURCES

Annual Report of the In-Situ Recovery of Uranium Research Program to The Joint Minerals, Business, and Economic Development Interim Committee

September 30, 2015

UNIVERSITY OF WYOMING

This Page Left Blank

Annual Report of the In-Situ Recovery of Uranium Research Program to the Joint Minerals, Business, and Economic Development Interim Committee September 30, 2015

This report provides a summary of the in-situ recovery of uranium (ISRU) research program for Fiscal Year 2015 (July 1, 2014 – June 30, 2015). It provides background on the ISRU program, status of funded research projects to date, and the balance of funds remaining in the program. By legislation, the ISRU research program had a sunset date of June 30, 2015; therefore, this is the final annual report for this program. All but $4,121.80 of the original $1.6 million program budget was spent and will revert back to the State of Wyoming.

Outcomes of the research projects funded by the ISRU program have proven beneficial to Wyoming's uranium mining industry and the environment. Of the seven research projects funded by this program, six of them were done in collaboration with the uranium industry here in Wyoming. Industry feedback regarding the research results has been extremely positive. The research funded by the Wyoming legislature demonstrated initial success at new technically and economically effective methods for groundwater restoration. The work done by the independent researchers funded through this program is having an impact on the regulatory agencies' view of existing restoration standards based on current science. This is demonstrated by the fact that the restoration research funded by the legislature (and other organizations) was discussed at EPA public meetings held in Casper in May 2015 that concerned proposed regulations for the ISRU industry.

Background

In the 2009 General Session, the Legislature of the State of Wyoming appropriated $1.6 million to the University of Wyoming, School of Energy Resources (SER) for activities related to the development of ISRU in Wyoming. SER spent $1,021,386 of that appropriation toward the following outreach and research activities:

- September 22, 2009 - Uranium Extraction Workshop, Cheyenne, WY.
- October 2009 –Research Priorities for In-Situ Uranium Recovery in Wyoming – report of findings.
- *Public Opinion in Wyoming about In-Situ Uranium Recovery,* (2010) Wyoming Survey & Analysis Center, University of Wyoming.
- August 4, 2010 – The Future of Uranium Production in Wyoming – A Public Forum on In-Situ Recovery, Laramie, WY.
- Analysis of Remediation Strategies for Radionuclide Contaminated Soils in Uranium Mining – graduate student research project completed April 30, 2012.
- University of Wyoming College of Law summer internship program – law student research project detailing the implications of Wyoming obtaining agreement state status from the Nuclear Regulatory Commission, completed September 30, 2011.

- In 2011, under the direction of the University of Wyoming Energy Resources Council and in consultation with the Wyoming mining industry, a competitive research program was developed focusing on optimizing the economic recovery of the resource through ground water restoration and research on waste water management. Two requests for proposals (RFP) released in 2011 and 2012, resulted in funding seven research projects related to aquifer restoration, groundwater treatment, identification of uranium deposits and restoration risk assessment modeling. More details on the RFP and the projects can be found below.
- April 21, 2015 – In-Situ Recovery of Uranium Research Symposium, Laramie, WY. The symposium showcased results from the seven funded research projects.

ISRU Program Account Sunset Date

In the 2012 budget session, the Legislature of the State of Wyoming provided for extension of the reversion date of the appropriation for the ISRU research program from June 30, 2013 to June 30, 2015 (HB29/HEA5). Extension of the reversion date allowed time to deploy the remaining funds to additional research efforts.

The sunset date has passed and all seven research projects were completed by this date and all final reports have been received. All but $4,121.80 of the original $1.6 million program budget was spent and will revert back to the State of Wyoming. (Table 1)

2015 In-Situ Recovery of Uranium Research Symposium

On April 21, 2015, SER hosted the In-Situ Recovery of Uranium Research Symposium on the University of Wyoming campus. The symposium provided a forum for researchers funded through the ISRU program to present the results of their work to the public. Each project funded through the ISRU program was presented and the event drew an attendance of close to 100 people. Costs to convene the symposium were $4,452.70 and were paid from the ISRU fund. Videos of the presentations can be found at: http://www.uwyo.edu/ser/conferences/conferences-past/isur-2015.html . A copy of the symposium program is attached to the end of this report.

2012 ISRU Research Program Request for Proposals

On June 14, 2012, SER issued an RFP for research focused on ISRU with the intent of deploying the $578,614 that remained from the original $1.6 million appropriation. The objective of the 2012 RFP was to stimulate research and development in the area of ISRU in Wyoming. Prior to release of the RFP, SER solicited input from representatives from the uranium industry to identify their preferred research focus areas. The areas they listed were consistent with those previously identified by industry and other stakeholders in the September 2009 workshop and August 2010 public forum. These research areas identified were:

- Exploration and ore body delineation
- Ore body characterization and uranium recovery
- Water management, treatment and disposal
- Cost efficient aquifer restoration technologies and practices
- Investigation of the impact of existing regulatory requirements on the economics and timing of ISRU projects in Wyoming

Provision of matching funds was not a requirement of this RFP; however, demonstration of matching funds improved the applicant's probability of success. Applicants were allowed to request between $25,000 and $300,000 in funding. Proposals were accepted from all university and community college faculty and staff, private industry, government agencies, and individuals and were evaluated for scientific feasibility of the research and probable benefit to the State of Wyoming.

Proposals in response to the 2012 RFP were submitted to SER by August 13, 2012. In accordance with the RFP, funds for successful proposals became available by November 30, 2012 and all projects were to be completed by March 31, 2015. Researchers were required to submit a final executive summary report and a final technical report within 90 days of the project end date. Researchers were also required to present the results of their research at a public workshop convened by SER on April 21, 2015.

The projects that were funded through the 2012 RFP are listed below and summarized in Table 2.

1. "Critical Evaluation of Restoration Goals Based on Improved Geochemical and Toxicological Characterization of Baseline and Post Mining Site Conditions," submitted by Colorado State University, Thomas Borch, Principal Investigator. This project focused on the determination of optimal aquifer restoration goals based on human and environmental risks. The award from the ISRU fund was $299,926 with provision of outside match of $60,000 for a project total of $359,926. This project was completed on March 31, 2015 and all but $1,410.22 of the awarded ISRU funds were spent.

2. "A Column Study for Enhanced Bioremediation of In-Situ Uranium Aquifers with Varying Levels of Total Dissolved Solids," submitted by University of Wyoming, John Wilford, Principal Investigator. This project focused on enhancing the efficacy of groundwater bioremediation strategies, monitoring, and timing of implementation. The award from the ISRU fund was $107,000 with outside match of $50,000 for a total project cost of $157,000. The project was completed on March 31, 2015 and all but $183.88 of the awarded ISRU funds were spent.

3. "A Novel One-Step Process for Uranium Production Bleed Water to Filter Trace Metals Using CuO (Cupric Oxide) Nanoparticles," submitted by University of Wyoming, KJ Reddy, Principal Investigator. This project focused on development of a cost effective method of removing trace metals from uranium production bleed water. The award from

the ISRU fund was $196,631 with provision of outside matching funds of $47,000 for a total project cost of $243,631. The project was completed on February 28, 2015 and all of the awarded ISRU funds were spent.

2011 ISRU Research Program Funded Projects

From the 2011 RFP, four proposals were funded in the amount of $826,849. Details about these projects are listed below and are summarized in Table 3.

1. "Enhancing Bioremediation of In-Situ Uranium Aquifers through Uranium and Carbon Isotopic Tracing of Biologic Activity," submitted by University of Wyoming, Kevin Chamberlain, Principal Investigator. This project focused on studying restoration of uranium aquifers using bioremediation at the Cameco Smith Ranch-Highland Ranch in-situ uranium mines near Douglas, WY. The award from the ISRU fund was $100,000 with provision of outside match of $25,000 for a project total of $125,000. The project was completed on June 30, 2013 and all awarded ISRU funds were spent.

2. "Testing the Chemical and Biological Efficacy of Cupric Oxide Nanoparticles to Remove Contaminants from Uranium ISR Produced Water," submitted by University of Wyoming, Suzanne Clark, Principal Investigator. This project used cupric oxide nanoparticles to remove arsenic from production bleed water. The effectiveness of this contaminant removal process was compared to other water decontamination systems currently used in the industry. The ISRU award was $71,723.46 with provision of an outside match of $25,000 for a project total of $96,723.46. The project was completed on March 31, 2015 and deployed all awarded ISRU funds.

3. "Field Evaluation of the Restorative Capacity of the Aquifer Downgradient of a Uranium ISRU Mining Site During Mining Operations," submitted by Los Alamos National Laboratory, Paul Reimus, Principal Investigator. This project predicted the degree of natural attenuation of uranium and other constituents of concern as groundwater migrates down gradient of an ISRU operation. This was done at a field site at the Cameco Smith Ranch-Highlands Ranch in-situ uranium mine near Douglas, WY. The ISRU program award was $399,400 with provision of an outside match of $100,000 for a project total of $499,400. The project was completed on March 31, 2015 and all awarded ISRU funds were spent.

4. "The Mineralogy and Provenance of Wyoming Uranium Roll Front Deposits and Their Significance to In-Situ Recovery Mining Processes," submitted by University of Wyoming, Susan Swapp, Principal Investigator. This project used various analytical methods to identify and characterize uranium deposits and their sources. The ISRU award was $227,449 with provision of an outside match of $92,400 for a project total of $319,849. The project was completed on March 31, 2015 and deployed all awarded ISRU funds.

Table 1. Budget Summary for ISRU Research Fund

In Situ Recovery of Uranium Research Program Budget Summary		
Beginning Budget	**$**	**1,600,000.00**
Outreach Projects		**Expenditures**
2009 Uranium Extraction Workshop	$	15,662.19
2009 Identification of Research Priorities	$	62,216.61
2010 Public Opinion Survey	$	18,809.15
2010 Public Forum	$	74,458.39
2011 Graduate and Law Student Research Programs	$	17,924.81
2015 ISRU Research Symposium	$	5,102.70
Miscellaneous Outreach Costs	$	1,000.00
Total - Outreach Expenditures	**$**	**195,173.85**
2011 and 2012 ISRU Research Projects		**Expenditures**
2011 UW Chamberlain Project	$	100,000.00
2011 UW Swapp Project	$	227,449.00
2011 UW Clark Project	$	71,723.46
2011 LANL Remius Project	$	399,400.00
2012 UW Wilford Project	$	106,985.11
2012 UW Reddy Project	$	196,631.00
2012 CSU Borch Project	$	298,515.78
Total - Research Expenditures	**$**	**1,400,704.35**
Remaining ISRU Funds to Return to State of Wyoming	**$**	**4,121.80**

Table 2. 2012 ISRU Research Program Funded Projects

Proposal Title	Submitted By	Funding Requested	Outside Match	Outside Match Source	Total Funds	Technology Areas
Critical Evaluation of Restoration Goals Based on Improved Geochemical and Toxicological Characterization of Baseline and Post Mining Site Conditions	Colorado State University	$299,926	$60,000	Cameco, Inc.	$359,926	Aquifer Restoration
A Column Study for Enhanced Bioremediation of In-Situ Uranium Aquifers with Varying Levels of Total Dissolved Solids	University of Wyoming	$107,000	$50,000	Cameco, Inc.	$157,000	Aquifer Restoration
A Novel One-step Process for Uranium Production Bleed Water to Filter Trace Metals Using CuO (Cupric Oxide) Nanoparticles	University of Wyoming	$196,631	$47,000	Uranium One Americas, Inc.	$243,631	Water Management, Treatment, Disposal
Totals:		$603,557	$157,000		$760,557	

Table 3. 2011 ISRU Research Program Funded Projects

Proposal Title	Submitted By	Funding Requested	Outside Match	Outside Match Source	Total Funds	Technology Areas
Enhancing Bioremediation of In-Situ Uranium Aquifers Through Uranium and Carbon Isotopic Tracing of Biologic Activity	University of Wyoming	$100,000	$25,000	Cameco	$125,000	Aquifer Restoration
Testing the Chemical and Biological Efficacy of Cupric Oxide Nanoparticles to Remove Contaminants from Uranium ISR Produced Water	University of Wyoming	$71,723	$25,000	University of Wyoming, Colorado State University	$96,723	Aquifer Restoration
Field Evaluation of the Restorative Capacity of the Aquifer Downgradient of a Uranium ISR Mining Site During Mining Operations	Los Alamos National Laboratory	$399,400	$100,000	Cameco	$499,400	Aquifer Restoration
The Mineralogy and Provenance of Wyoming Uranium Roll Front Deposits and Their Significance to In-Situ Recovery Mining Processes	University of Wyoming	$227,449	$92,400	University of Wyoming	$319,849	Exploration and Ore Body Delineation
Totals:		$798,572	$242,400		$1,040,972	

AGENDA

2015 In-Situ Recovery of Uranium Research Symposium
April 21, 2015

In 2009, the Legislature of the State of Wyoming appropriated $1.6 million to the University of Wyoming, School of Energy Resources (SER) for activities related to the development of in-situ recovery of uranium (ISRU) in the state. The ISRU research program was created to stimulate research and development in the area of ISRU in Wyoming. The ISRU Research Symposium is a forum for ISRU researchers to present their findings.

9:00 – 9:30 am	Registration (University of Wyoming, Union Ballroom Foyer, 2nd Floor)
9:30 – 9:45 am	Welcome and Opening Remarks – Jonathan Downing, Executive Director, Wyoming Mining Association
9:45 – 10:30 am	*Enhancing Bioremediation of In-Situ Uranium Aquifers through Uranium and Carbon Isotopic Tracing of Biologic Activity,* Kevin Chamberlain, University of Wyoming
10:30 – 11:15 am	*A Column Study for Enhanced Bioremediation of In-Situ Uranium Aquifers with Varying Levels of Total Dissolved Solids,* John Willford, University of Wyoming
11:15 am – 12:00 pm	*Field Evaluation of the Restorative Capacity of the Aquifer Down Gradient of a Uranium In-Situ Recovery Mining Site During Mining Operations,* Paul Reimus, Los Alamos National Laboratory
12:00 – 1:00 pm	**Networking Lunch**
1:00 – 1:45 pm	*The Mineralogy and Provenance of Wyoming Uranium Roll Front Deposits and their Significance to In-Situ Recovery Mining Processes,* Susan Swapp, University of Wyoming
1:45 – 2:30 pm	*Critical Evaluation of Restoration Goals Based on Improved Geochemical and Toxicological Characterization of Baseline- and Post-Mining Site Conditions,* Thomas Borch and Thomas Johnson, Colorado State University, and James Stone, South Dakota School of Mines and Technology
2:30 – 2:45 pm	**Break**
2:45 – 3:30 pm	*Testing the Chemical and Biological Efficacy of Cupric Oxide Nanoparticles from Uranium In-Situ Recovery Produced Water,* Jodi Schilz, University of New Mexico

3:30 – 4:15 pm	*A Novel One-step Process for Uranium Production Bleed Water to Filter Trace Metals Using Cupric Oxide Nanoparticles,* Brandon Reynolds, Wyoming State Engineer's Office
4:15 – 4:30 pm	Closing