U.S. Department of the Interior

Annual Report on Technology Transfer

FY 2016 Activities

June 2017

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I. Introduction

Technology transfer for the Department of the Interior (Department) includes a range of activities designed to disseminate scientific and technical information and knowledge between the Department and other Federal and non-Federal entities. It includes, but is not limited to, publishing and exchanging scientific and technical information, protecting and licensing intellectual property rights, and sharing — or otherwise making available — for scientific or technical purposes the expertise and specialized scientific material and resources which the Department manages. In general, technology transfer activities within the Department are consistent with its mission to protect and manage the Nation's natural resources and cultural heritage; to make available scientific and other information about those resources; to honor trust responsibilities to Tribes; and to supply energy for the future.

This report describes the actions the Department took in FY 2016 to advance technology transfer. These range from helping develop new technologies such as nanofiltration membranes to reduce contaminants in potable water to testing and demonstrating the USGS ShakeAlert System to broadcast early warning of temblors in earthquake-prone areas. These activities demonstrate the innovation, expertise and dedication of the Department's employees, including its many scientists and engineers, to help reduce risks to public health, safety and the environment from natural and man-made hazards. This report also addresses actions being taken to stimulate the development and dissemination of new technologies using prize competitions authorized by the America COMPETES Reauthorization Act of 2010 and other authorities. Finally, this report includes a Data Appendix that provides cumulative data tables for the Department for FYs 2012–2016, as requested by the Office of Management and Budget, and the National Institute of Standards and Technology. These tables include updates to previous years' data where appropriate.

II. Advancing Technology Transfer in the Department of the Interior

The FY 2016 enacted budget for the Department of the Interior included $963.5 million for research and development. Much of the funding was for applied research ($764.5 million), while basic research and basic development received $53.8 million and $145.2 million, respectively. The programs supported through these funds generate large amounts of knowledge, information, and technology, which help the Department meet its mission objectives and are transferred to resource managers, stakeholders, and the general public.

The Department's bureaus have varying levels of involvement with scientific and technical research and innovation, and technology transfer. In FY 2016, as in previous years, the majority of technology transfer activities reported by the Department under the Federal Technology Transfer Act of 1986 (FTTA) were undertaken by the U.S. Geological Survey (USGS) because it is the largest research and development (R&D) organization within the Department, both in terms of budget and personnel. Typically, USGS accounts for over 70 percent of the Department's R&D budget.

The Department's scientists, engineers, and other technical personnel advance the state of knowledge related to the Department's resources, and ensure that this information is accessible to resource managers, private industry, and the general public. The vast majority of the Department's technology transfer activities use traditional technology transfer mechanisms such as publications of peer reviewed papers and reports, webpage postings, fact sheets, and presentations at meetings and conferences. In 2016, USGS and U.S. Fish and Wildlife Service (FWS) personnel authored or co-authored over 9,500 reports, books, fact sheets, and other publications, including approximately 3,500 scientific publications. The other bureaus, while also active in publishing and distributing scientific, technical, and engineering results, do not systematically track these products, so their contributions are not included in these counts.

Bureaus also use other conventional approaches to share scientific and technical resources and expertise with each other, universities and other entities to address resource management issues. For example, seven DOI bureaus are active participants in the network of seventeen Cooperative Ecosystem Studies Units (CESUs), a collaboration among more than 400 partner organizations, including 15 Federal agencies and nearly 400 non-Federal partners (including universities, Tribes and tribal organizations, State agencies, museums, aquariums, arboretums, and conservation organizations). Each CESU is hosted by a university.

Bureaus that are active in research and development, or have research capabilities that complement U.S. commercial interests, may also utilize technology transfer agreements authorized by the FTTA to join forces with non-Federal partners. Such agreements allow the Department's bureaus and private sector industries to pool their expertise and resources to jointly create and advance technologies that could help fulfill agency missions while helping U.S. industries innovate and commercialize technologies, which can strengthen our national economy and create jobs. This report focuses primarily on, but is not limited to, aspects of technology transfer related to the FTTA.

FY 2016 Accomplishments

In FY 2016, the Department continued to build on actions initiated since FY 2011 to institutionalize technology transfer programs within the Department. These actions also enable all bureaus to more effectively and efficiently implement the FTTA and related legislation while maintaining focus on their missions.

In a manifestation of increased coordination and cooperation within the Department, bureaus with greater experience with FTTA-authorized instruments shared their knowledge and experience with less experienced bureaus to develop a joint Cooperative Research & Development Agreement (CRADA) with a Canadian non-profit, Bird Studies Canada (BSC). Specifically, this CRADA involved three DOI bureaus — USGS, FWS and BOEM. This CRADA was developed to coordinate and manage data on the movements of birds and bats on the Northeastern coast of the United States.

Expert staff from USGS helped develop this CRADA by familiarizing bureau technical staff and BSC on the process and the pros and cons of the CRADA approach. This CRADA will enable bureaus to use cutting edge technology developed by BSC to track these movements and will,

with some limitations, allow DOI bureaus to access data obtained by research and monitoring programs funded by non-DOI entities. This effort also illustrates the benefits of using these FTTA instruments to leverage and augment appropriated resources made available to bureaus to pursue their mission.

During FY 2016, the Department's scientific, technical, and engineering personnel continued to engage in a broad range of cooperative activities to develop and disseminate innovative technologies, including:

- Publishing over 9,500 reports, books, papers, fact sheets, and other publications, including about 3,500 in scientific publications.
- Collaborating on 873 Cooperative Research & Development Agreements (CRADAs), of which 511 were new that fiscal year. By contrast, the previous year the numbers were 826 and 586, respectively. In addition, the Department engaged in at least 319 other collaborative R&D relationships, virtually the same number as in FY 2015 (318).
- Further expanding the number of non-traditional CRADAs, i.e., material use and facility use agreements, which they engaged in under the FTTA from 787 in FY 2015 to 836 in FY 2016.
- Disclosure of eight (8) new inventions. In addition, four (4) patents were filed and one (1) patent was received.
- Managing 22 active licenses for inventions and other intellectual property earning about $83,000.

Developing and advancing innovative concepts and technologies are the first steps in technology transfer. To aid in this, a number of bureaus have turned to offering prize competitions under the America COMPETES Reauthorization Act of 2010, and other authorities to address their mission needs. Specifically:

- The Bureau of Reclamation's Water Prize Competition Center (WPCC), established in FY 2015, continues to lead several interagency efforts to develop new, or improve existing, technologies to increase water availability, improve infrastructure sustainability, and ensure sustainable ecosystems. By the end of FY 2016, the WPCC had initiated five competitions, of which four had been completed. Collectively, these 5 competitions awarded a total of $110,000 in prize awards dispersed across 23 winning solutions.

  The estimated value of the problem solving efforts made by all competing solvers for these 5 competitions is $1,010,000, an approximate 10:1 return on the prize purse investments. Many solutions not receiving awards also included promising concepts or ideas. As a result of the competition rules, the Federal Government received licenses to use 175 of the concepts/ideas submitted by solvers from four of these competitions even if their solutions were not awarded a cash prize.

  In addition, Reclamation initiated the design of 6 additional prize competitions scheduled to launch during the first half of FY 2017, offering potentially $1,180,000 in prize awards.

- Reclamation was awarded the *Newcomer of the Year* and *Best in Technology* prizes in October 2015 for, among other things, establishing the WPCC and developing federal partnerships to advance technologies to improve water resource management. In addition, Saied Delagah, a Reclamation desalination research expert, received the *Unsung Hero* award for his outstanding, behind the scenes coordination of the technical efforts that enabled the Desal(ination) Prize.

- In addition to participating in the implementation of various competitions offered by the Reclamation's WPCC, USGS is partnering with the Environmental Protection Agency (EPA) and other Federal and non-Federal agencies on the Nutrient Sensor Challenge. This is an initiative to accelerate development and commercial availability of affordable, reliable, and accurate nutrient sensors in aqueous environments.

- The Bureau of Safety and Environmental Enforcement (BSEE) launched an initiative to promote science, technology, engineering and math (STEM) education, and engage and raise its profile with the future STEM workforce. The first competition under this initiative was for the best adaptation for offshore use of a piezoelectric technology developed by NASA. The competition, which was offered under its general authority to promote safety, protect the environment, and conserve resources offshore, was jointly sponsored by BSEE and the Ocean Energy Safety Institute (OESI),

- The National Park Service (NPS) conducted a prize competition in conjunction with the National Capital Planning Commission (NCPC) and Van Alen Institute on *Memorials for the Future*, an ideas competition to reimagine how Americans may think about, feel, and experience memorials in the future.

- FWS announced winners of its Ivory Crush Design Challenge, which had solicited proposals for powerful visual concepts for public displays fabricated from crushed ivory from the U.S. ivory crushes.

III. Overview of Technology Transfer Activities

Table 1 indicates that the Department's bureaus use, or are contemplating using, a diverse range of mechanisms to transfer information, knowledge, and technology within and outside their agencies.

Table 1: Principal Technology Transfer Mechanisms Identified by Each Bureau

	USGS	FWS	OSMRE	NPS	BSEE	Reclam-ation	BOEM	BLM
Technical/Scientific Publications	X	X	X	X	X	X	X	X
Workshops/Seminars	X	X	X	X	X	X	X	X
Educational Courses & Other Outreach	X	X	X		X	X	X	X
Cooperative Research and Development Agreements (CRADAs)	X	X		X		X		
Technical Assistance Agreements (TAAs)	X					X		
Facility Use/Service Agreements (FUSAs)	X					X		
Material Transfer Agreements	X			X		X		
Demonstration/Joint Projects					X	X		X
Patents	X	X		X		X		
Licenses	X	X		X		X		
Other Cooperative Ventures & Agreement Types		X	X	X	X	X		
Web and other mechanisms	X	X	X	X	X	X	X	X

IV. Technology Transfer Agreements

Table 2 provides a summary of new and active technology transfer agreements undertaken within the Department in FY 2016. There were a total of 873 active CRADAs in FY 2016, of which 511 were newly executed. By contrast, in FY 2015, there were a total of 826 CRADAS (including 586 new ones).

Table 2: Collaborative Relationships for Research & Development (FY 2016)

	USGS	Recla-mation	NPS	FWS	Total
● **CRADAs**, total active in the FY(1)	858	10	1	4	873
- New, executed in the FY	506	4	1	0	511
▪ Traditional CRADAs,(2) total active in the FY	29	3	1	4	37
- New, executed in the FY	8	0	1	0	9
▪ Non-traditional CRADAs,(3) total active in FY	829	7	0	0	836
- New, executed in the FY	498	7	0	0	505
● **Other collaborative R&D relationships[4]**					
▪ (Collaborative Agreements), total active in the FY	318	1	0	n/a	319
- New, executed in the FY	126	0	0	n/a	126

CRADA = Cooperative Research and Development Agreement
(1) "Active" = legally in force at any time during the FY. "Total active" is comprehensive of all agreements executed under CRADA authority (15 USC § 3710a).
(2) CRADAs involving collaborative research and development by a federal laboratory and non-federal partner.
(3) CRADAs used for special purposes -- such as, material transfer or technical assistance that may result in protected information. For USGS, Technical Assistance Agreements (TAA) and Facility Use/Service Agreement (FUSA) fit this category.
(4) Based on available data. These figures do not account for the majority of collaborative agreements that bureaus engage in under authorities other than the FTTA.

Table 3 summarizes invention and patenting activity within the Department during FY 2016 broken out by bureau. This activity was limited to USGS, Reclamation and the National Park Service. The table indicates that eight new inventions were disclosed, six new patent applications were filed and one new patent was issued.

Table 3: Invention Disclosure and Patenting (FY 2016)

	USGS	Recla-mation	NPS	Total
● New inventions disclosed in the FY(1)	6	2	0	8
● Patent applications filed in the FY(2)	2	1	1	4
● Patents issued in the FY	0	1	0	1

These included non-provisional U.S patent applications for a process to measure ground elevation using a Laser Rod surface Elevation table, a distributed temperature sensor probe for measuring temperature at multiple depths, and a device to facilitate water quality measurement in

high biofouling environments. Several additional applications are being drafted, including one for a process of using moving cameras to capture three-dimensional mapping of ocean waves at discrete moments in time, and a method to characterize mechanisms for entire populations of micro seismic earthquakes within relatively sparse seismic network. A provisional application was filed for a water sampler that enables non-contaminated in-situ growth of microbials within its chamber that is capable of capturing and testing gas, which is under consideration for patenting. Also, one International Patent Application has been filed for the use of ultraviolet light as a bat deterrent for wind turbines in an effort for USGS to determine if the patent applications should be filed in various countries.

Table 4 provides a summary of the number of active licenses managed by the Department's bureaus.

Table 4: Active and Income Bearing Licenses (FY 2016)

	USGS	Reclam-ation	Total
● **All licenses**, number, total active in the FY	17	5	22
▫ New, executed in the FY	0	0	0
● **Income bearing licenses**	14	3	17

Additional data, broken out by bureau and covering FY 2012–FY 2016, are contained in the Data Appendix to this report. These show that total income in FY 2016 from all licenses amounted to about $83,000 (from 17 income bearing licenses), compared to $106,000 from 18 income-bearing licenses in the previous fiscal year.

Table 5 provides a summary of the scope and nature of technology transfer activities and mechanisms that the various bureaus implement currently or might implement in the future.

Table 5: Scope of Activities and Plans Related to the FTTA, by Bureau

Mission	Technology Transfer
U.S. Geological Survey (USGS). The mission of the USGS is to serve the Nation by providing reliable scientific information to describe and understand the Earth, minimize loss of life and property from natural disasters, manage water, biological, energy, and mineral resources, and enhance and protect our quality of life.	The USGS serves the Nation as an independent fact-finding agency that collects, monitors and analyzes scientific and technical information to provide scientific understanding about natural resource conditions, issues, and problems. The USGS makes this information and knowledge readily available to decision makers and the public. Thus, one of the USGS's main thrusts is broad and open dissemination of its knowledge and information. USGS also pursues technology transfer opportunities under the FTTA and the Stevenson-Wydler Act in a variety of ways (see Table 1).
U.S. Fish & Wildlife Service (FWS). The mission of the U.S. Fish & Wildlife Service is working with others to conserve, protect, and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people.	FWS's Research and Development (R&D) is primarily focused on providing the basis for effective conservation in order to meet its mission. The agency's primary research nexus with the private sector centers on the Fish and Aquatic Conservation Program. FWS Fish Technology Centers were established in 1965 to develop and improve fish culture technology and to provide assistance to Federal and State agencies, Tribes and other nations interested in aquaculture research and solutions. Today there are seven such centers working with industry and government to improve aquaculture opportunities.
Office of Surface Mining Reclamation and Enforcement (OSMRE). OSMRE helps States develop and implement their own approved surface coal mining programs.	OSMRE advances it mission by providing technical assistance based on sound science, and training to its State and tribal partners to enhance their ability to maintain effective programs. Although OSMRE has no formal research and development activities, its Technology Development and Transfer program promotes and disseminates information on technological innovations to better protect the environment during mining and in reclaiming and restoring active and abandoned mines. The program also provides training to ensure that States, Tribes, and OSMRE's other partners continue to administer their surface mining programs efficiently and effectively.
National Park Service (NPS). The National Park Service preserves unimpaired the natural and cultural resources and values of the national park system for the enjoyment, education, and inspiration of current and future generations. The NPS cooperates with partners to extend the benefits of natural and cultural resource conservation and outdoor recreation throughout this country and the world.	Under the NPS benefits-sharing policy and procedural guidance (available at http://www.nps.gov/applications/npspolicy/DOrders.cfm), benefits sharing occurs when NPS receives monetary or non-monetary benefits from the commercial use of a discovery or invention resulting from research originating under an NPS Scientific Research and Collecting Permit, or other NPS permit or authorization. The benefits-sharing policy and guidance address technology transfer and employee inventions. Authorities under the FTTA are essential to the NPS benefits-sharing program.

Table 5: Scope of Activities and Plans Related to the FTTA, by Bureau

Mission	Technology Transfer
Bureau of Safety and Environmental Enforcement (BSEE). The BSEE works to promote safety, protect the environment, and conserve resources offshore through vigorous regulatory oversight and enforcement.	The BSEE R&D program operates through the Emerging Technologies Branch (ETB) and the Oil Spill Response Research program (OSRR) in the Response Research Branch. BSEE research is associated with operational safety, pollution prevention, and oil spill cleanup techniques and technologies. BSEE research results are used to inform regulatory decision making and to promote the use of Best Available and Safest Technology on the U.S. Outer Continental Shelf.
Bureau of Reclamation (Reclamation). The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.	Reclamation has the lead Federal responsibility for water management and hydropower in the 17 Western States. Its research program is highly applied towards development of solutions that benefit its operations and infrastructure reliability. The research programs use technology transfer fundamentals to help speed field deployment of new innovations.
Bureau of Ocean Energy Management (BOEM). The Bureau of Ocean Energy Management manages the exploration and development of the Nation's offshore energy and mineral resources in an environmentally and economically reasonable way. It seeks to appropriately balance economic development, energy independence, and environmental protection through oil and gas leases, renewable energy development and environmental reviews and studies.	BOEM's Environmental Studies Program (ESP) develops, conducts and oversees scientific research specifically to inform policy decisions regarding development of Outer Continental Shelf (OCS) energy and mineral resources. Research covers physical oceanography, atmospheric sciences, biology, protected species, social sciences, economics, submerged cultural resources and environmental fates and effects. BOEM also funds research into offshore renewable energy technology.
Bureau of Land Management (BLM). The BLM mission is to sustain the health, diversity, and productivity of America's public lands for the use and enjoyment of present and future generations. The Federal Land Policy and Management Act of 1976 (FLPMA) mandates that the BLM manage public land resources for a combination of balanced and diverse resource uses that takes into account the long-term needs of future generations for renewable and non-renewable resources, including, but not limited to, recreation, range, timber, minerals, watershed, wildlife and fish, and natural scenic, scientific and historical values	BLM's science and technical focus has been on place-based applications to improve the management of public lands in accordance with FLPMA's multiple use mandate. In addition to its traditional technological transfer activities, BLM is exploring additional technology transfer opportunities under 15 U.S.C. 3710 and U.S.C. 205 and 207 that could be employed to help advance its multiple-use mandate.

Subsequent sections briefly describe each bureau's technology transfer program and a sample of their activities in FY 2016. The tabular data requested by OMB Circular A-11 are reported in the Data Appendix, to the extent data are available.

V. U.S. Geological Survey

The United States Geological Survey (USGS) is a scientific bureau within the Department of the Interior whose mission is to serve the Nation by providing reliable scientific information to describe and understand the Earth, minimize loss of life and property from natural disasters, manage water, biological, energy, and mineral resources, and enhance and protect our quality of life. Under its science strategy outlined in "Facing Tomorrow's Challenges—U.S. Geological Survey Science in the Decade 2007-2017," USGS focuses on the following interdisciplinary mission areas: Ecosystems; Climate and Land Use Change; Energy and Minerals; Environmental Health; Natural Hazards; Water Resources; Core Science Systems; Administration and Enterprise Information; and Facilities. These mission areas combine expertise from several Earth Science disciplines (e.g., hydrology, geochemistry, biology) to address relevant issues of concern to people and other living things on the planet. Organization around these mission areas allows the USGS to better address the needs of its customers and partners.

Delivery of science information is a primary purpose of the bureau. Technology transfer activities with the public and private sectors, including academia and non-profits, are, therefore, integral to fulfilling this purpose. They typically support the collection and transfer of scientific data (knowledge dissemination). In FY 2016 USGS personnel, for example, authored or co-authored over 9,153 reports, books, fact sheets, and other publications and information products, including over 2,410 scientific journal articles, 724 USGS Series scientific publications, and 3,984 abstracts. The USGS also cooperates with its public and private collaborators to help them maintain necessary services, better understand the environmental consequences of their commercial and non-commercial activities, and develop new products and services. The USGS has 35 major laboratories and several hundred field offices located around the country.

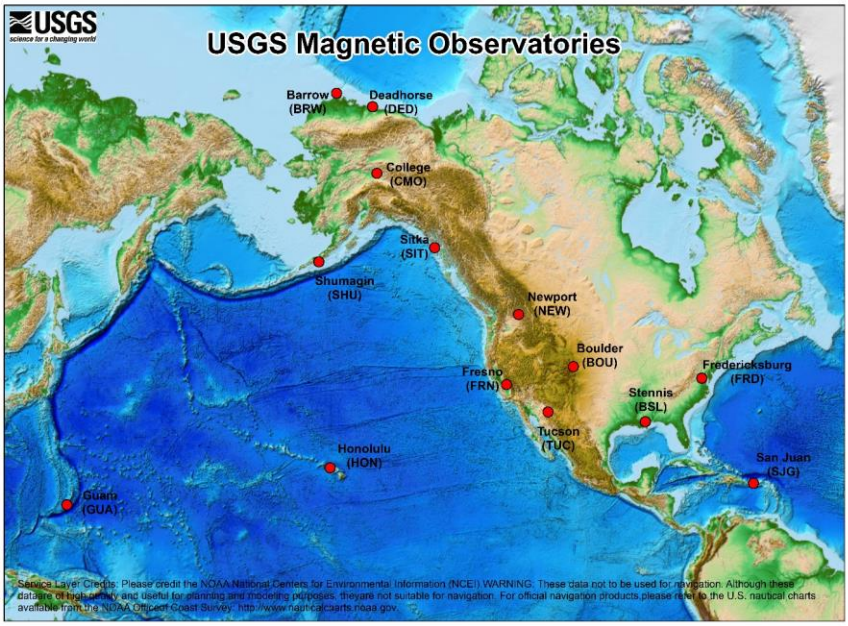
Within the USGS, technology transfer that extends beyond traditional publications, meetings and conferences and is related to the Stevenson-Wydler Innovation Act and the FTTA is managed through the Office of Policy and Analysis (OPA). OPA staff service USGS Science Centers and offices throughout the country.

OPA, on behalf of the USGS, negotiates and drafts Cooperative Research and Development Agreements (CRADAs), Technical Assistance Agreements, Facility Use Agreements, Material Transfer Agreements, and Patent Licenses. In 2016, OPA extended this service to help develop a proposed CRADA involving USGS, two other bureaus — BSEE and FWS – and a Canadian non-governmental agency to help coordinate collection, processing, and archiving of data related to bird and bat movements. This office also manages the USGS intellectual property and inventions program; markets USGS technology opportunities; and facilitates partnerships with industry, non-profits, academic institutions, Tribal nations, and State agencies. OPA also provides training to USGS personnel on technology transfer and intellectual property matters.

In 2016, USGS had 858 active traditional and non-traditional CRADAs, the majority of which (829) were technical assistance and facility use agreements. By contrast, in FY 2015 it had 814 active CRADAs, including 783 non-traditional CRADAs. In addition, USGS executed 318 other collaborative agreements, managed a total of seventeen (17) active licenses. In addition, it filed four (4) patent applications and received one (1) patent.

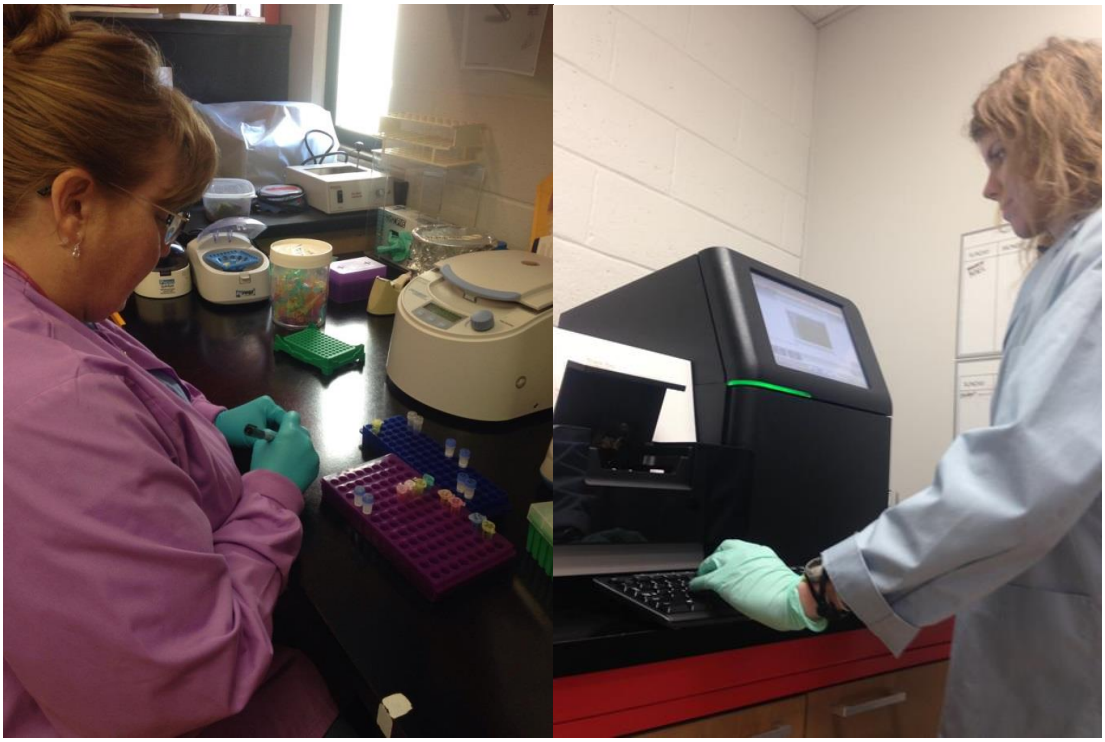
USGS science and research contributes to a broad range of collaborative projects in the private and academic sector. The USGS provides unique analytical laboratory services to U.S., foreign, and academic partners through the USGS' Facility Use program. Examples include:

- **Geomagnetism Laboratory.** The Geomagnetism Lab, strictly speaking, is not a traditional laboratory. The Geomagnetism Program monitors and records the Earth's magnetic field. To do so, the USGS has 14 Geomagnetic Observatories located around the U. S. and its possessions (see figure below). Most of these Observatories are fairly modest facilities, and some have been operating for over 100 years. The Observatory located in Boulder, CO, is the one site that regularly performs testing and calibration of magnetometers and data acquisition equipment. These data are used in real-time by NOAA's Space Weather Prediction Center and the US Air Force 557th Weather Wing for monitoring space weather, and by industry for directional drilling. They are also used to generate the International Geomagnetic Reference Field (IGRF) models in five-year intervals, and are available for research and applications uses. The USGS is continually evaluating new magnetometers and data acquisition systems for increased resolution and accuracy, and works with a wide variety of partners in government, academia, and private industry in these efforts.



- **The Leetown Science Center's Molecular and Environmental Microbiology laboratory** studies microbial and animal diversity at the molecular level to understand the function of microbes and how they impact trust aquatic species and environmental health. Molecular methods are also used to study the effects of environmental contaminants including endocrine-disrupting compounds on sub-cellular metabolic pathways. The laboratory is equipped with a range of modern instrumentation and uses

cutting edge technologies that include high throughput genomic sequencing, quantitative polymerase chain reaction, single-molecule analysis, and bioinformatics capabilities. Accepted classical methods are routinely combined with newly developed approaches to support research needs including fecal source tracking, bee pollen sourcing, and the determination of animal food sources by analyzing digesta.



Left: Cindy McDaniels prepares DNA samples for analysis. Right: Cynthia Adams operates Illumina MiSeq next-generation high throughput sequencer. [Photo Credits: Deborah Iwanowicz, USGS].

In FY 2016, seven new analytical services available for use by or on behalf of other federal and non-federal entities were established:

- Bacteria qPCR Analysis of Water Filters
- Geomagnetism Program Services
- Low Ionic Strength Sample Analysis
- Molecular Surface Water Sampling
- Organic Geochemistry
- Stable Isotope Sample Analysis
- TRIGA Reactor Lab — a TRIGA reactor is a class of small nuclear reactor that does not need a containment facility.

The following are examples of USGS technology transfer activities undertaken in FY 2016 using the CRADA mechanism.

CRADA with the Inter-American Development Bank (IDB). On behalf of the USGS, its Office of International Programs entered into a Master CRADA for five years with IDB to collaborate on scientific and technical issues related to extractive industries (including petroleum resources) in Latin America and the Caribbean (LAC).

The IDB is a major source of multilateral financing for economic, social and institutional development in the LAC region through loans, grants, guarantees, policy advice and technical assistance to public and private sectors of its borrowing member countries. The IDB is seeking to develop information and to help promote sustainability and transparency in the extractive industries in the LAC region. Under this CRADA, the USGS, with its geotechnical expertise and global understanding of resource geology and extractive industries, will provide the science and information needed by the IDB for this effort.

The initial project under this CRADA compiled and analyzed geospatial data within the LAC region, focusing on the mineral industries and on the associated physical and economic infrastructure that supports these industries, such as railroads, ports, and electrical power generating facilities. The project incorporated and synthesized new datasets that were researched and created by the Minerals Resources Program, the National Minerals Information Center and the Energy Resources Program (all within USGS), as well as other publicly available data. The outcomes from this project during FY 2016 included a specialized map product of the LAC region, a geodatabase containing all relevant geospatial data, and a report covering data sources and methods.

Test of Earthquake Early Warning Notifications. USGS and Global Security Systems, LLC (GSS) have established a collaboration to test the use of the latter's ALERT FM system to broadcast earthquake early warnings generated by the USGS ShakeAlert System. The USGS ShakeAlert System in California consists of sensors placed strategically throughout the state that detect seismic vibrations. If these vibrations exceed a pre-determined level, that would trigger an alert, and send out warnings. These warnings could be distributed across outdoor sirens, ALERT FM receivers, automated equipment using the control data from alert, smartphone apps, and other notification pathways such as radio and TV broadcasts.

ALERT FM is unique since it operates a dedicated emergency notification system that is satellite-based and is not reliant on potentially vulnerable Internet connectivity. It is already being used in the New York City area and many southern states for tornados and hurricane notification. ALERT FM uses the digital data subcarrier of local FM radio stations, including Univision station in southern California and public radio station KQED in northern California, to distribute critical alerts in as little as 6 seconds.

An objective of the partnership is to have ShakeAlert earthquake early warning alerts posted to GSS alert software and broadcast to a set of GSS receivers and other devices like cellphones equipped with FM radio chips. In addition, the USGS and GSS will collaborate on system design and best practices for alerting different sectors, including emergency response personnel, utilities, and other industries. Early warning of earthquakes will allow businesses to take actions to protect their employees, customers, and critical infrastructure from strong shaking. Even a few

seconds of warning is enough notice to shutdown vulnerable processes, move people from unsafe places, and for people to drop, take cover and hold on.

Information would be received on portable or fixed receivers with FM receiver chip installed that can be programmed for specific groups, counties, or areas. ALERT FM receivers automatically tune to and lock on to the strongest FM signal in the area similar to mobile phone behavior. As the USGS ShakeAlert System begins issuing public alerts for the West Coast of the US, ALERT FM receivers would be available for purchase by residents and businesses.

USGS has partnered with Global Security Systems because it is a systems integrator, service provider, and manufacturer of the ALERT FM, Alert Studio, and GSSNet, a satellite data delivery system that has developed a commercially available end-to-end notification platform based on FM radio broadcasts fed by satellite for distributing mass notifications. GSS has a nationwide satellite delivery system to originate and uplink Common Alert Protocol (CAP) based emergency audio and text alerts. GSS Alert FM receivers, cell phones equipped with a radio chip and software, and other consumer devices receive the alert messages.

In FY 2016, the collaboration included a recent partnership with NextRadio to supply FM RDS messages to cellular users through the NextRadio app. The GSSNet satellite data delivery system for emergency alerts currently is currently in operation on over 500 radio stations in 17 states and Canada.

Improved Characterization of Fluorescence Sensors. USGS and Xylem Analytics, Inc. have entered into an agreement to improve the accuracy of sensor measurements of dissolved organic matter in water by better characterizing and correcting for the effects of suspended particles and color that affect the sensor performance. By helping develop a test process to better characterize the sensors, data quality and comparability across sites will be improved for all users. The collaboration is mutually beneficial, with YSI, a subsidiary of Xylem Analytics, receiving technical assistance with experimental design and instrument testing for interferences. The USGS and other sensor users will receive fluorescence sensor data that has been corrected for these effects through on-sonde, real-time data processing capability through YSI software development.

Microbial inhibition of fungal pathogens of snakes. Snake fungal disease (SFD) is an emerging infection caused by the fungus *Ophidiomyces ophiodiicola* (*O.o.*). Fungal diseases, including SFD, have been linked to fatal infections and population declines in many types of wild animals. Since many species of wildlife provide important services, such population declines can have negative effects on the environment and human health. For example, snakes consume large numbers of rodents that can damage agricultural crops and transmit diseases to humans. They also serve as prey for many birds and thus are essential components of the food web.

Currently, the major roadblock in mitigating the impacts of fungal infections is a lack of effective tools to manage the diseases. The USGS is a leader in investigating the reasons behind the recent emergence of fungal infections in wildlife and is helping wildlife managers develop strategies to protect vulnerable animals. This is accomplished through collaborations with

outside agencies that have expertise in various methods for controlling fungi that can cause disease. For example, USGS is working with researchers at the University of Massachusetts to identify microorganisms, and substances produced by microorganisms, that can inhibit the growth of *O.o*. This work will be important in understanding how the beneficial bacteria that naturally live on snakes and in the environment might be able to protect snakes from deadly fungal diseases, and may also help wildlife managers develop strategies for conserving rare snake species.

The eastern massasauga (*Sistrurus catenatus*) is a federally threatened species of snake that is being affected by fungal skin infections in some areas. [Photo credit: Rori Paloski, Wisconsin Department of Natural Resources].

Challenge Related Activities

In addition to the more conventional technology transfer activities illustrated by the above examples, in FY 2016 USGS participated in several prize competitions and related activities that were led by other agencies within and outside the Department. In these, the USGS role typically consisted of providing technical and scientific expertise, including judging submissions, familiarizing participants with and providing access to USGS data, helping develop the challenge design, helping identify best challenge practices, and supplementing, where necessary and appropriate, prize purses. For example, the USGS is a supporting partner with EPA and other Federal and non-Federal agencies on the Nutrient Sensor Challenge, which is an effort to accelerate development and commercial availability of affordable, reliable, and accurate *in situ* nutrient sensors in aquatic environments. The coalition of federal agencies, universities, and non-profits is bringing incentive prizes and open innovation to the problem of nutrients. In addition to providing technical expertise, the USGS has partnered directly with the University of Maryland's Alliance for Coastal Technology — funded by NOAA and leading the Challenge testing — to further evaluate sensor performance in riverine settings. In particular, the USGS provided site access and technical expertise in the development of the testing infrastructure, and will work with the Alliance for Coastal Technology and other partners on future sensor testing.

Similarly, the USGS is cooperating with the Bureau of Reclamation's Water Prize Competition Center (WPCC) to help identify, coordinate, and run multiple challenges focused on water availability, ecosystem restoration, and infrastructure sustainability. Subject matter experts from both Reclamation and the USGS are actively working as part of the design and judging teams on various WPCC prize competitions (see Section IX).

VI. U.S. Fish and Wildlife Service

The U.S. Fish and Wildlife Service (FWS or the Service) is dedicated to the conservation, protection, and enhancement of fish, wildlife and plants, and their habitats. FWS is the only agency in the Federal Government whose primary responsibility is management of fish and wildlife resources for the American public. It manages more than 850 million acres of lands and waters in the National Wildlife Refuge System, including five marine national monuments, 565 national wildlife refuges and 38 wetland management districts. FWS also operates 70 National Fish Hatcheries which, in conjunction with its Fish Health Centers and Fish Technology Centers (see below), restore native aquatic populations, mitigate for fish lost as a result of Federal water projects, and support recreational fisheries throughout the United States.

Research and Development (R&D) within FWS is primarily focused on applying the latest scientific and technical information to fulfill its mission of working with others to conserve, protect, and enhance fish, wildlife, plants, and their habitats for the continuing benefit of the American people. The transfer of FWS's technology and knowledge to the public and collaborators accelerates the adoption and use of agency research while improving the economic and societal impact from its R&D investments to help solve natural resource problems.

The technology transfer function of FWS is shared among several FWS programs/divisions including the Division of Science Applications, the Division of Policy, Performance and Management Programs (PPM), and the Office of the Solicitor. The vast majority of FWS's technology transfer is done via dissemination to the public and scientific community through traditional avenues such as peer reviewed papers, reports and fact sheets.

In addition, FWS employees are actively involved in the larger scientific community, including participating in scientific societies, meetings and conferences, and generating and publishing scientific research. Sharing scientific and technical information via public outreach and partnerships is a high priority for FWS. For example, the Service is a partner to all units within the 17 Cooperative Ecosystem Studies Units (CESU) Network, allowing the Service to be involved in interdisciplinary and multi-agency research projects with the host university and other non-federal partners. Each year the Service pursues dozens of projects through the CESU network including surveying and monitoring efforts, climate change vulnerability assessments, streamflow projections, and many others.

FWS manages two online peer reviewed publications focused on the practical application and integration of applied science to wildlife conservation and management — the *Journal of Fish and Wildlife Management* and the *North American Fauna Monograph Series*. These journals are in the public domain and are completely electronic. Overall, in FY 2016, FWS personnel published approximately 350 articles in peer reviewed science journals. Many of those articles

are available online via open access journals, while others are available through paid subscription because of publishers' terms of copyright.

FWS also uses its research to help inform a wide range of wildlife management decisions in the interest of the general public. For example, the National Wildlife Refuge Inventory and Monitoring Program systematically obtains a range of biological data about the status, trends and management responses of species and habitats within the Refuge System. Those data inform and improve conservation of fish, wildlife, and plant natural resources.

Patents: In 2016, FWS's Division of Policy, Performance, and Management Programs (PPM) continued to help the National Wildlife Refuge System pursue a patent filed for one of its program employees. The patent would be for a device that may help fight invasive plant species on both public and private lands. PPM worked with the Bureau of Reclamation to establish an Interagency Agreement with USDA's Agricultural Research Service (ARS) to obtain patent law expertise. The U.S. Patent and Trademark Office (PTO) has yet to take final action on this patent, which was filed in January, 2014. Although PTO issued a non-final rejection, FWS is continuing the pursuit of the patent and has (with the assistance of ARS) requested that the PTO Examiner reconsider. If the patent is issued, it would add to the four obtained by FWS since 1998. These include a patent for calcein detection devices developed at FWS' Northeast Fishery Center in Lamar, PA, for detecting non-invasively-marked hatchery-reared Atlantic salmon for up to three years post-marking which has been licensed exclusively to Western Chemical (Ferndale, Washington) for a period of eight years. Other inventions include a rocker/agitator for transportation and storage of fish sperm (e.g., in captive breeding programs of imperiled species), a fistula device to gather eggs from inside a fish, and a method for agglomerating fine powders for larval aquatic feed.

CRADAs: In 2016, FWS in collaboration with USGS and BOEM developed a new multi-bureau Collaborative Research and Development Agreement (CRADA) with Bird Studies Canada (BSC), an international non-profit entity, to enable DOI bureaus to formally participate in a cross continent wildlife tracking system known as the Motus system.

The system employs nanotag tracking technology that will substantially increase the ability to understand spatial and temporal movement patterns of small-bodied wildlife (e.g., birds and bats). The number of projects using this technology is rapidly increasing within FWS, other agencies, and non-governmental groups. An increasing number of nanotag receiving stations operated by different projects and funded by various agencies can detect all tags on a common frequency within the detection range, while distinguishing between the individual tags. This would allow researchers to track and understand the movements of individual birds or bats that they have tagged. This opens up opportunities for large-scale collaboration and data sharing among projects and investigators that tag wildlife, erect receiving stations, and collect data.

The CRADA would help ensure the arrangements with BSC are fair, equitable, and adequately account for the value of equipment and services provided by the various partners. This new agreement, which was going through the signature process as of the end of FY 2016, would add to the four CRADAs in place through the Aquatic Animal Drug Approval Program (AADAP) within the FAC Division (see below).

Following is a brief description of FWS programs and entities engaged in technology development and transfer activities.

National Conservation Training Center. FWS Conservation Library at the National Conservation Training Center (NCTC) in Shepherdstown, West Virginia, provides a searchable collection of selected documents, images, historical artifacts, audio clips, publications, and video, most of which are in the public domain. FWS also makes internal publications, reports, and other information available to the public through FWS website. Collections of current and legacy publications are available online from the NCTC library catalog and websites. NCTC also maintains links to biological and technical publications, as well as additional publications regarding birds, wetlands, fish hatcheries, and National Wildlife Refuges.

NCTC also hosts publicly-accessible webinars dealing with a variety of scientific and technical issues that affect the nation's fish and wildlife resources. During FY 2016, NCTC and FWS hosted over 100 science, technology, and education webinars on topics covering climate change, conservation genetics, conservation biology, habitat restoration, invasive species, environmental education, youth leadership and supervision, youth outdoor skills, and other scientific/technical topics related directly to managing the nation's fish, wildlife, and plant resources.

Fisheries and Aquatic Conservation Division. The agency's primary research nexus with the private sector centers on programs and facilities within the Division of Fisheries and Aquatic Conservation (FAC). This division includes a network of Fish Hatcheries, Fish and Wildlife Conservation Offices, Fish Health Centers, Fish Technology Centers, the Conservation Genetics Laboratory in Anchorage, Alaska, and the Aquatic Animal Drug Approval Program. These centers and programs provide assistance and support to conservation partners of FWS, including Federal, State, tribal, and non-governmental organizations that cover a broad range of disciplines including biostatistics, population ecology, genetics, nutrition, and fish health and pathology.

FWS Aquatic Animal Drug Approval Program. The Aquatic Animal Drug Approval Program (AADAP) within the FAC Division currently has four CRADAs in place. Individual CRADAs have been established with AquaTechnics, Inc. (Sequim, WA), Merck Animal Health (Summit, NJ), Aquatic Life Sciences (Ferndale, WA), and Frontier Scientific (Logan, UT). These agreements permit the parties to identify research opportunities that support development of new aquatic animal drugs, broaden the U.S. technology base, and support accomplishment of FWS scientific mission objectives. For example, in 2016, AADAP developed a research study protocol to define the objectives, design, procedures, and methods used to an FDA-acceptable research study evaluating the target animal safety of 17α-methyltestosterone, a chemical used for gender manipulation in rainbow trout fry. The protocol was submitted and accepted by FDA and made available with funding support via one of the above-described CRADAs. A study will soon be conducted to provide critical data required by FDA to support an initial approval for the use of 17α-methyltestosterone in rainbow trout.

Fish Technology Centers. Fish Technology Centers (FTCs) were established in 1965 to develop and improve fish culture technology and provide assistance and advice on fish culture to National Fish Hatcheries, other Federal and State agencies, Tribes, other Nations, and the aquaculture industry. The FTCs developed culture techniques and fish diets now used around the world, including dehydrated long-lasting feeds that revolutionized the fish-culture industry. Results of studies conducted by FWS scientists are published in peer-reviewed journals and

management recommendations are communicated within the Service and to our partners through conservation science partnerships. Following are descriptions of the various FTC laboratories and examples of advances shared through publications and reports in 2016.

Fish Technology Centers contribute to a more sustainable and productive fish-culture industry via improvements in the technologies and practices employed in the industry around the world. [Photo credit: Wendy Sealey].

- **Nutrition and Diet Development Laboratories.** These facilities allow for the manufacture of experimental larval, fingerling, and broodstock fish feeds and the testing of many different kinds of ingredients to improve fish nutrition, performance, and quality. This program also develops specialized diets for use in captive rearing of endangered fish species. Recent work includes development of alternative fish feeds to reduce reliance on fish meal and fish oil, in partnership with public and industry partners. Due to the limited supply and increasing cost of fish meal and fish oil, alternative ingredients are needed to replace these common feed ingredients. Alternative ingredients must be evaluated in feeding trials before they can be used in commercial fish feeds. For example, in 2016, Bozeman Fish Technology Center continued to work with partners to develop new alternative commercial feeds that are optimized for the needs of fish grown in the high intensity systems cultured in a pond environment.

- **Physiology Laboratories**. These laboratories support conservation- and management-related needs of FWS and its partners, including, but not limited to understanding the physiological needs of fish to support their culture for conservation and/or commercial purposes. For example, in FY 2016, Abernathy FTC (AFTC) conducted studies on the impact of rearing fish in recirculating aquaculture system (RAS) on smolt quality. The AFTC also worked with Hagerman National Fish Hatchery and Idaho Fish and Wildlife Conservation Office to investigate composition differences in steelhead raised in RAS systems compared to standard serial reuse raceways. This information added to the data collected during the steelhead RAS study at AFTC to provide a more complete picture of the effects of the RAS on steelhead.

- **Conservation Genetics Laboratories.** These laboratories support conservation and management related needs of FWS and its partners, including, but not limited to: (a) using genetic DNA methods to meet real-time fishery needs to conserve and manage species; (b) assisting with Endangered Species Act status reviews and recovery planning via baseline data on genetic population structures and genetic monitoring and evaluation

of listed populations and species; (c) establishing and maintaining genetic tissue/DNA repositories for imperiled species; and (d) characterizing diversity within and among wild populations. For example, in 2016 the Abernathy Fish Technology Center continued to use genetic markers to compare late returning coho to the hatchery stock and to adjacent wild populations of coho salmon. Understanding the impacts of hatchery operation on adjacent wild populations is critical for the conservation of the species, and has implications for commercial fish production as well.

- **Ecology Laboratories.** These laboratories focus on understanding the physiological requirements and tolerances of threatened and endangered species. Less-invasive or non-invasive tools, such as measurement of plasma sex steroids and ultrasound, are used to determine gender, stage of sexual maturity, and spawn readiness of individual fish in wild and captive populations of threatened and endangered species. These laboratories also provide contract services to federal and states agencies, universities, and NGOs for a variety of analyses employing these less-invasive tools, as well as blood chemistry analysis, histology, proximate analysis, and radio-immunoassays. Recent accomplishments include developing methods to prevent the spread of invasive species such as quagga mussels with minimal impact on native fish species. In addition, laboratories are looking at potential impacts of climate change on fish growth, which could be significant for aquaculture facilities.

- **Fish Passage Research and Engineering.** In 2016, FWS National Fish Passage Program (NFPP) supported research on fish ecology, behavior, and life-history requirements relative to selected environmental factors by using open-channel flumes, swim tunnels, and artificial streams, where researchers can simulate varied stream conditions to address a wide variety of questions for partners conducting fish passage restoration work. NFPP also supported on the ground collaboration and information exchange with local townships and cities on engineering and designing fish friendly road stream crossing structures that are also resilient to flooding events.

Research into fish passage. [Photo credit: USFWS].

- **Fish Health Centers.** FWS's Fish Health Centers play an integral role in applied science and technical transfer. Their scientists are leaders both nationally and internationally in the diagnosis of wildlife diseases and in the science of aquatic animal health, developing and validating tests that benefit, and are adopted by, the aquaculture industry. Fish Health Centers work closely with Federal, State, Tribal, academic, and NGO partners to promote the scientific management of fisheries and aquaculture by reducing the effects of wildlife pathogens. For example, in 2016, the Southwestern Native Aquatic Resources & Recovery Center in Dexter, New Mexico, continued to develop non-lethal screening techniques for the Amphibian chytridiomycosis (*Batrachochytrium dendrobatidis*) in regionally important frogs and toads. One such method is quantitative real-time Polymerase Chain Reaction (PCR), a method to multiply the number of copies of a DNA sequence in a sample in order to increase the likelihood of detecting the presence of that sequence. The laboratory hopes to develop the expertise in quantitative real-time PCR diagnostics of the amphibian pathogen, *B. dendrobatidis* to enable the Center to provide diagnostic services to FWS and its partners.

Demonstration of amphibian swabbing technique to collect a DNA sample. [Photo credit: USFWS].

Aquatic Invasive Species: FWS Aquatic Invasive Species program works to prevent transfer and introductions of exotic, introduced, non-native, and other potentially harmful species and to develop early detection and rapid response capabilities. For example:

- FWS worked with numerous partners to develop environmental DNA or eDNA methods using the previously-described PCR techniques for the detection of minuscule amounts of free-floating DNA in water samples to confirm the presence (or absence) of species at levels undetectable by traditional sampling methods. This innovative technology is now being applied in widespread monitoring programs and, as it continues to be further developed and refined, will significantly benefit both FWS programs and partners by allowing earlier detections of invasive species. For instance:

    - The initial investment in this technology from the Great Lakes Restoration Initiative (GLRI) has created a geographically widespread surveillance program for Silver and Bighead Asian carp implemented by several Fish and Wildlife Conservation Offices and the Midwest Fisheries Center, the newest FTC. Over 25,000 water samples have been collected and processed for eDNA from tributaries of all five Great Lakes, and the Ohio, Upper Mississippi, Tennessee, and Missouri River systems, and states. The test results

will be used in planning management actions. These eDNA methods and tests will be refined and adapted for use for Black and Grass Carp surveillance in the near future.

- FWS is working with University of California, Davis, to develop eDNA markers for use in the early detection of southern watersnake (*Nerodia fasciata*);
- In Alaska, FWS is working with Joint Base Elmendorf-Richardson and the Corp of Engineers to develop an eDNA assay for waterweed (*Elodea spp*.), and with other partners to develop eDNA markers for invasive northern pike (*Esox lucius*).
- FWS is also working with the USGS and EPA to develop Next Generation Sequencing (NGS) methods to evaluate entire community-level data from environmental samples to detect several species at one time. This technique can be utilized beyond invasive species detection to evaluate effects of climate change or other environmental factors on aquatic communities or to evaluate native species community diversity.

Silver Carp jumping in the Fox River. [Photo credit: USFWS].

- FAC has developed rapid screening tools to help determine a species' risk for invasion. Knowledge of both low- and high-risk species will help industry, states, and consumers make responsible choices about which species to acquire and use. In addition, these tools will help state agencies make decisions on potentially invasive species and work with industry to manage risky species in their jurisdictions.
- To help prevent further spread of aquatic invasive species by recreational boats, FWS has funded a proposal from the American Boat and Yacht Council to develop a Technical Information Report that would give manufacturers of boats and associated equipment guidelines and best practices to mitigate the spread of invasive species and assist in the "clean, drain and dry" (including decontamination) process.

Crushed Ivory Design Challenge Prize. The Service announced winners of its Ivory Crush Design Challenge in May, 2016, which invited entrants to propose visual concepts for powerful public displays of crushed ivory from the U.S. ivory crushes. The winners, Kelly Lance of Monterey, Calif., and Jacqueline Nott of Auburn, Calif., will see their ideas translated from paper to three dimensions during the coming months as FWS works with the Association of Zoos and

Aquariums (AZA) to build their designs and identify publicly accessible venues with high visibility to display the exhibits.

VII. Office of Surface Mining Reclamation and Enforcement

The Office of Surface Mining Reclamation and Enforcement (OSMRE) is responsible for ensuring, through a nationwide regulatory program, that coal mining is conducted in a manner that protects communities and the environment during mining, restores the land to beneficial use following mining, and mitigates the effects of past mining by aggressively pursuing reclamation of abandoned mine lands. OSMRE achieves this in part by providing technical assistance based on sound science, and training to its State and Tribal partners to enhance their ability to maintain effective programs.

While OSMRE has no formal research and development program, its Technology Development and Transfer program promotes and disseminates information on technological innovations to better protect the environment during mining and in reclaiming and restoring active and abandoned mines. The program also provides training to ensure that State and Tribal partners continue to administer their surface mining programs efficiently and effectively.

The goals that underlie OSMRE's Technology Development and Transfer program include: (a) increasing the technical knowledge of the reclamation of active and abandoned coal mines; (b) developing and enhancing working relationships among the bureau's partners in Federal, State, and tribal governments, and industry and academia; and (c) leveraging its resources through partnerships.

OSMRE accomplishes these goals via the Technical Innovation and Professional Services (TIPS) program, the National Technical Training Program (NTTP) and the National Technology Transfer Team, as elaborated below.

Technical Innovation and Professional Services (TIPS). The goal of TIPS is to provide State, Tribal, and OSMRE personnel with a comprehensive set of analytical tools to aid in technical decision-making related to regulatory and reclamation processes. The services TIPS provides rely on off-the-shelf scientific and engineering computer hardware and software. This technical assistance has grown from a few software applications available on a single specially-designed shared workstation, to a suite of software on each user's desktop computer.

TIPS is a national program that continues to research emerging technologies and their application to the Surface Mining Control and Reclamation Act of 1977 (SMCRA). A fundamental premise of TIPS is that it enables every official responsible for the implementation and enforcement of SMCRA to use the same technological tools, thereby promoting consistent enforcement of SMCRA nationwide. This also means that personnel enforcing SMCRA can easily exchange data with one another, and since the tools that TIPS provides are predominantly the same as those used by coal mining companies and reclamation contractors, data is easily exchanged between mining and SMCRA officials.

The following are examples of activities undertaken by the TIPS program in FY 2016.

GeoMine Web Application: GeoMine is designed to be an interactive web-based digital map of coal mining and reclamation activities in the United States. During FY 2016, the GeoMine Team tested DOICloud. GeoMine uses a web-based viewer (GeoMine Viewer) developed by OSMRE in collaboration with the Fish and Wildlife Service (FWS), Environmental Protection Agency (EPA), Army Corps of Engineers (ACE), and coal mining regulatory authorities in Kentucky, Tennessee, Virginia and West Virginia. GeoMine supports decision-making associated with surface coal mining activities by improving accessibility to data, improving the timely delivery of authoritative information, and enhancing understanding and visualization of geospatial data at various scales. It also helps mines comply with the requirements of SMCRA, the Clean Water Act (CWA) and the Endangered Species Act (ESA). When fully deployed, the application will display geospatial data that is already publicly available from each contributing coal-producing State and Tribe nationwide. This would increase transparency and allow the public to better understand the impacts of both coal mining and reclamation activities. The OSMRE also continued digitizing mine boundary maps in Kentucky and West Virginia through various AmeriCorps programs, including the Environmental Stewards Program, as well as college students from OSMRE's Mid-Continent and Western Regions. The GeoMine Viewer should be ready for public launch in 2017.

Appalachian Regional Technology Testing Effort: The OSMRE Appalachian Regional office (AR) has initiated a partnership with the AR Field Offices to test new devices that may assist staff in completing their SMCRA tasks. One goal of this effort is to efficiently evaluate emerging technologies by a central group with specific expertise, and provide potential users with reviews so that States and OSMRE Field Offices can select equipment that has been tested, and demonstrated to meet their needs without each office purchasing and testing their own equipment. The majority of the work to date has been aimed at identifying devices and applications that will assist mine inspectors in the field. Smartphones and tablets have been purchased and several apps have been loaded and tested for use in the field. These apps allow AR staff to georeference permit maps for viewing, and use in conjunction with several GPS devices of varying accuracy for data collection and on-site navigation. Specialized equipment such as laser rangefinders, water testing meters, infrared cameras, and small sonar devices are also being tested by AR staff. Reports covering the capabilities and limitations of these devices are made available to potential users. Technical staff from the AR has been assisting inspectors in setting up and troubleshooting the devices as needed. Although initial efforts have been conducted primarily with OSMRE Field Offices, State personnel have been involved. Further efforts are planned to expand this effort, extending the use of the successful tools to our partners within the State Regulatory Authorities (SRAs) through training and technical assistance. AR staff is also working with staff in the other OSMRE regions to coordinate these efforts.

OSMRE staff performing comparative testing of multiple digital divices at a mine site in Pennsylvania. [Photo credit: Stefanie Self, OSMRE].

Bathymetric Survey Equipment: The OSMRE Mid-Continent Region (MCR) purchased a bathymetric survey system which can be used in conjunction with a survey-grade GPS receiver (accurate to within 4 to 6 inches) to faithfully model the bottoms of water-filled pits. Staff from the MCR has used the equipment throughout their region successfully to assist with both Title IV and Title V reclamation work. In partnership with staff from the Appalachian Region (AR), the equipment was used in Tennessee to test the application at an idle slurry impoundment using a small boat. These tests prove that this technology will be useful in completing SMCRA-related projects throughout the nation. Numerous potential applications exist for this equipment and OSMRE staff is currently evaluating its capabilities and limitations.

OSMRE staff preparing the bathymetric survey equipment for use in an impoundment at a coal mine in Tennnessee. [Photo credit: Stefanie Self, OSMRE].

Unmanned Aerial Systems: As part of a multi-year ongoing project, the OSMRE Charleston and Lexington Field Offices and the TIPS Technology Transfer Team also conducted aerial inspections of several mine sites in West Virginia and Kentucky using a small Unmanned Aerial System (UAS), the RQ-16 T-Hawk Micro Air Vehicle (T-Hawk), to help determine whether UASs might be used effectively, efficiently, and at a reasonable cost to enhance OSMRE's mandated oversight duties. The OSMRE was able to inspect areas covered under multiple coal mining permits over a two week period using a high definition video camera mounted on the T-Hawk. These areas covered approximately 235 acres and several miles of mine boundaries. The data captured was used to create 3D models of mining structures, perform volume calculations of approved spoil areas, locate tree planting areas, assess blasting sites (pre- and post-blast) and evaluate permit perimeters to determine if there are disturbances off the permitted site. Tested aircraft (the T-Hawk) was discontinued for use by the DOI Office of Aviation Services (OAS), and a proposal was put out for inclusive, non-military UAS for use by DOI bureaus. OSMRE Appalachian Regional Office and Charleston Field Office have been working with the OAS to procure several smaller UAS for use, and plan to begin deploying the systems into the field in FY17. Several OSMRE State Regulatory Authorities (SRAs) have already purchased UAS for their use in enforcing SMCRA. Cooperation between the OAS, OSMRE and the SRAs will allow all involved to use the best equipment and processing tools to ensure that the enforcement of SMCRA is as efficient and effective as possible.

ArcGIS Image Server: In FY 2016, the OSMRE deployed the ArcGIS Image Extension for Server (ArcGIS Image Server) for internal testing and loading of satellite images. In FY 2016, OSMRE used the ArcGIS Image Server to deliver over eight terabytes of imagery into the hands of TIPS SMCRA program customers in an efficient and effective manner. In FY 2017, OSMRE users will be able to connect to the Image Server, set specific search parameters and readily view and download geospatial data pertinent to their individual projects. The TIPS Remote Sensing Team has cataloged a searchable digital library of raw and processed satellite imagery and derived products. OSMRE will provide these products through the ArcGIS Image Server and they will be accessible to multiple users throughout OSMRE, State, and Tribal offices.

University Partnerships - Minority Higher Education Program: The OSMRE continues to work on building mutually beneficial partnerships with minority serving colleges and universities under its Minority Higher Education Program (MHEP). This includes collaborating with its MHEP partners on training and education programs and providing guidance and direction to ensure that the intended results are achieved. In addition to traditional training within the SMCRA community, the TIPS program continued its collaborative partnership with Adams State University (ASU), a Hispanic Serving Institution in Alamosa, Colorado, through a cooperative agreement with ASU, recognizing that cooperation on resources and knowledge, as well as the advancement of the Clean Energy Economy, would benefit the government, ASU, its students, and the public. The agreement guides the parties in pursuit of common objectives to enhance education, job opportunities, and access to "real world" experience.

TIPS Training Program. This is a collaborative effort among OSMRE, States, and Tribes that provides training to use specialized hardware and software tools related to mining and reclamation. Course developers and instructors are reclamation experts who use TIPS software to solve a wide-range of complex permitting, enforcement and abandoned mine land problems. TIPS training is unique in that OSMRE tailors the training exclusively to mining and reclamation uses. Importantly, most of the tools it uses and provides training for are off-the-shelf applications. The OSMRE delivers TIPS courses on-site at the customers' requests, and in dedicated training centers in OSMRE Regional Offices. TIPS conducted 21 instructor-led classes in FY 2016 with 236 students completing class sessions and another four online training courses for 47 students. The OSMRE conducted three of the training classes at on-site locations to meet the specific training needs of particular offices or groups of students, and enable broader participation throughout the SMCRA community. In FY 2016, the TIPS Training Program received a customer satisfaction rating of 99 percent, meeting the annual Government Performance and Results Act goal.

National Technical Training Program (NTTP). Established in 1985, NTTP is an ongoing training program designed to aid the bureau's mission by increasing the technical competence and professionalism of State, Tribal and OSMRE regulatory and reclamation staff. The NTTP provides comprehensive training in the skills needed to carry out the mandates of SMCRA. The entire program, from identification of training needs through course development and presentation, is a cooperative effort between State, Tribal, and OSMRE offices. The NTTP utilized 126 subject matter expert instructors (mostly volunteers) from State, Tribal, and OSMRE

offices in FY 2016 to teach classes. The instructors are experts in mining regulatory and reclamation practices who keep abreast of changing technologies, evolving methodologies, and policies to ensure the training reflects the best protection and land restoration practices. These instructors participate in course instruction, development, and content revisions. In FY 2016, NTTP trained 700 students from State, Tribal and OSMRE programs. It offered 36 training sessions covering technical, legal, and programmatic subjects ranging from best practices and technologies to protect society and the environment from the adverse effects of surface and underground mining to methods to restore land use capabilities. The course subjects are, where possible, tailored to conditions and characteristics specific to each mining region, and offered in or near those regions. Course subjects include a wide variety of technical areas including design of abandoned mine land restoration, proper inspection tools and techniques, soils and revegetation, identification and handling of acid/toxic forming materials, water quality assessment, legal aspects of enforcement procedures, and preparation of evidence and testimony. In FY 2016, the program achieved an overall effectiveness rating of 95 percent, based on student and supervisor responses regarding the value of the training in their current positions.

National Technology Transfer Team. The OSMRE National Technology Transfer Team (NTTT) brings together members of OSMRE, State, and Tribal SMCRA programs as well as representatives from the Interstate Mining Compact Commission, the Western Interstate Energy Board, and the National Association of Abandoned Mine Land Programs in order to coordinate understanding of mining related issues across the country. Through regular meetings, the parties involved identify, discuss and try to find solutions to common issues that arise through their programs' daily implementation of SMCRA. The team also hosts and participates in technical programs such as workshops, forums, and symposia, in order to collaborate with partners outside the SMCRA community. In addition, the NTTT manages and promotes the Applied Science Program**,** whose goal is to develop and demonstrate improved technologies to address environmental issues related to the mining of coal and the reclamation of the land after mining. The program has accomplished this by funding studies by universities, non-profit organizations, and SMCRA Regulatory Authorities covering topics such as coal mine reclamation, revegetation, blasting, hydrology, coal mine voids and fires, soil productivity, acid mine drainage, and other topics relevant to environmentally responsible mining and reclamation. Applied Science projects are also an important component of OSMRE's Minority Higher Education Program, contributing to the goal of improving the science and technology capabilities of minorities' institutions and their graduates.

When funding is available for Applied Science projects, the NTTT solicits Requests for Proposals (RFPs) to advance environmentally responsible mining and reclamation. The NTTT evaluates and ranks these proposals, and provides its recommendations for funding to the OSMRE Executive Council and Director. OSMRE funds selected Applied Science projects through cooperative agreements with the relevant institutions.

The Applied Science Program had eight (8) ongoing projects at the beginning of FY 2016, of which two (2) were completed during that fiscal year. The seven (7) Technical Investigations funded in FY 2015 are still ongoing with an additional twelve (12) new Applied Science projects funded in FY 2016. Final reports for completed projects are available at http://www.osmre.gov/programs/tdt/appliedscience/projects.shtm.

The NTTT also supports public outreach, through the Youth Initiative Program via participation in such activities as Chemistry Week, Engineer's Week, and the Ohio River Watershed Celebration activities. The main target audiences for these events are elementary students, high school students, and upcoming young professionals.

VIII. National Park Service

As part of its mission, the National Park Service (NPS) actively manages the natural, cultural and historical resources entrusted to it. This management includes preserving and maintaining these resources and, where necessary, preventing impairment, mitigating adverse impacts, or restoring these resources. The vast majority of these activities are undertaken at the level of each individual park unit, but servicewide networks, programs, and centers make related scientific contributions in areas such as inventory and monitoring, and preservation technology.

Scientific activities within NPS focus on improving the understanding and management of park natural and cultural resources. In cooperation with partners, NPS also works to preserve and interpret similar resources outside parks. The information generated by these activities is shared with park managers and stakeholders, including public and private land managers, as well as the broader public, largely through interpretive programs, exhibits, conferences, meetings, training, and standard publication media such as reports, newspapers, journals, magazines, fact sheets, and webpage postings.

In order to expand the range of expertise and tools available to it, NPS participates in many collaborative ventures with universities and other governmental and non-governmental organizations, including the Cooperative Ecosystem Studies Unit Network.

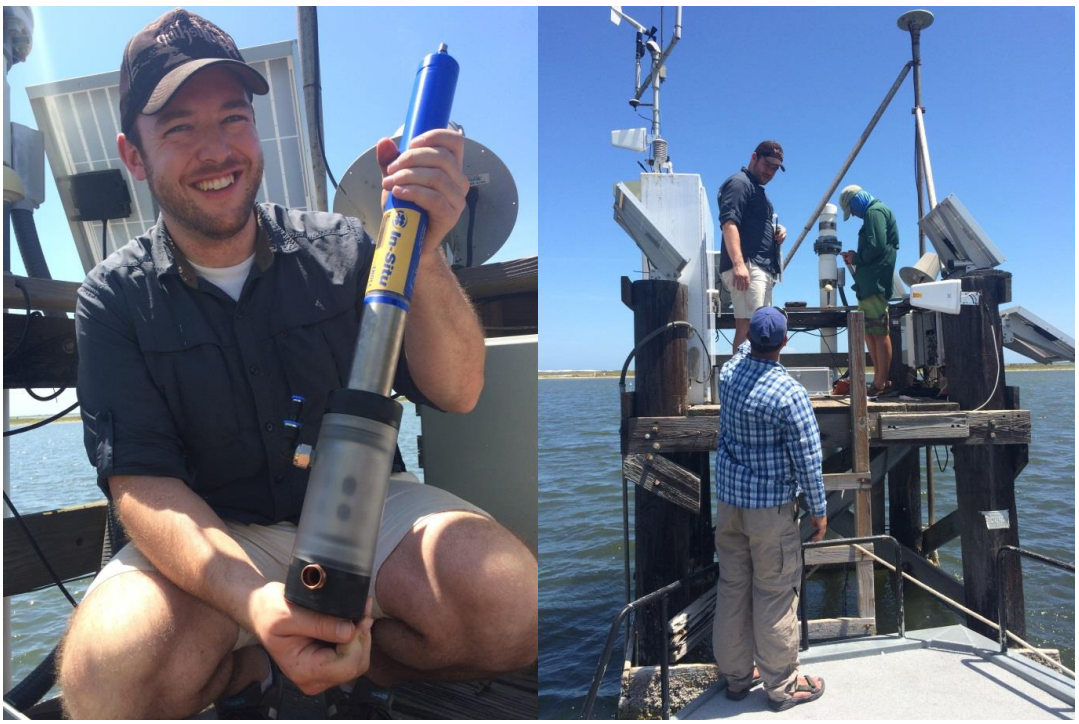
The NPS Cultural Programs include the National Center for Preservation Technology and Training (NCPTT), which was created by Congress to fill a fundamental need for research and technology transfer among Federal, State, and local historic preservation programs. NCPTT serves as a research and development laboratory for historic preservation and advances the application of science and technology to preservation problems. The NCPTT also supports applied research, partners with professional and scientific organizations, publishes technical guidance for preservation professionals, and trains students and practitioners in the latest preservation techniques.

The NPS also encourages qualified scientists to undertake research on park physical, biological, and other resources under the aegis of park Scientific Research and Collecting Permits and other permits. Such permits are issued for scientific and educational purposes only. The collected specimens and other materials and components of such specimens and materials may not be used for commercial or other revenue-generating purposes. Parties proposing commercial use of research results must enter into an agreement to share benefits with NPS or an agreement in which NPS explicitly declines to share benefits. In accordance with the National Parks Omnibus Management Act of 1998, which authorizes the Secretary of the Interior to enter into negotiations with the research community and private industry for equitable, efficient benefits-

sharing arrangements, NPS has developed policy and procedures to implement benefits sharing. For each benefits-sharing agreement, NPS proposes to choose an applicable agreement type from among several available authorities. The CRADA, authorized by the FTTA, is one such option. NPS issued the benefits-sharing policy on December 19, 2013, and the benefits-sharing handbook on September 29, 2014. See http://www.nps.gov/applications/npspolicy/DOrders.cfm.

Device to Facilitate Water Quality Measurement in High Biofouling Environments. The Gulf Coast Inventory and Monitoring Network entered into a CRADA with In-Situ, Inc., to develop and test an NPS employee's invention and evaluate its potential for commercial manufacture and sale. The device enables currently available datasondes, which are used to measure water quality, to greatly increase the length of unmanned or continuous monitoring deployments in biofouling environments. It may also increase accuracy under turbulent flow conditions. The device modifies the calibration chamber of the sondes so that instrument/sensor drift, rather than water quality conditions, drives recalibration frequency requirements. By extending service intervals, this device may reduce operational costs by 50% or more.

The NPS and the company are collaborating to produce beta test instruments and deploy them at sites with high biofouling or sediment issues in differing conditions, such as warm marine, cold marine, and fresh water lake and river environments.



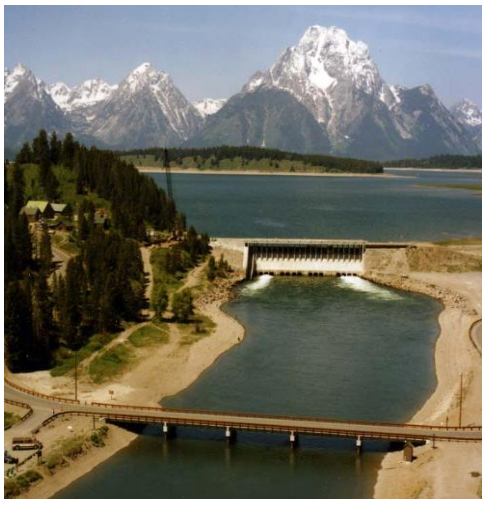
The modified datasonde is installed on August 18th in the Laguna Madre, Padre Island National Seashore. This shallow, high biofouling marine environment will test the effectiveness of the invention to minimize the impact of biofouling on data collection. Biofouling increases instrument maintenance and decreases data quality. LEFT: Andrew Warwick of In-Situ holds a datasonde showing added copper ports associated with the invention. RIGHT: The CRADA team adjusts the above-water solar-powered instrumentation that controls the operation of the datasonde, collects data, and sends the data in real time via a radio transmitter to researchers at distant locations. [Photo credit: Joe Meiman, NPS, 2016].

Prize Competition: *Memorials for the Future*

NPS initiated a prize competition in partnership with the National Capital Planning Commission (NCPC), and Van Alen Institute on *Memorials for the Future*, an ideas competition to reimagine how future Americans may think about, feel, and experience memorials. This competition was initiated as part of the National Park Service 2016 Centennial. Submissions from around the world involved over 300 participants. From the proposals, 30 semifinalists were identified, and a jury chose four finalists. The final proposals helped NPS to think beyond the boundaries of the existing memorial landscape, but none will be built as part of this competition. Climate Chronograph, the winning concept, is a forward-looking memorial that takes a complex global process—climate change—and turns it into a tangible, personal experience. This initially traditional-looking memorial offers a reimagined landscape and a living observatory that allows people to interact with the space as it evolves unpredictably over time. Themes and trends are summarized in a findings report—*Not Set in Stone: Memorials for the Future*.

IX. Bureau of Reclamation

The Bureau of Reclamation (Reclamation) is a water management agency whose mission is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public. It is the largest wholesaler of water in the country. It brings water to 31 million people, and to one out of five Western farmers, who produce 60 percent of the Nation's vegetables and 25 percent of its fruit and nut crop. Reclamation is the second largest producer of hydroelectric power in the Western United States. Its 53 power plants annually provide more than 40 billion kilowatt hours of electricity, enough to power 6 million homes, generating $1 billion in revenues.



Jackson Lake Dam, with the Grand Tetons in the background. [Photo credit: Dave Walsh, Bureau of Reclamation].

Reclamation R&D – Reclamation's R&D is primarily focused on applications to identify and develop solutions related to the broad spectrum of water and hydropower related issues. Reclamation's Research and Development Office manages two appropriated R&D programs. The Science and Technology (S&T) Program is the primary R&D program for Reclamation and funds intramural research that spans the spectrum of water and water related resources research. The Desalination and Water Purification Research (DWPR) Program invests in extramural R&D that advances the capabilities of water treatment technologies to become more broadly used by others in creating new water supplies. Such new water supplies can relieve water stress on Western communities, Tribes, Western river basins supporting Reclamation projects, and the Nation as a whole.

S&T Program goals are to identify and develop cost effective solutions to the technical and scientific problems affecting accomplishment of Reclamation's mission and to communicate

those solutions to Reclamation offices, its stakeholders, other water and power management officials, and the general public. This applied R&D Program addresses the full range of technical issues confronting Reclamation water and power managers and their project stakeholders. It has contributed many tools and capabilities that are currently used by Reclamation and western water managers. Program products strengthen the scientific basis of Reclamation's decision-making related to policy development, program implementation, and water and power operations.

Program funding is allocated and coordinated across following areas: (1) Research and Development Projects (2) Water and Power Technology Prize Competitions, and (3) Technology Transfer.

Reclamation Research and Development Projects – The S&T Program research and development projects are competitively selected based on relevancy to Reclamation mission and on technical adequacy. This ensures projects have the ability to meet priority needs that have broad application across Reclamation and the West. These projects address a wide range of scientific and technical challenges facing Reclamation water and power managers spanning four areas:

- Conservation or expansion of water supplies
- Environmental compliance issues confronting water delivery and management
- Water and power infrastructure reliability
- Water operations decision support

Needs identification and prioritization under each area is guided by input from Reclamation end-users and informed by perspectives from partner agencies and stakeholders. In response to these needs, the program invites research proposals through internal research solicitation and external research brokering. Research funding is awarded to employees bureau-wide, based on proposal relevancy to Reclamation mission and on technical adequacy. Projects address any of the above four areas and typically have strong cost-sharing and collaboration with Reclamation end-users, stakeholders, other agencies, and/or universities. External research is often used to complement internal research to be responsive to agency science priorities that evolve over time and typically cut across the four areas. Such external research is implemented through contracts, cooperative agreements, interagency agreements, and technology transfer agreements. It often involves leveraging external expertise and specialized collaborative capabilities, which enable targeted research to more rapidly address priority science needs.

Desalination and Water Purification Research: This program provides financial assistance for desalination and advanced water treatment research and development leading to improved technologies for converting unusable waters into useable water supplies. Expanding water supplies through advanced water treatment is central to a strong portfolio of climate change adaptation tools that water managers need to adapt to changes in water availability. It also contributes to Reclamation's goal of creating new water supplies in a sustainable manner, which helps relieve stress on Western communities, Native Americans, and the Western river basins supporting Reclamation projects.

Program priorities include development of improved methods of desalination, incorporating renewable energy into desalination processes, and reducing the costs and environmental impacts of treating impaired waters including, but not limited to, sea water, inland brackish groundwater, municipal wastewater, and produced waters from oil and gas extraction activities. Through the program's competitive extramural funding opportunity announcements, Reclamation identifies and enters into research and development cooperative agreements with non-Federal recipients. Through these funding opportunities, the program leverages investment from other federal and non-federal entities to facilitate the advancement and deployment of new technologies. Knowledge generated from this investment is made available to communities, organizations, and industry.

In addition to research and development financial assistance, the program also supports the operation and maintenance of Reclamation's Brackish Groundwater National Desalination Research Facility (BGNDRF). This facility provides pilot and field test facilities for program award recipients, as well as other research and development entities working in government, private, academic and other sectors.

Reclamation Technology Transfer – Although Reclamation's R&D focuses on water and power issues specific to the arid and variable climates characteristic of the Western U.S., the new solutions, tools, and information developed can have broad applicability regardless of location. The transfer of Reclamation's technology and knowledge across the national and international communities of practice maximizes public benefits of Reclamation's R&D investments.

The majority of Reclamation's technology advancements are transferred through public dissemination, while others require the capabilities and know-how of the private sector to mature, mass produce and otherwise commercialize the technology into market-ready products. Reclamation's research nexus with industry is typically in the area of hydroelectric power generation, water infrastructure, water conservation, and desalination/water purification technologies.

If an industry partner is needed to ultimately transfer the technology into a market-ready product, Reclamation utilizes the authorities available under Federal technology transfer legislation to protect intellectual property, as needed, and form research and licensing partnerships with U.S. manufacturing industries. Reclamation's R&D Office implements these authorities on behalf of the bureau, and serves as the Bureau's Office of Research and Technology Applications (ORTA), as required by 15 USC § 3710(b).

The R&D Office utilizes a funded interagency agreement with the USDA Agricultural Research Service (ARS) Office of Technology Transfer to have access to their full range of expert skills needed to implement technology transfer authorities (e.g. experienced technology transfer specialists, patent advisors, license specialists, CRADA specialists) on a project-by-project basis. This arrangement benefits the government since it avoids the need to build similar capabilities within Reclamation or the Department.

Reclamation also works to create more awareness across U.S. industries and other non-governmental organizations about the specialized research resources (people, lands, and

facilities) that they can access through technology transfer agreements authorized by 15 USC § 3710a. In addition to physical research laboratories, Reclamation's R&D assets include engineering and scientific expertise, and extensive water storage, water delivery and hydropower facilities that offer unsurpassed real-world laboratories for field tests, evaluations, and demonstrations of new technologies and processes related to water and hydropower. Although the majority of its R&D activities do not involve development of patents or industry involvement to mature technologies into viable products, the technology transfer activities that Reclamation conducts under the authorities of the Federal technology transfer legislation are an important subset of its technology transfer responsibilities.

Highlights of activities conducted under the Federal Technology Transfer Act during FY 2016 include the following:

Notable Technology Development Award. In addition to disclosing two inventions, filing a patent application and receiving one patent in FY 2016, Reclamation received a Notable Technology Development Award, an award that recognizes new technologies that serve the common good, from the Federal Laboratory Consortium Mid-Continent (FLC MC) Region for its Flexible Magnetic Flux Probe.

Electricity is generated by exposing coils of wire to a fluctuating magnetic field (or flux). The amount of electricity generated depends, among other things, on the strength of the magnetic field created by the electromagnets. The electromagnets themselves consist of many loops of electricity-carrying insulated wire wound around an iron core to create magnetic poles. With age, the insulation deteriorates, short circuits develop in the windings, and the magnetic field strength declines, reducing electricity generation. Eventually, this could lead to an extended shutdown of the generator in order to rewire the rotor.

Reclamation's Hydropower Technical Services Group has developed and patented (#6466009) a flexible magnetic flux probe that detects deteriorating insulation in large-scale spinning electrical generators, preventing failure as well as expensive repairs and replacements. The inexpensive, small, flat, light, and flexible probe accurately measures the magnetic flux, and can be mounted in the air gap without rotor removal or shutdown. The designed probe is very thin, allowing for easy installation into the air gap. If the probe is dislodged during generator operation, because of its flexibility, it will not damage the generator. Reclamation has a non-exclusive license agreement with Iris Power LP, and currently has sold over 200 probes.

The inventors for the flexible magnetic flux probe include Reclamation's Jim Dehaan, Malin Jacobs and Bert Milano. Jim Dehaan received the award at the FLC MC's Regional Meeting and Award Event in Albuquerque, New Mexico.

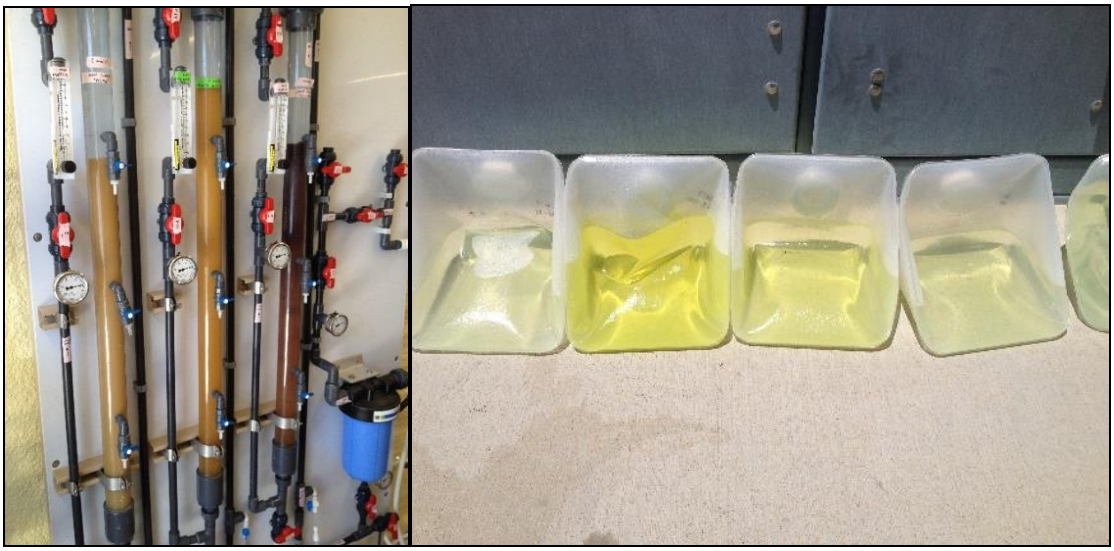
Reclamation's Samantha Zhang, Technology Transfer Coordinator (left), and Jim Dehaan, Electrical Engineer (center), received the Notable Technology Development Award at FLC Mid-Continent Regional Meeting and Award Event, from the Regional Coordinator, John "Jack" James, NASA Johnson Space Center, Houston, in Albuquerque, New Mexico. [Photo credit: FLC].

Developing Reclamation Technology Transfer Directives and Standards. The Research and Development Office finalized the Reclamation Directive and Standard (D&S RES 01-01) for implementing the new Department Manual Chapter for Technology Transfer (761 DM1) that was issued on May 16, 2014. The D&S RES 01-01 was released in March 2016. It establishes responsibilities and requirements for Reclamation to maximize the benefits provided by the Federal Technology Transfer Act of 1986. This Act authorizes all agencies, including Reclamation, to jointly work with non-Federal entities in developing and commercializing new solutions to water and water -related problems.

The purpose of this D&S is to facilitate effective partnerships that can leverage shared capabilities and costs, and more effectively develop and move technologies to stakeholders in the public and private sectors. Additionally, these partnerships allow Reclamation and the non-Federal partners to efficiently and cost-effectively generate user ready solutions that can improve the economic, environmental and social well-being of the United States.

Testing brine waste using nanofiltration membranes. Hexavalent chromium (Cr^{6+}) or brine waste occurrence in potable water sources is of concern to water utilities due to undetermined human carcinogenic and toxic health effects. EPA is currently reviewing health assessments to determine if new federal standards need to be set for Cr^{6+}. Independently, California's department of public health set a drinking water maximum contaminant level (MCL) for Cr^{6+} at10 µg/L. Limiting Cr^{6+} brine is beneficial to all water utilities.

Reclamation's Denver Water Treatment Engineering and Research Laboratory has entered into a Material Transfer Agreement with an environmental consulting company to combine their specialized capabilities to test reductions in Cr^{6+} using nanofiltration membrane processes. Nanofiltration processes are used to recover regeneration salt (a liquid solution used in the regeneration process and an important contributor to chemical cost) which reduces the volume of waste. This agreement would allow both parties to gain insight on treating Cr^{6+} from ion exchange potable water treatment plants to levels that would comply with EPA and State of California standards. It would also allow both parties to better understand the potential for nanofiltration membranes to play a larger role in expanding our nation's usable water supplies.



Left: Pilot-scale ion exchange resin columns. Right: Regeneration brine. [Photo credit: Reclamation].

Prize Competitions to Develop Innovative Solutions to Water-Related Problems

Reclamation's Research and Development Office (through the Science and Technology Program) established the Water Prize Competition Center in FY 2015 to launch nationwide prize competitions under the authorities provided by the America COMPETES Reauthorization Act of 2010 (15 USC § 3719), an amendment to the Stevenson-Wydler Technology Innovation Act.

The Reclamation Water Prize Competition Center began launching prizes that sought innovative solutions related to the following mission-critical areas.

- *Infrastructure Sustainability.* These prizes would be designed to help increase the efficiency and effectiveness of operations, maintenance, and repair of the extensive inventory of water storage, water delivery, and hydropower generation infrastructure managed by Reclamation. They would help meet increasing water demands of the West while protecting the environment and the public's investment in these facilities.

- *Environmental Compliance*. These prizes are intended to help recover fish species listed as threatened and endangered, and prevent new listings under the Endangered Species Act. Effective solutions will help Reclamation comply with environmental laws and

regulations and sustain healthy aquatic ecosystems, while continuing to meet its water delivery obligations.

- *Water Availability.* These prizes would assist Reclamation to better conserve and manage existing water supplies, create new sources of useable supplies, and forecast and manage water supplies to meet competing water needs under a variable and changing climate.

Collaborative Prize Challenges. Prior to FY 2016, Reclamation had established the WPCC and forged coalitions with other federal agencies that have a stake in mission areas related to water resource management to work with the Center to collaboratively design, launch, and judge the prize competitions. Federal collaborators currently include USGS, NOAA, USACE, FWS, USDA, NASA, EPA, and NIST. The Federal collaboration enables agencies to leverage Federal capabilities, catalyze interagency working relationships, better define and solve joint problems, avoid duplication, and find solutions that have a broader impact across the mission of multiple Federal agencies, stakeholders, and overall public good. For these efforts, in October 2015, Reclamation received awards at the five-year anniversary of *Challenge.gov* for *Newcomer of the Year* and *Best in Technology*. In addition, Saied Delagah, a Reclamation desalination research expert, received the *Unsung Hero* award for his outstanding, behind the scenes coordination of the technical efforts that enabled the Desal(ination) Prize.

During FY 2016, Reclamation initiated efforts to recruit non-federal collaborators. This included posting a FedBizOpps Notice seeking non-federal partners, and actively reaching out to non-federal organizations. Opportunities for non-Federal partners to collaborate included contributing to the prize purse; providing technical experts, judges, and testing facilities; promoting the competition to the public and solver communities; commercializing winning solutions; and helping administer the competitions.

These efforts resulted in the States of Colorado and California contributing technical experts and judges for several competitions. Reclamation also entered into an agreement with Xylem Inc., a global water technology company, to collaborate on two prize competitions. Xylem will contribute to the prize purse, and provide subject matter experts to help design and judge competitions. The company will also have the opportunity to broker business deals with competitors to commercialize their solutions, and thereby accelerate the process of innovation into market ready products that can serve the water resources community while driving the economy and creating jobs. In addition, Reclamation entered into an agreement with the Water Environment and Reuse Foundation to help promote specific competitions to solver communities. Reclamation is also in the process of negotiating additional collaborations and reaching out to others. Continuing to build non-Federal collaborations will be an emphasis for FY 2017.

New Prize Competitions. During FY 2016, Reclamation launched four new prize challenges:

1. Quantifying Drift Invertebrates in River and Estuary Systems
2. Downstream Fish Passage at Tall Dams
3. Detecting the Movement of Soils (Internal Erosion) Within Earthen Dams, Canals, Levees, and their Foundations

4. Preventing Rodent Burrows in Earthen Dam, Canal, and Levee Embankments

Additional information on these challenges can be obtained at:
https://www.usbr.gov/research/challenges/past/index.html

All four of these competitions consisted of ideation challenges for new and better concepts to tackle persistent tough problems. Each involved multiple Federal agencies as well as the States of Colorado and California.

The prize competition approach enables Reclamation to engage individuals and organizations with impressive credentials that do not work for Reclamation. Results to date illustrate the value of using prize competitions to solicit solutions and concepts from the broader public, introduce new or improved ideas into the thinking of subject matter experts, and stimulate thinking about other ways of implementing some of these ideas.

Many of the awarded solutions were novel to Federal subject matter experts while others offered improvements to existing methods. While each solution will also require additional development and testing before they can be fully proven and implemented, the overall results to date vindicate the hopes for offering prize challenges as a method of stimulating innovative solutions and technologies.

X. Bureau of Safety and Environmental Enforcement

The Bureau of Safety and Environmental Enforcement (BSEE) works to promote safety, protect the environment, and conserve resources offshore through vigorous regulatory oversight and enforcement. BSEE's R&D focus is on offshore operational oil, gas and renewable energy issues.

Within BSEE, the Office of Offshore Regulatory Programs (OORP) develops standards and regulations to enhance operational safety and environmental protection for the exploration, development, and production of offshore oil and natural gas on the U.S. Outer Continental Shelf (OCS).

The Oil Spill Preparedness Division (OSPD) is responsible for developing standards and guidelines to ensure that offshore operators are prepared to respond to an offshore oil spill. It also ensures their Oil Spill Response Plans comply with regulatory requirements. OSPD plays a critical role in the review and creation of policy, guidance, direction and oversight of activities related to the agency's role in ensuring industry's preparedness for oil spill response. The Division oversees the Oil Spill Response Research (OSRR) program, and works closely with sister agencies such as the U.S. Coast Guard, the National Oceanic and Atmospheric Administration, and Environmental Protection Agency to continually enhance response technologies and capabilities.

OSPD also operates Ohmsett in Leonardo, NJ, which serves as the National Oil Spill Response Research and Renewable Energy Test Facility. Although not classified as a Federal laboratory,

Ohmsett is available for use by industry and government. Advances made by research conducted at the Ohmsett facility are vital to the oil spill response industry.

BSEE R&D programs operate through the Emerging Technologies Branch (ETB) within the Office of Offshore Regulatory Programs, and the Oil Spill Response Research (OSRR) program housed in the Response Research Branch/Oil Spill Preparedness Division. The former supports research associated with operational safety and pollution prevention (including renewable energy). The ETB, established in 2012 to replace the Technology Assessment and Research (TA&R) group, is the agency's focal point on operational safety and pollution prevention research. It also helps ensure that industry operations on the Outer Continental Shelf incorporate the use of Best Available and Safest Technologies (BAST), as required in the 1978 Outer Continental Shelf Lands Act amendments. The OSRR program was established through the Oil Pollution Act of 1990 to research oil spill response technology and operational techniques. Within OSRR, the Ohmsett facility is available to provide independent and objective performance testing of full-scale oil spill response equipment and marine renewable energy devices. Additionally, the facility is available to improve existing technologies through research and development.

The majority of the bureau's technology advancements are transferred through public dissemination. In addition to making the final reports of research projects publicly available on its website, BSEE also makes its research results available via conferences, and other fora, e.g., the annual Clean Gulf Conference; the Pacific States-British Columbia Oil Spill Task Force Annual Meeting; and the Ocean Energy Safety Institute's Public Research Forum.

BSEE's primary research synergy is with state, federal, and international government organizations; the oil/gas and renewable energy industries; and oil spill response organizations. It is typically in the area of ensuring that the best available and safest technology is used on the US Outer Continental Shelf and the best available science is utilized in regulatory decision making. Additional information and research deliverables are available at https://www.bsee.gov/what-we-do/research/tap and https://www.bsee.gov/what-we-do/oil-spill-preparedness/oil-spill-response-research.

BSEE is a member of the International Committee on Regulatory Authority Research and Development (ICRARD), which focuses on transferring knowledge worldwide between governmental entities in the area of health, safety, and environment in the petroleum sector. Although membership is only available to government entities, ICRARD cooperates with industry to coordinate and transfer technology.

BSEE is also a member of the Interagency Coordinating Committee on Oil Pollution Research (ICCOPR). Comprised of 15 Federal agencies, ICCOPR was established as part of the Oil Pollution Act of 1990 to "coordinate a comprehensive program of oil pollution research, technology development, and demonstration among the Federal agencies, in cooperation and coordination with industry, universities, research institutions, state governments, and other nations, as appropriate."

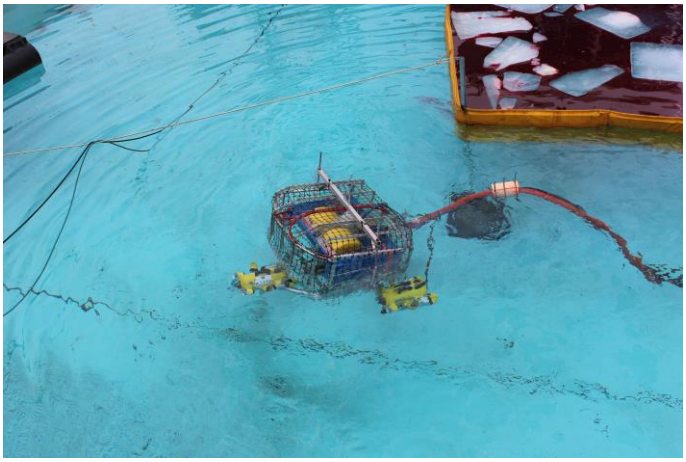
The following are examples of publicly available research projects, completed or ongoing, in FY 2016 which would, among other things, advance technological options and transfer knowledge about best technological practices to industries and regulators operating on the Outer Continental Shelf.

Development of an Autonomous Oil Skimmer (AOS): The goal of this project was to develop a strap-on navigation, sensor, and computer control system that could be used to direct a variety of commercial off the shelf (COTS) skimmers and vessels to autonomously maneuver and skim the oil from a given area, with automatic tracking and reporting of progress and performance. This project resulted in a prototype for an autonomous oil skimmer (AOS) system that consisted of a commercial off-the-shelf (COTS) skimmer and vessel, a COTS autopilot system, a high precision navigation package, oil thickness and recovery efficiency sensors, and a custom computer algorithm. This system was designed to monitor the thickness of the oil being skimmed in real time and track oil thickness versus position as it was skimming. Based on the oil thickness gradients, the tracking algorithm directed the vessel/skimmer to head in the direction of thickest oil concentration. As oil was recovered, statistics on oil thickness and oil recovery rate as a function of position were tabulated for real time performance monitoring. During this effort a proof of concept prototype was developed and tested at the Ohmsett facility. It was determined that the COTS oil thickness and recovery efficiency sensors were not adequate for use in this system, and would require further development.

Technology Readiness Level (TRL) Definitions for Oil Spill Response Technologies and Equipment: The objective of this project was to establish a uniform and objective means to determine the level of maturity of a new oil spill response technology, and assess its readiness for use in the field. TRLs are used extensively in the aerospace and defense communities. This project adapted this existing framework and refined the standard definitions so that they are appropriate for use in the oil spill response community. It also provided examples of simulated and intended environments for appropriate testing at the various levels. The project integrated feedback from subject matter experts from government, manufacturers, testing facilities, and the offshore oil spill response providers. These new TRLs will be utilized by BSEE for assessing future oil spill response technology development projects. Additionally, BSEE is working with other federal partners such as the U.S. Coast Guard to integrate TRL assessments into their evaluation process.

A Novel Experimental Approach to Enhance Burning of Oil-Water Emulsions by Immersed Objects: The objective of this study was to test a theory that using conductive metal rods would enhance the burning rate of a liquid pool of emulsified oil. The researchers developed experiments in order to evaluate and optimize various parameters of importance in testing this concept, including the length, diameter, and spacing of the rods. A simplified computational fluid dynamics (CFD) analysis was performed in parallel to help guide the experiments and to develop an understanding of how simplifications could be successful in developing empirical relationships that would ultimately be used for designing burners deployed in the field. A prototype field burner was designed. Four large scale tests were performed using crude oil with emulsified water content at 25%, 40%, and 60%. The outcome of these large scale tests could inform the design of a simple, efficient burner that could be deployed in the field.

Development of Universal Submersible Skimmer Delivery System: This project investigated a new approach for removing oil from ice-water mixtures. It leveraged a submersible, remotely operated vehicle (ROV) technology to develop a prototype system to deploy and maneuver a skimmer underwater to the location of the oil, where it would then surface and begin recovery operations. The prototype skimmer was encased within an "ice cage" that was designed to keep ice away from the skimmer's brushes and pumps (see picture below). This robotic technology could advance industry's ability to remove oil from otherwise inaccessible locations. During this effort a proof of concept prototype was successfully tested at the Ohmsett facility.



The skimmer prepares to submerge and maneuver under the containment skirt to recover the oil. [Photo credit: BSEE].

Composite Repair Guideline Document for Nonmetallic Repairs for Offshore Applications: BSEE's Office of Offshore Regulatory Programs (OORP) collaborated with the U.S. Department of Transportation's Pipeline and Hazardous Materials Safety Administration (PHMSA) to evaluate the use of composite repair technologies for reinforcing offshore pipelines and risers, as well as onshore pipelines. The principal aim of the work was to provide both BSEE and PHSMA with a technical document providing guidance for using composite repair technology to repair and reinforce damaged offshore pipelines, risers, and onshore pipeline systems. This was accomplished by conducting a comprehensive state-of-the-art assessment integrating an extensive body of work completed over the past 10 years. Full-scale testing of these technologies, including a 10,000 hour simulated seawater test, was also planned to simulate both offshore and onshore environments.

Subsea Blowout Preventer (BOP) Stack Shear/Seal: This project addresses the need for a uniform verification method to assure that BOPs function as intended when blind-shear rams used to seal a wellbore are actuated to prevent a blowout. It would conduct computational analyses for a set of general cases where the following parameters are varied: tubing/string geometry (size/thickness), flow conditions/well pressure, fluid properties, and ram geometry. Computational analysis will include finite element analysis (FEA) and well modeling simulations to analyze shear forces and deformation within the well tubing resulting from both ram action and fluid forces (hydrostatic pressure at water depth & wellbore kick). The results from these simulations would enable the development of a modeling tool with the ability to

interpolate ram forces on the well structure during BOP operation. This project is currently on-going.

Hampering Active Wellbore Kit (HAWK): Complementary Safety Tool for Blowout Preventers: This project would result in the development of a machine that would predictably stem an uncontrolled flow from a failed Blowout Preventer. The tool, referred to as the "Hampering Active Wellbore Kit" (HAWK), is a machine that can feed a wire from a spool it carries through a BOP's existing ports and into the wellbore. The wire forms a tangled wire mass that would gradually constrict the uncontrolled flow. A prototype machine for direct attachment to a BOP as a backup safety system will be presented based on operating constraints and industry requirements.

Venting and Flaring Research: Venting and flaring of natural gas on offshore operations impose costs to the environment and opportunity costs to society associated with the gas not being captured and sold. The objective of this study was to assess offshore engineering technology to reduce such venting and flaring, in accordance with clear agency regulatory objectives. Venting and flaring research aims to provide BSEE with analyses in a timely manner to increase knowledge of venting and flaring practices in offshore operations. Such advanced knowledge may, in turn, lead to improvements in the oversight and regulation of methane gas venting and flaring activities.

XI. Bureau of Ocean Energy Management

The Bureau of Ocean Energy Management (BOEM) is charged with managing the Nation's offshore energy and mineral resources in an environmentally and economically responsible way.

BOEM manages access to and fair return for conventional and renewable energy and mineral resources of the Outer Continental Shelf (OCS) to help meet the energy demands and mineral needs of the Nation while also balancing such access with the protection of the human, marine, and coastal environments. As the Nation's offshore energy and mineral resource manager, BOEM is committed to using the best available science to administer a comprehensive, progressive cycle of analyses to provide the key information necessary for decisions about whether, where, and when offshore energy and mineral development can or should occur.

Management of the energy and mineral resources of the OCS is governed by the OCS Lands Act, which sets forth procedures for leasing, exploration, and development and production of those resources, including oil, gas, offshore renewable energy, and marine minerals such as sand and gravel used for coastal restoration projects.

BOEM's Office of Environmental Programs (http://www.boem.gov/Environmental-Stewardship/) conducts environmental reviews, including *National Environmental Policy Act* (NEPA) analyses and compliance documents for each major stage of energy development planning. These analyses inform the Bureau's decisions on its 5-Year OCS Oil and Gas Leasing Program, and a variety of conventional and renewable energy leasing and development activities.

Additionally, BOEM's scientists conduct and oversee environmental studies to inform policy decisions relating to the management of energy and marine mineral resources on the OCS through its Environmental Studies Program (ESP).

BOEM's three regional offices — New Orleans, Louisiana; Camarillo, California; and Anchorage, Alaska — manage oil and gas resource evaluations, environmental studies and assessments, leasing activities, including the review of plans for exploration, development and production, fair market value determinations, and geological and geophysical permitting.

BOEM Environmental Studies Program. The BOEM Environmental Studies Program applies the best science available for informed decision-making. It plans, conducts and oversees world-class scientific research to inform policy decisions regarding leasing and development of OCS energy and mineral resources. BOEM works to manage the exploration and development of the Nation's offshore resources in a way that appropriately balances economic growth, energy development, and environmental protection through oil and gas leases, renewable energy development, and environmental reviews and studies.

BOEM's environmental studies cover a broad range of disciplines including archaeological resource protection, physical oceanography, meteorology and air sciences, biology, protected species, social sciences and economics, submerged cultural resources evaluation, and the overall environmental effects of energy development. BOEM continues to be a leading contributor to the growing body of scientific knowledge about the Nation's marine and coastal environment.

BOEM oversees scientific research conducted through contracts, partnerships with other governmental bureaus, cooperative agreements with State institutions or universities and interagency agreements. These arrangements enable the bureau to leverage resources, meet national priorities and satisfy common needs for robust scientific information. Many of the Bureau's studies are collaborations with partners under the umbrella of the National Oceanographic Partnership Program.

BOEM Technology Transfer. BOEM's technology transfer activities include the dissemination of information, knowledge and technologies to the various regions, and to commercial entities and other stakeholders with interests in the OCS.

Studies that have been undertaken by or through funding from BOEM are available to the public through the Environmental Studies Program Information System (ESPIS), and technical summaries of more than 700 BOEM-sponsored environmental research projects, as well as copies of more than 2,000 research reports, are available for online full text search. To learn more about BOEM's ongoing work to further environmental studies, go to: http://www.boem.gov/studies.

BOEM also partners with BSEE to select and fund research into renewable energy to facilitate industry development, and promote operational safety and pollution prevention through BSEE's Technology Assessment Program. More information on this research is available at https://www.boem.gov/Technology-Assessment/.

Many large interdisciplinary projects with funding from BOEM have included partnerships with other Federal agencies and academic institutions as well as private companies directed towards offshore ecosystem studies that utilize state-of-the-art technologies such as autonomous underwater vehicle surveys, deep-water human-occupied submersibles and remotely operated vehicles. Many projects have developed innovative imaging technologies and digital analysis techniques for establishing long-term biological monitoring stations in deep water. These partnership studies have leveraged expertise and technologies to meet common management goals.

Following are few examples of BOEM's scientific research and development activities undertaken in FY 2016, including some conducted in cooperation with other parties.

Passive Acoustic Monitoring. BOEM's Gulf of Mexico Region (GOMR), Office of Renewable Energy Programs (OREP) and Environmental Studies Program (ESP) funded various passive acoustic monitoring efforts. These include a GOMR-led effort to establish long-term hydrophone stations in the Northern Gulf of Mexico to help characterize noise impacts to protected species, primarily cetaceans, that may occur due to BOEM regulated seismic, decommissioning, drilling, and vessel activity in the Gulf of Mexico OCS. Similarly, OREP has set up hydrophone arrays in close proximity to Atlantic Wind Energy Areas to monitor marine life and help mitigate noise produced from the construction and operation of OCS wind energy facilities. The ESP is helping to coordinate these efforts by funding the phase II development of Tethys, a knowledge management system that gathers, organizes, and disseminates information on the environmental effects of marine and wind energy development and which is used to annotate recordings with detections of marine mammals for further analysis and use.

Ocean Animal Telemetry. BOEM's Marine Minerals Program (MMP), Office of Renewable Energy Programs (OREP) and Environmental Studies Program (ESP) have funded acoustic telemetry efforts. MMP has, for example, an ongoing tagging program to understand how fish use areas under consideration for dredging. OREP's tagging efforts are to help determine the presence of important commercial and protected fish species in the Atlantic wind energy areas. ESP is contributing funds to establish a National Animal Telemetry Network hosted at the US Integrated Ocean Observing System program, to coordinate research investments across the federal community, and manage data from these disparate efforts.

Nanotagging of Migratory Seabirds and Bats. The Office of Renewable Energy Programs (OREP) conducts studies of avian species movement and migratory behavior to better understand the potential impacts on protected species from the installation and operation of offshore wind turbines. These efforts are being coordinated with the USFWS Migratory Species Division in the Northeast Regional Office, and the USGS bird banding laboratory in Patuxent, MD. Previous efforts had focused on proving the efficacy of nanotagging using the common terns as a model species. Initial tests were conducted in the Long Island Sound tagging the protected Red Knot, and this species will be the focus of future tagging efforts in the Massachusetts wind energy area. Additional efforts are underway to leverage the Motus system, a database and dissemination platform to collect and track nanotag hits from birds and bats that have been tagged under multiple DOI projects and detected at various receiving towers deployed on federal lands such as FWS Refuge System, NPS National Seashores and Forest Service lands. This

presents significant opportunities for leveraging DOI efforts, and technology that has been pioneered by the Canadian non-profit, Bird Studies Canada.

Molecular Genetics Informing Wildlife Conservation. The BOEM Alaska Regional Office is partnering with the USFWS, Alaska Region, to employ molecular genetic techniques to estimate the size of the Pacific Walrus population. This technique relies on Single Nucleotide Polymorphisms (SNPs) to identify individuals, as a kind of virtual tag that can be used in the analysis of rates of mark and recapture. BOEM's contribution will pay for a cruise in 2017, and will help leverage the activities of USFWS and other local, regional, federal, and international partners.

Web-Access to Large-Array, Meteorological Model Output. The BOEM Alaska Region has partnered with the Alaskan Ocean Observing System (AOOS) to provide web-access to Weather Research and Forecast, a hindcast model output that BOEM uses to parameterize Oil Spill Risk Analysis (OSRA) modeling for the Arctic. The hindcast model output has been analyzed to summarize weather patterns and trends in the Arctic. The meteorological estimates nearest the ocean surface are most relevant to ocean circulation modeling used in OSRA, and a web-access technology is being pursued that will enable researchers to develop subsets of the large array data (20 TB in volume) that would apply to their specific temporal and spatial needs.

XII. Bureau of Land Management

The Bureau of Land Management's (BLM's) multiple-use and sustained yield mandate, set forth in the Federal Land Policy and Management Act of 1976, directs it to manage America's public land resources for a variety of uses, such as energy and minerals development, livestock grazing, recreation, and timber harvesting, while also protecting a wide array of natural, cultural, and historical resources for the use and enjoyment of present and future generations. The BLM administers more public land – over 245 million surface acres – than any other Federal agency in the United States. Most of this land is located in the 17 Western States and Alaska. The BLM also manages 700 million acres of sub-surface mineral estate throughout the Nation. In Fiscal Year 2015, the BLM generated $4.1 billion in receipts from activities occurring on public lands.

BLM focuses many of its technology transfer efforts on information dissemination to partners, public, and its own staff. Examples of these activities include the following:

- BLM's Geographic Information System (GIS) Transformation Project, serves geospatial data in a web-based environment using a common architecture to make data readily available internally to BLM employees and externally to BLM's partners. The Public Land Survey System (PLSS) data set is an example. The PLSS data set is used, maintained and published in partnership with other federal agencies as well as tribal, state and local governments. The states of Utah and Montana host PLSS data on their web sites for publication and distribution and the data is used by the Bureau of Census to standardize the mapping of state, county and other jurisdictional boundaries. This PLSS data set also serves as the basis for automating the mapping of land transactions such as oil and gas leasing, permitting, timber sales and the withdrawal of lands for military use or preservation. The Western Governors' Association (WGA) recognizes the published PLSS data set (also referred to as Cadastral National Spatial Data Infrastructure

CadNSDI), land record modernization and cadastral data as "… critical for maintaining livable communities, encouraging economic development and developing tools that give community leaders the ability to manage both."

- In FY16, the BLM launched the public facing version of the Terrestrial Assessment, Inventory, and Monitoring (AIM) Database (TerrADat). TerrADat houses the terrestrial data generated by the BLM's AIM program, which is used to report on the condition of BLM lands, and by extension, some resources managed by the Bureau. It is used to report on land health, the effectiveness of our Resource Management Plans, and conditions relative to habitat needs of sagebrush obligate species. Various state government agencies such as the Nevada Department of Wildlife, Wyoming Game and Fish, and the Alaska Department of Environmental Conservation are engaged in data collection that is compatible with AIM. AIM data is utilized by a wide variety of federal and state agencies, universities, non-governmental organizations, and private industry.

- Web services and web maps that are intended to help members of the public 1) better understand land use plans and project proposals 2) view decision areas within plans, 3) compare proposed alternatives, and 4) provide comments on proposed land use plans and projects. Interactive maps developed to support the Preliminary Alternatives Report for the Eastern Colorado Resource Management Plan are one example of this type of technology transfer.

- All research projects performed on BLM's National Conservation Lands have a public outreach component including presentations and publications of manuscripts. In 2016, projects performed on National Conservation Lands with local partners and Cooperative Ecosystem Studies Units (CESU) networks included pollinator habitat studies, paleontology resources inventories, assessing wetland conditions, and testing the use of remote sensing data for rare species survey work. In addition to partnering with researchers, BLM also encourages scientists to perform research on National Monuments and Conservation Areas by obtaining scientific research and collection permits. As part of the effort to promote science on National Conservation Lands, all permittees are requested to prepare a short presentation or other public education outreach to be given at a visitor center, as well as a research brief that can be shared with staff, volunteers, and visitors.

- The BLM heritage program works with partners to conduct research, make scientific collections, and disseminate information about cultural and paleontological resources. This is accomplished by partnering with researchers to inventory the public lands and learn about the location and significance of cultural and paleontological resources, partnering with museums and universities to manage important cultural and scientific collections, and sharing research results. In addition, BLM partners with state historic preservation offices, state geologic surveys, Indian tribes, museums, and universities, as appropriate, in order to facilitate research and to better manage cultural and paleontological site and locality information. This is often a reciprocal relationship, with scientific data shared by and with the BLM and partners. These partnerships address requirements of the National Historic Preservation Act of 1966, the Archaeological

Resources Protection Act of 1979, and the Paleontological Resources Preservation Act of 2009.

- Development and use of advanced tools and knowledge pertaining to remote sensing technologies to increase access to multiscale data and information (e.g., unmanned aerial systems, satellite imagery, and 3D close range photogrammetry).

The BLM is also seeking new tools to meet its mission needs. For example, the goal of its Wild Horse and Burro program is to manage healthy wild horses on healthy public rangelands. As wild horse populations continue to increase above appropriate management levels, the BLM is seeking new approaches and tools to help control growth and maintain herd size at a level compatible with multiple use and that the land can support. As part of this effort, the BLM worked with stakeholders and an innovation management firm to design a Prize Competition that would seek new solutions to control herd growth, funded through private contributions and/or sponsorships. Though the BLM intends to launch the Prize Competition in the future, further development of the competition has been postponed until funding is available for the prize.

Wild horses in the White Mountain Herd Management Area near Rock Springs, Wyoming. [Photo credit: Jay D'Ewart, BLM].

XIII. Conclusion

Over the past year the Department has continued its progress toward institutionalizing technology transfer as a routine part of its science, engineering and other technical activities. Specifically, during FY 2016, its scientists, engineers and technical personnel:

- Published over 9,500 reports, books, papers, fact sheets, and other publications.
- Increased the numbers of Cooperative Research & Development Agreements (CRADAs) that they engaged in from 826 in FY 2015 to 873 in FY 2016.

- Engaged in at least 319 other collaborative R&D relationships.
- Increased the number of non-traditional CRADAs, i.e., technical assistance, material use and facility use agreements, which they executed, from 787 in FY 2015 to 836 in FY 2016.
- Disclosed eight (8) new inventions, filed four (4) new patents and received one (1) patent.
- Managed twenty two (22) active licenses for inventions and other intellectual property that earned over $80,000.

In addition, DOI bureaus started implementing the use of prize competitions as a cost effective method of identifying and developing innovative technologies and approaches to dealing with natural resource issues affecting their mission: Reclamation's Water Prize Competition Center (CWPC), established in FY 2015, is leading several interagency efforts to develop new, or improve existing, technologies to restore ecosystems, and improve the sustainability of water and power infrastructure and water availability through improved conservation and management.

- For these, and related efforts, Reclamation and its personnel received a number of national awards in October of 2015, sponsored by the Office of Science and Technology Policy. These included *Newcomer of the Year Award* and the *Best in Technology Award*. Also, Saied Delagah, a Reclamation desalination research expert, won the *Unsung Hero Award* for his outstanding, behind the scenes coordination of the technical efforts that enabled the international Desal Prize.
- By the end of FY 2016, the WPCC had initiated five competitions, of which four had been completed. The completed competitions have dispersed a total of $80,000 in prize awards for a total of 18 winning solutions. In addition, Reclamation initiated the design of six additional prize competitions scheduled to launch during the first half of FY 2017.
- The Bureau of Safety and Environmental Enforcement (BSEE) launched an initiative to promote STEM education, and engage and raise its profile with the future STEM workforce. The first competition under this initiative was for the best adaptation for offshore use of a piezoelectric technology developed by NASA.
- USGS is partnering with other federal agencies, universities and non-profits on an effort to accelerate development and commercial availability of affordable, reliable, and accurate *in situ* nutrient sensors in aquatic environments.
- The NPS conducted a prize competition in conjunction with the National Capital Planning Commission (NCPC), and Van Alen Institute on *Memorials for the Future*, an ideas competition to reimagine how Americans may think about, feel, and experience memorials in the future.
- FWS announced winners of its Ivory Crush Design Challenge, which had solicited proposals for powerful visual concepts for public displays fabricated from crushed ivory from the U.S. ivory crushes.

DATA APPENDIX

The following tables provide cumulative data for the Department. Data for individual bureaus are available on line at https://www.doi.gov/techtransfer/annual-reports.

Data are provided if they are collected and readily available. Note that a blank cell or N/A indicates either zero, the data is not collected or it is otherwise unavailable. These tables include updates to previous years' data, where appropriate.

Table 1: Invention Disclosures and Patents

		FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
	Invention Disclosures						
1	Number of new inventions disclosed	5	10	9	6	7	8
	Patents						
2	Number of patent applications filed	2	3	8	4	8	4
3	Number of patents received	1	3	4	2	3	1

Table 2: Income Bearing Licenses

		FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
	Income Bearing Licenses						
4	Number of income bearing licenses	22	22	16	14	18	17
5	Exclusive licenses	3	12	4	5	7	8
6	Partially exclusive licenses	0	0	0	0	0	0
7	Non-exclusive licenses	19	10	12	9	11	9
	Elapsed Amount of Time for Granting Licenses						
8	Average (months)	12	12	12	12	4.5	N/A
9	Minimum (months)	12	12	12	12	2	N/A
10	Maximum (months)	12	12	12	12	8	N/A
"0" indicates that there are no incidences of a mechanism that is being used by the agency, and "N/A" that data is not available at time of report.							

Table 3: Licensing Income

		FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
	Total income (all licenses active in FY)	114963	75975	96250	58248	105580	82997
	Total income distributed	110678	71450	91813	55690	97198	81559
	Total income from patent licenses	114963	75975	96250	58248	105580	82997
	Total income distributed	110678	71450	91813	55690	97198	81559
	Disposition of Earned Royalty Income						
17	Total amount of Earned Royalty Income received	103963	64651	96250	58248	105580	81997
	Total amount of ERI distributed	110678	71450	91813	55690	97198	81559
20	Licenses terminated for cause	0	0	0	0	0	0
“0” indicates that there are no incidences of a mechanism that is being used by the agency, and "N/A" that data is not available at time of report.							

Table 3A: License Activity

	Metric	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
	Licenses, Total Active	25	26	20	18	20	22
	New Licenses	2	1	3	0	3	0
	Invention Licenses, Total Active	23	24	20	16	18	20
	New Invention Licenses	2	1	3	0	3	0
	Income Bearing Licenses, Total Active	22	22	16	15	18	17
	Income Bearing Exclusive Licenses	3	12	4	5	7	8

Table 4: CRADAs

		FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
	CRADAs						
21	Number of active CRADAs	351	379	476	601	826	873
22	Number of newly executed CRADAs	295	284	376	423	586	511
	Traditional CRADAs						
25	Active traditional CRADAs	22	28	21	35	38	37
26	Newly executed traditional CRADAs	13	5	2	11	12	9
	Non-traditional CRADAs						
27	Active non-traditional CRADAs	327	351	455	566	787	836
28	Newly executed non-traditional CRADAs	282	279	378	411	574	505
	Other collaborative R&D relationships						
	(Collaborative Agreements), total active in the FY	209	283	322	292	318	319
	New, executed in the FY	155	165	137	112	121	126
"0" indicates that there are no incidences of a mechanism that is being used by the agency.							

Frequently-Used Acronyms

AADAP	Aquatic Animal Drug Approval Program
ARS	Agricultural Research Service (within USDA)
BAST	Best Available and Safest Technologies
BLM	Bureau of Land Management
BOEM	Bureau of Ocean Energy Management
BSEE	Bureau of Safety and Environmental Enforcement
CESU	Cooperative Ecosystem Studies Units
CRADA	Cooperative Research & Development Agreements
CWA	Clean Water Act
DHS	Department of Homeland Security
eDNA	environmental DNA
EPA	Environmental Protection Agency
EPM	Electron Microprobe
ESA	Endangered Species Act
ETB	Emerging Technologies Branch
FAC	Division of Fisheries and Aquatic Conservation
FEMA	Federal Emergency Management Agency
FTC	Fish Technology Center
FTTA	Federal Technology Transfer Act of 1986
FUSA	Facility Use/Service Agreement
FWS	Fish and Wildlife Service
GSA	General Service Administration
GSS	Global Security Systems
MHEP	Minority Higher Education Program
MTA	Material Transfer Agreement
NASA	National Aeronautics & Space Administration
NCPTT	National Center for Preservation Technology and Training
NCR	Natural and Cultural Resources
NCTC	National Conservation Training Center
NDRF	National Disaster Recovery Framework
NEPA	National Environmental Policy Act

NFPP	National Fish Passage Program
NGA	National Geospatial-Intelligence Agency
NGO	Non-governmental Organization
NIST	National Institute of Standards & Technology
NOAA	National Oceanic & Atmospheric Administration
NPS	National Park Service
NRF	National Response Framework
NTTP	National Technical Training Program
NTTT	National Technology Transfer Team
OCS	Outer Continental Shelf
OEPC	Office of Environmental Policy and Compliance
OPA	Office of Policy and Analysis (within USGS)
ORTA	Office of Research and Technology Applications
OSMRE	Office of Surface Mining Reclamation and Enforcement
OSPD	Oil Spill Preparedness Division
PHMSA	Pipeline and Hazardous Materials Safety Administration
R&D	Research & Development
READ	Resource Advisor
RSF	Recovery Support Function
SEM	scanning electron microscope
SMCRA	Surface Mining Control and Reclamation Act of 1977
TAA	Technical Assistance Agreement
TIPS	Technical Innovation and Professional Services
UAS	Unmanned Aerial System (or drone)
USACE	US Army Corps of Engineers
USAID	US Agency for International Development
USDA	US Department of Agriculture
USGS	United States Geological Survey