



Annual Report on Technology Transfer

FY 2022 Activities

U.S. Department of the Interior



DESCRIPTION OF COVER PHOTOS

TOP LEFT: BLM MANAGES MILLIONS OF ACRES OF PUBLIC LANDS WITH EXCELLENT ONSHORE SOLAR ENERGY POTENTIAL. PHOTO BY JESSICA K. ROBERTSON, USGS

TOP RIGHT: USGS USES UNMANNED AERIAL SYSTEMS (UAS) FOR REMOTE SENSING. PHOTO BY USGS.

BOTTOM LEFT: WATER IS RELEASED FROM NIMBUS FISH HATCHERY INTO A NEW FISH LADDER. PHOTO BY RECLAMATION.

BOTTOM RIGHT: TIDEPOL PROTECTION, EDUCATION AND RESTORATION PROGRAM (TPERP) VIPs SEARCH FOR SEA LIFE IN CABRILLO NATIONAL MONUMENT. PHOTO BY NPS.

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I. Executive Summary

This report identifies and describes how the Department of the Interior (DOI) advanced technology transfer in Fiscal Year (FY) 2022. These activities demonstrate the innovation, expertise, and dedication of DOI employees to help reduce risks to public health, safety, and the environment, and to honor federal trust and treaty responsibilities or special commitments to American Indians, Alaska Natives, and affiliated Island Communities.

During FY 2022, DOI continued to engage in a broad range of cooperative technology transfer activities – 32 cooperative research and development agreements (CRADAs), 1,034 other cooperative research and development (R&D) activities, 3 new invention disclosures, 2 new invention licenses, 1 new patent, and over 3,600 publications – to achieve key outcomes including:

- To improve oil recovery in broken ice offshore, DOI developed an ice-management system increasing the amount of oil removed from the marine environment.
- To facilitate environmentally friendly food research, DOI participated in a nontraditional CRADA with a small business that is commercializing research results from a study of microbial mats collected from a thermal area in a park.
- To enhance coal mine reclamation and help ensure successful reclamation work, DOI provided technical assistance and training to our state and tribal partners.
- To advance the scientific exploration of Mars, DOI entered into a technical assistance agreement supporting the science and operation of three investigations during the Mars Science Laboratory mission.
- To safeguard the health of anglers and fish consumers, DOI established two new CRADAs through the Aquatic Animal Drug Approval Partnership Program (AADAP) to work towards drug approvals for use in aquaculture and fisheries management.
- To protect aquatic ecosystems, DOI established a material transfer agreement to develop an automated sampling device for detecting the larvae of invasive zebra and quagga mussels in the environment.
- To facilitate scientific research on public lands, DOI initiated a pilot project of an online system for permitting and tracking paleontological and scientific research.
- To support communities affected by wildfire, DOI researched and developed ecosystem mapping tools that will enhance fire and fuels management.

II. Introduction

Each year, technology transfer at DOI advances the goals of the Technology Transfer Commercialization Act of 2000. In FY 2022, DOI strengthened the Nation's competitive ability in the global marketplace; furthered collaboration among government, industry, and universities that carry out the scientific enterprise; and improved the quality of life for the American people. Achieving these goals also helped advance DOI's mission:

- To protect and manage the Nation's natural resources and cultural heritage;
- To provide scientific and other information about those resources; and
- To honor our trust and treaty responsibilities or special commitments to American Indians, Alaska Natives, and affiliated Island Communities.

The FY 2022 report shares examples of technology transfer activities at DOI in three categories:

- Publishing and exchanging scientific and technical information;
- Protecting and licensing intellectual property rights; and
- Sharing specialized scientific material and resources that DOI manages.

The report is the result of a cooperative effort by DOI's Departmental Working Group on Technology Transfer, which is coordinated by DOI's Office of Policy Analysis. The working group, which included bureau and office personnel involved with their respective research and development programs, provided the underlying data. DOI prepared this report using data compiled according to the most recent guidance from the Interagency Working Group on Technology Transfer.¹ Historical data (i.e., data before FY 2021) for new metrics introduced in the guidance are not available for comparison with FY 2022 data.

¹ The Technology Partnerships Office, National Institute of Standards and Technology, in conjunction with the Interagency Working Group on Technology Transfer, Guidance for Preparing Annual Agency Technology Transfer Reports Under the Technology Transfer Commercialization Act, April 2020. Available at: https://www.nist.gov/system/files/documents/2021/06/23/Final_2020_Metrics_Guidance.pdf

III. Advancing Technology Transfer in the Department of the Interior

DOI's FY 2022 enacted budget included over \$1.1 billion for R&D. Most funding, about \$876 million, was for applied R&D, while basic R&D and experimental development received about \$91 million and \$177 million, respectively.² The programs supported through these funds generate new and improved knowledge, information, and technology, which are then transferred to resource managers within and beyond DOI, other stakeholders, and the public to help DOI meet its mission objectives.

DOI's bureaus have varying levels of involvement with scientific and technical research and innovation and technology transfer. In FY 2022, as in previous years, most technology transfer activities reported by DOI under the Federal Technology Transfer Act of 1986 (FTTA) were undertaken by the U.S. Geological Survey (USGS), which is DOI's largest R&D organization, both in terms of budget and personnel. Typically, the USGS accounts for about two-thirds of DOI's R&D budget.

DOI advances the state of knowledge related to the resources it manages and ensures that this information is accessible to resource managers, private industry, and the public. The vast majority of DOI'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 2022, Bureau of Reclamation (Reclamation or BOR), Bureau of Ocean Energy Management (BOEM), the Bureau of Land Management (BLM), National Park Service (NPS), and U.S. Geological Survey personnel authored or co-authored at least 3,600 reports, books, fact sheets and other publications disseminating mission-relevant scientific and other technical information to the public and peers in and out of government. (Other DOI bureaus do not collect this information in a readily accessible manner.)

Bureaus also use other conventional approaches to share scientific and technical resources and expertise with universities and other entities to address resource management issues. For example, eight DOI bureaus and offices are active participants in the Cooperative Ecosystem Studies Units (CESU) Network, a collaboration among 19 federal agencies and nearly 490 non-federal partners (including universities, tribes and tribal organizations, state agencies, museums, aquariums, arboretums, and conservation organizations). The CESU Network extends

² Estimates furnished by the Office of Budget, Department of the Interior.

across biogeographic regions in all 50 states, the District of Columbia, and U.S. insular areas. Each CESU is hosted by a university.³

In addition, some bureaus and offices have offered prizes to help develop new or improve existing technologies. The bulk of the prize competition activities at DOI are undertaken by Reclamation's Prize Competitions Program.

Bureaus that are active in R&D 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 DOI's bureaus and the non-governmental sector (including private entities) to pool their expertise and resources to jointly create and advance technologies that support agency missions while helping U.S. industries innovate and commercialize technologies that strengthen the economy and create jobs. This report focuses primarily on, but is not limited to, aspects of technology transfer related to the FTTA.

³ Cooperative Ecosystem Studies Units National Network: <http://www.cesu.psu.edu/materials/default.htm>

IV. Overview of Technology Transfer Activities

During FY 2022, DOI continued to engage in a broad range of cooperative activities to develop and disseminate innovative technologies, including:

- Collaborated on 32 CRADAs, of which 5 were initiated in FY 2022. In addition, DOI engaged in at least 1,034 other collaborative R&D relationships.
- Disclosed 3 new inventions; 3 new patent applications were filed; 1 new patent was awarded.
- Managed 11 active patent licenses for inventions and other intellectual property, which collectively earned \$108,761.
- Published more than 3,600 reports, books, fact sheets, and other publications disseminating mission-relevant scientific and other technical information to the public and peers in and out of government.

DOI's bureaus used 12 mechanisms to transfer information, knowledge, and technology within and outside their agencies (Table 1).

Table 1: DOI Technology Transfer Activities by Bureau

	USGS	FWS	OSMRE	NPS	BSEE	BOR	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	X	
Technical Assistance Agreements (TAAs)	X							
Facility Use/Service Agreements (FUSAs)	X					X		
Material Transfer Agreements	X			X		X		
Demonstration/Joint Projects	X				X	X	X	X
Patents	X	X		X				
Licenses	X	X		X		X		
Other Cooperative Ventures & Agreement Types	X	X	X	X	X	X	X	X
Web and Other Mechanisms	X	X	X	X	X	X	X	X

V. Technology Transfer Agreements

DOI's bureaus were involved in 32 active CRADAs in FY 2022, of which 5 were newly executed. See table 2.

TABLE 2: COLLABORATIVE RELATIONSHIPS FOR RESEARCH & DEVELOPMENT (FY 2022)

	USGS	BOR	BOEM	FWS	NPS	BLM	Total
CRADAs							
Total Active CRADAs	25	2	0	4	1	0	32
New CRADAs	3	0	0	2	0	0	5
New CRADAs Involving Small Businesses	0	0	0	1	0	0	1
Other collaborative R&D relationships							
Other Collaborative Agreements, total active in FY 2022	768	5	0	0	0	261	1,034

DOI disclosed 3 new inventions, filed 3 new patent applications, and was issued 1 new patent in FY 2022. See table 3.

TABLE 3: DOI PATENT ACTIVITY (FY 2022)

	USGS	BOR	Total
Invention Disclosures			
Total Invention Disclosures Received	3	0	3
Patents			
Total Patent Applications Filed	3	0	3
<i>US</i>	3	0	3
<i>Foreign</i>	0	0	0
Total PCT Applications Filed (NOTE: PCT = Patent Cooperation Treaty. See https://www.wipo.int/pct/en/)	0	0	0
Total Patents Issued	0	1	1
<i>US</i>	0	1	1
<i>Foreign</i>	0	0	0

DOI managed 10 licenses in FY 2022 and averaged 7 months to grant licenses. See table 4.

TABLE 4 ACTIVE LICENSES MANAGED BY THE DOI’S BUREAUS

	USGS	BOR	FWS	Total
Invention Licenses, Total Active	9	1	1	11
New Invention Licenses	2	0	0	2
New Invention Licenses to Small Businesses	2	0	0	2
Income bearing licenses, Total Active	9	1	0	10
New Income Bearing Licenses	2	0	0	2
Exclusive licenses	8	0	1	9
Partially exclusive licenses	0	0	0	0
Non-exclusive licenses	1	1	0	2
Other Licenses, Total Active	61	0	0	61
New Other Licenses	13	0	0	13
New Other Licenses Granted to Small Businesses	10	0	0	10
Average (months)	7	0	0	7
Minimum (months)	5	0	0	5
Maximum (months)	9	0	0	9
Licenses terminated for cause	0	0	0	0

Total income in FY 2022 from all licenses amounted to \$108,761 (from 10 income-bearing licenses), compared with \$67,694 (from 9 income-bearing licenses) in the previous fiscal year. Under 15 USC § 3710c, for all inventions originating in a federal agency, the agency must pay to the employee-inventors the first \$2,000 per year in license income, and a minimum of 15% of the yearly income thereafter. Each agency has discretion to implement its own sharing scheme, but the maximum that a single inventor can receive per year is \$150,000. Any residual funds are usually retained by the agency or laboratory where the intellectual property was developed.⁴

The scope and nature of DOI bureaus’ technology transfer activities is a reflection of their missions. See table 5.

⁴ <https://www.govinfo.gov/content/pkg/USCODE-2011-title15/html/USCODE-2011-title15-chap63-sec3710c.htm>

TABLE 5: SCOPE OF ACTIVITIES AND PLANS RELATED TO THE FTTA, BY BUREAU

Mission	Technology Transfer
<p>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.</p>	<p>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. The USGS also pursues technology transfer opportunities under the FTTA and the Stevenson-Wydler Act in a variety of ways.</p>
<p>U.S. Fish & Wildlife Service (FWS). The mission of FWS is working with others to conserve, protect, and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people.</p>	<p>FWS’s R&D is primarily focused on providing the basis for effective conservation to meet its mission. For example, the FWS Fish Technology Centers (FTCs) were established in 1965 to develop and improve fish culture technology and to assist federal and state agencies, tribes, and other nations interested in aquaculture research and solutions. FTCs have worked with industry and government to improve aquaculture opportunities.</p>
<p>Office of Surface Mining Reclamation and Enforcement (OSMRE). OSMRE is responsible for ensuring, through a nationwide regulatory program, that coal mining is conducted in a manner that protects communities and the environment, restores the land to beneficial use following mining, and mitigates the effects of past mining by aggressively pursuing reclamation of abandoned mine lands.</p>	<p>OSMRE advances its 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 R&D 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.</p>
<p>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. NPS cooperates with partners to extend the benefits of natural and cultural resource conservation and outdoor recreation throughout this country and the world.</p>	<p>Technology transfer and employee inventions are addressed under the NPS benefits-sharing policy and procedural guidance. Benefits sharing occurs when NPS receives monetary or nonmonetary 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. Authorities under the FTTA are essential to the NPS benefits-sharing program.</p>
<p>Bureau of Safety and Environmental Enforcement (BSEE). BSEE works to promote safety, protect the environment, and conserve</p>	<p>The BSEE R&D program activities operate through the Office of Offshore Regulatory Programs (OORP) Emerging Technologies Branch (ETB) and the Oil Spill Preparedness</p>

Mission	Technology Transfer
resources offshore through vigorous regulatory oversight and enforcement.	Division (OSPD) Oil Spill Response Research (OSRR) role. 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 promote Best Available and Safest Technology on the U.S. Outer Continental Shelf (OCS).
<p>Bureau of Reclamation (Reclamation or BOR). 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.</p>	Reclamation has the lead federal responsibility for water management and hydropower in the 17 western states. Its research program is applied toward the development of solutions that increase efficiency, reduce maintenance costs, improve work safety, enhance infrastructure reliability, and increase the effectiveness of using desalination and other water treatment technologies to expand water supplies. The research programs use technology transfer fundamentals to help speed field deployment of new innovations.
<p>Bureau of Ocean Energy Management (BOEM). BOEM manages the exploration and development of the Nation’s offshore energy and mineral resources in an environmentally and economically responsible 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.</p>	BOEM’s Environmental Studies Program develops, conducts, and oversees scientific research specifically to inform policy decisions regarding development of OCS energy and mineral resources. The 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 technologies.
<p>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 BLM manages public land resources for a combination of balanced and diverse resource uses that take into account the long-term needs of future generations for renewable and nonrenewable resources, including, but not limited to, recreation, range, timber, minerals, watershed, wildlife and fish, and natural scenic, scientific, and historical values.</p>	BLM’s scientific and technical focus has been on place-based applications to improve public land management in accordance with FLPMA. BLM focuses on traditional technology transfer activities to help advance FLPMA’s multiple-use mandate.

Subsequent sections briefly describe each bureau’s technology transfer program and provide examples of their activities in FY 2022. The tabular data requested by OMB Circular A-11 are reported in section XVI, “Data Appendix.”

VI. U.S. Geological Survey

The U. S. Geological Survey (USGS) is a science bureau within DOI 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. The USGS focuses on the following interdisciplinary mission areas: Ecosystems; Energy and Minerals; Natural Hazards; Water Resources; and Core Science Systems. The combined expertise from several earth-science disciplines (such as hydrology, geology, biology) addresses 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 the Nation, customers, and partners.

Delivery of scientific information is the USGS's primary mission. Technology transfer activities with the public and private sectors, including academia and nonprofits, are integral to fulfilling this mission. These efforts typically support knowledge dissemination, including the collection and transfer of scientific data. The USGS also cooperates with its public and private collaborators to help them maintain essential and necessary services, better understand the environmental consequences of their commercial and noncommercial activities and develop new products and services. The USGS has over 283 laboratories across the country.

Within the USGS, technology transfer extends beyond traditional publications, meetings, and conferences. It builds on the Stevenson-Wydler Innovation Act of 1980, as amended by the Federal Technology Transfer Act of 1986 (FTTA) and the National Technology Transfer and Advancement Act of 1995 and is managed through the USGS Office of Policy and Analysis (OPA). OPA staff services USGS centers and offices throughout the country.

OPA negotiates and drafts CRADAs and other types of collaborative agreements, including technical assistance agreements, facility use service agreements, material transfer agreements, data use licenses, and patent licenses. OPA also manages the USGS intellectual property and inventions program; markets USGS technology opportunities; and facilitates partnerships with industry, nonprofits, academic institutions, federally recognized tribal nations, and state agencies. OPA also provides training to USGS personnel on technology transfer and intellectual property matters.

In fiscal year 2022, the USGS had 25 active CRADAs, three of which were new. In addition to those CRADAs, the USGS executed 749 other collaborative agreements. Of these agreements, 516 were joint funding agreements for topographical mapping or water resources investigations. The remaining agreements were comprised of 89 technical assistance agreements, 74 collaborative agreements, and 70 facility use and service agreements.

The USGS published 3,219 scholarly articles, papers, or book chapters in publications focused on diverse areas such as matters about understanding the Earth, minimizing loss of life and property from natural disasters, managing water, biological, energy and mineral resources. The USGS also managed a total of 70 active intellectual property licenses, with two newly filed patent applications. One notable license led to world-wide commercialization of a method to eliminate invasive species in ballast tanks using the invention described in the USGS's U.S. Patent 9,688,551. Based on that license and USGS technology transfer efforts, the Federal Laboratory Consortium selected the USGS as a national awardee for Excellence in Technology Transfer.

USGS science and research contributes to a broad range of collaborative projects in the private and academic sectors. Examples include the following:

Mars Mission Support. The USGS Astrogeology Science Center, Flagstaff, Arizona, and Malin Space Science Systems, San Diego, California, have entered into a Technical Assistance Agreement (TAA) for the project entitled "MSL Mastcam/MAHLI/MARDI." This is a project that combines multiple agencies including NASA into a single team that will support the science and operation of the three investigations during the Mars Science Laboratory (MSL) mission.



IMAGE FROM MAST CAMERA (MASTCAM) ONBOARD NASA'S MARS ROVER CURIOSITY ON SOL 2842, THE 2,842ND MARTIAN DAY OF THE MISSION. MASTCAM SENDS PHOTOS OF THE MARTIAN SURFACE BACK TO EARTH, EXPANDING HUMANITY'S KNOWLEDGE OF OUR PLANETARY NEIGHBOR. SOURCE: NASA/JPL-CALTECH/MSSS PUBLIC

Dr. Kenneth Herkenhoff of the USGS serves as Co-Investigator on the science team. He has decades of experience in Mars rover mission operations and data analysis. His expertise will be applied to continuing MSL operations.

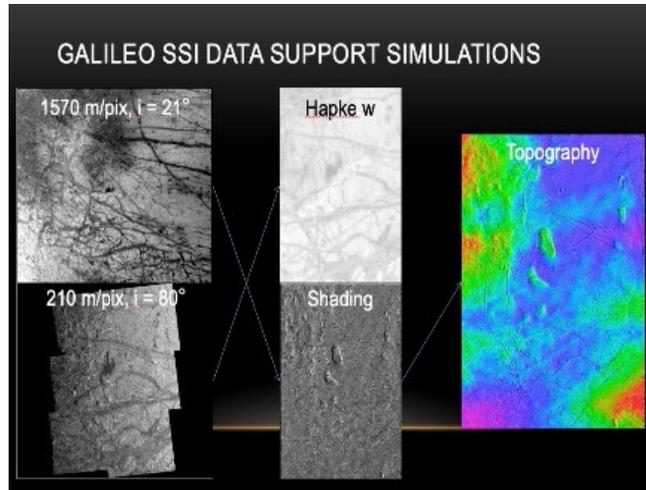
Malin Space Science Systems has decades of experience in the design, fabrication, testing and operation of cameras on Mars, and requires the USGS' expertise in MSL mission operations and data analysis.

The project includes the collection, processing, calibration, validation, and analysis of multispectral narrowband filter imaging data sets obtained by the MSL Mastcam investigation. This includes maintenance of a team-accessible database of multispectral images and delivery to NASA's Planetary Data System archive.

Support for NASA Space Exploration. The USGS is supporting NASA's mission to explore space by providing expertise related to geologic processes on planetary bodies and converting spacecraft data into useful scientific information within a geospatial framework. The USGS's Astrogeology Science Center, located in Flagstaff, Arizona, has entered into a Technical Assistance Agreement (TAA) with Johns Hopkins University Applied Physics Lab (APL), Laurel, Maryland. This project will provide imager and imager-related science for NASA's Europa Clipper mission by utilizing the Europa Imaging System (EIS).

APL leads the development and delivery of this dual camera imaging system and co-manages the Clipper project for NASA.

The EIS instrument plays a central role in deciphering the geology and subsurface structure of Jupiter's moon, Europa, and will measure the locations, topography, and color of key features at very high spatial resolution, in addition to carrying out global mapping.



USGS SCIENTISTS USED SPACECRAFT IMAGES OF JUPITER’S MOON EUROPA TAKEN BY THE SOLID STATE IMAGER (SSI) ON THE NASA GALILEO MISSION IN THE 1990S FOR SIMULATIONS IN SUPPORT OF NASA’S EUROPA CLIPPER MISSION NOW IN DEVELOPMENT. EUROPA CLIPPER WILL CONDUCT FLYBYS OF EUROPA, JUPITER’S FOURTH-LARGEST MOON, SO SCIENTISTS CAN BETTER UNDERSTAND ITS GEOGRAPHY AND COMPOSITION, INCLUDING THE POSSIBLE PRESENCE OF LIQUID WATER. SOURCE: NASA

USGS Astrogeology's participation in this project will enhance the quality and usability of the data returned from Europa. Former USGS scientist and current scientist emeritus, Dr. Randy Kirk, will serve as a co-investigator on the EIS team. He provides expertise on camera system integration, testing, ground calibration, planning of operations for global- to local-scale mapping, and the design of cartographic data products. He will also contribute his expertise in icy satellite geophysics and surface processes and provide scientific and cartographic guidance.

Another USGS scientist, Dr. Mike Bland, currently serves as Kirk’s associate on the EIS and Clipper teams. He is an expert in icy satellite geology and is currently helping to design and prioritize EIS observations. He also has experience in planetary topographic mapping. He will help in the acquisition, processing, archiving, and scientific analysis of EIS data.



USGS RESEARCHERS CONDUCT RESEARCH TO HELP IMPROVE THE CONTROL OF INVASIVE SPECIES, WHICH ARE ECONOMICALLY COSTLY AND ECOLOGICALLY DAMAGING, SUCH AS CARP. SOURCE: JON VALAZZA, USGS.

Novel Biological Solutions for Controlling US Aquatic Invasive Species. Invasive species are highly impactful to ecosystems and economies throughout North America. Methods currently available to address invasives are limited to just a few chemicals that have nontarget effects. Natural resource managers highly desire controls that can target a particular species while minimizing impacts on native fauna. Synthetic biology technologies have the potential to effectively control populations of an invasive species and be truly species-specific, resulting in minimal impacts to non-target species. There are several technologies to consider, but RNA interference (RNAi) technology seems to have the most immediate practical application. RNAi has been developed to control terrestrial pests for agriculture and the regulatory paths have been established.

The USGS Upper Midwest Environmental Sciences Center (UMESC), French Island, Wisconsin, and Sundew ApS, Copenhagen, Denmark, have entered into a CRADA for a project entitled, “Novel Biological Solution for Controlling US Aquatic Invasive Species.”

The UMESC has a long history of developing controls for aquatic invasive species and is investigating the development, efficacy, and delivery of RNAi in aquatic invasive species control. Sundew ApS is a biotechnology company that has developed a technology to produce RNAi in microalgae to deliver RNAi to aquatic organisms. Scientists from UMESC and Sundew are working together to develop and test the effectiveness of RNAi to control aquatic invasive species.

Eco-friendly Anticoagulant Rodenticides. Anticoagulant rodenticides (ARs) have a long history of successful use for control and eradication of vertebrate pest and invasive species. Despite regulatory efforts to mitigate risk to non-target species, wildlife may be exposed to ARs through various trophic pathways.

USGS scientist Dr. Barnett Rattner, of the USGS Eastern Ecological Science Center at the Patuxent Research Refuge, Laurel, Maryland, finalized a Cooperative Research and Development Agreement (CRADA) in 2022 in partnership with Dr. Virginie Lattard. Dr. Lattard is the Senior Scientist at the Institut national de recherche pour l'agriculture, l'alimentation et l'environnement (INRAE) and the Institut national d'enseignement supérieur et de recherche en alimentation, santé animale, sciences agronomiques et de l'environnement (National Institute of Higher Education and Research in Food, Animal Health, Agronomic and Environmental Sciences) (VetAgro Sup) in Paris, France. The objective of this CRADA is to study anticoagulant rodenticides and the potential for formulations that may reduce toxicity in non-target animals, such as predatory and scavenging bird species.



PREDATORY BIRDS LIKE THIS AMERICAN KESTREL (FALCO SPARVERIUS) CAN BE INJURED OR KILLED THROUGH EXPOSURE TO ANTICOAGULANT RODENTICIDES. A USGS RESEARCH PARTNERSHIP IS EXPLORING WAYS TO REFORMULATE THESE RODENTICIDES SO THEY ARE LESS DANGEROUS TO WILDLIFE. SOURCE: USFWS DIGITAL LIBRARY.

Depending on the dose, exposure can result in adverse effects and mortality. Current second-generation AR (SGAR) bait formulations are a mixture of *cis*- and *trans*-diastereoisomers. A recent discovery demonstrated that while *cis*- and *trans*-diastereoisomers of several ARs are equally toxic to laboratory rats, one of the diastereoisomers is preferentially metabolized resulting in lower liver residues. It is not clear if the toxicity characteristics and preferential metabolism of SGAR stereoisomers extend to non-target birds. Research conducted under this

CRADA is examining brodifacoum stereoisomer toxicity, accumulation, metabolism and excretion in the American kestrel and other predatory and scavenging birds.

In addition, *in vitro* studies will be conducted using liver microsomes from various species of birds to compare the inhibitory potency of AR stereoisomers on the target enzyme vitamin K epoxide reductase. Resulting findings will enhance understanding of AR toxicity in birds. This may support the development of rodenticide baits composed of rapidly metabolized SGAR diastereoisomers. Such baits may serve as an eco-friendly alternative to reduce exposure and toxicity in non-target wildlife.

VII. U.S. Fish and Wildlife Service

The U.S. Fish and Wildlife Service (FWS) is dedicated to the conservation, protection, and enhancement of fish, wildlife, and plants and their habitats. FWS is the only federal agency whose primary responsibility is managing fish and wildlife resources for the American public. The National Wildlife Refuge System's 850 million acres of lands and waters includes 568 national wildlife refuges, waterfowl production areas in 209 counties managed within 38 Wetland Management Districts and 49 Coordination Areas, 7 National Monuments, and 760 million acres in Marine National Monuments. FWS also operates National Fish Hatcheries, which, in conjunction with Fish and Wildlife Conservation Offices, its Fish Health Centers and Fish Technology Centers, restore native aquatic populations, mitigate fish losses 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. Transferring FWS's technology and knowledge to the public and collaborators accelerates the adoption and use of agency research while improving the economic and societal benefit from its R&D investments to help solve natural resource problems.

The technology transfer function of FWS is shared among several programs, including Science Applications, Fish and Aquatic Conservation (FAC), and Joint Administrative Operations (JAO). The majority of FWS's technology transfer is done via dissemination to the public and scientific community through traditional avenues such as peer-reviewed papers, presentations, reports, and fact sheets. Science Applications and JAO help coordinate technology transfer activities in the Service while other programs are more directly involved with partners.

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

Scientists within the agency published 439 scholarly articles, papers, or book chapters in publications focused on diverse topics such as ecology, biodiversity conservation, fisheries, zoology, ornithology, environmental sciences, and evolutionary biology. FWS also 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 electronic journals are in the public domain. 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 National Wildlife Refuge System.

CRADAs. In FY 2022, FWS maintained two CRADAs it has in place and established two new CRADAs through the Aquatic Animal Drug Approval Partnership Program (AADAP) for a total of 4 within FAC. These CRADAs were created with pharmaceutical companies in collaboration to work towards drug approvals for use in aquaculture and fisheries management. On behalf of DOI, FWS also maintains a joint CRADA involving the USGS and BOEM and Bird Studies Canada.⁵

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

National Conservation Training Center. The [FWS Conservation Library](#)⁶ 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 videos, most of which are in the public domain. FWS also makes internal publications, reports, and other information available to the public through the [FWS website](#).⁷ Collections of current and legacy publications (including biological and technical 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 hosts publicly accessible webinars dealing with a variety of scientific and technical issues that address the nation’s fish and wildlife resources. During fiscal year 2022, NCTC hosted 38 in-person classes, 54 online science, technology, and educational webinars and 126 e-courses related to managing the Nation’s fish, wildlife, and plant resources. These are important components of FWS’s traditional technology transfer activities.

⁵ Because the FWS/USGS/BOEM/Bird Studies CRADA is already accounted for in the USGS tally of CRADAs, it is not included in the tallies for the other bureaus in Section V and the data tables in the Appendix.

⁶ URL: <http://digitalmedia.fws.gov>.

⁷ URL: <https://www.fws.gov>.

Fish and Aquatic Conservation Program. FWS's primary research nexus with the private sector centers on programs and facilities within the Fish and Aquatic Conservation (FAC) Program. These centers and programs provide assistance and support to conservation partners—including federal, state, tribal, and nongovernmental organizations (NGOs). The program includes a network of National Fish Hatcheries, Fish and Wildlife Conservation Offices, Fish Health Centers, Fish Technology Centers, the Conservation Genetics Laboratory in Anchorage, Alaska and the Whitney Genetics Laboratory in Onalaska, Wisconsin, and the Aquatic Animal Drug Approval Partnership (AADAP). Work that supports programs covers a broad range of disciplines, including biostatistics, population ecology, genetics, nutrition, and fish health and pathology. FWS's Fish Health Centers, Fish Technology Centers, and AADAP play an integral role in applied science and technology transfer.

FWS Aquatic Animal Drug Approval Partnership. The AADAP program allows fisheries professionals to more effectively and efficiently rear and manage a variety of fish species to meet production goals, stock healthy fish, and maintain a healthy environment. AADAP is the only program in the United States singularly dedicated to obtaining U.S. Food and Drug Administration (FDA) approval of new medications needed for use in fish culture and fisheries management. Since the late 1990s, AADAP has contributed to virtually every new fish medication approved by the FDA.

Fish Technology Centers. Starting in 1965, Fish Technology Centers (FTCs) were established to develop and improve fish culture technology and to provide assistance and advice on fish culture to National Fish Hatcheries, other federal and state agencies, tribes, other nations, and the aquaculture industry. Today, seven FTCs provide applied science products and transfer technology related to fish and fisheries for the Nation. The FTCs have 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 FWS and its partners through conservation science partnerships.

Nutrition and Diet Development Laboratories. These facilities allow for the manufacture of experimental larval, fingerling, and broodstock fish feeds and the testing of 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.

Physiology Laboratories. These laboratories support conservation and management needs of FWS and its partners, including understanding the physiological needs of fish to support conservation and commercial opportunities.

Conservation Genetics Laboratories. These laboratories support conservation and management needs of FWS and its partners, including (a) using genetic 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 and repositories for imperiled species; and (d) characterizing diversity within and among wild populations.

Ecology Laboratories. These laboratories focus on understanding the physiological requirements and tolerances of threatened and endangered species. Less invasive or noninvasive 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 state 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.

Fish Health Centers. 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, playing an integral role in applied science and technology transfer. Their scientists are leaders, both nationally and internationally, in diagnosing wildlife diseases, contributing to the science of aquatic animal health, and developing and validating tests that benefit—and are adopted by—the aquaculture industry.

Aquatic Invasive Species. The FWS Aquatic Invasive Species (AIS) program works to prevent the transfer and introduction of injurious and other potentially harmful non-native species and to develop early detection, rapid response, and control measures for such species. For example, the program worked with numerous partners to develop methods for detecting minuscule amounts of free-floating DNA (environmental DNA or eDNA) in water samples to confirm the presence (or absence) of species that are often undetectable by traditional sampling methods. This innovative technology is now being applied widely in 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.

The Aquatic Invasive Species program is also applying rapid screening tools it has developed to help determine a species' risk for invasion. Knowledge of both low- and high-risk species will help industry, states, tribes, and consumers make informed decisions about trading, transporting, or possessing a particular species. These tools will also help state agencies develop species watch list and work with industry to manage invasive species in their jurisdictions. For example, Michigan's Public Act 537 established new protections to minimize

the risk of invasive species that require, among other things, the use of FWS's risk assessment protocol.

The AIS program also oversees injurious wildlife listing (under 18 U.S.C. 42 (a)) for DOI. More than 700 species are federally listed as injurious wildlife; the law prohibits the importation of injurious species and transport of injurious species between the enumerated jurisdictions (the continental United States, the District of Columbia, Hawaii, the Commonwealth of Puerto Rico, and any territory or possession of the United States), except by permit because of harm they can cause to humans, agriculture, forestry, horticulture, wildlife, or wildlife resources of the United States. Using the regulatory process, AIS can add species to the list, which thereby prohibits the importation of those species and limits their transport within the United States, except by permit.

VIII. Office of Surface Mining Reclamation and Enforcement

The Office of Surface Mining Reclamation and Enforcement (OSMRE), established by the Surface Mining Control and Reclamation Act of 1977 (SMCRA), is responsible for ensuring that coal mining is conducted in a manner that protects communities and the environment and restores the land to beneficial use following mining, and mitigating the effects of past mining by aggressively pursuing reclamation of abandoned mine lands. OSMRE achieves this in part by providing technical assistance and technology transfer activities based on sound science and by offering training to its state and Tribal partners to enhance their ability to maintain effective programs.

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 in 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 (NTTT).

Technical Innovation and Professional Services (TIPS). TIPS is a national program that continues to research and apply emerging technologies to SMCRA workflows. TIPS provides 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 provided are centered on off-the-shelf scientific and engineering computer software and technical hardware supported by OSMRE in partnership with the states and Tribes. TIPS hardware is available to states and Tribes that regulate coal mining to advance reclamation projects nationwide. The TIPS suite of scientific, hydrologic, and mapping core software aids the technical decision-making associated with a wide variety of tasks that surface mining agencies have to perform regularly: conducting reviews of permits, performing cumulative hydrologic impact assessments, quantifying potential effects of coal mining, preventing acid mine drainage, quantifying subsidence impacts, measuring revegetation success, assisting in the design of abandoned mine lands projects, and providing the scientific basis for environmental assessments and environmental impact statements.

Currently, TIPS assistance includes providing commercial software applications and hardware to state, Tribal, and OSMRE offices at considerable cost savings by sharing the commercial licenses for 20 commercially available software applications via the Internet and an OSMRE-wide area network. These software applications cover a wide range of regulatory and abandoned mine

lands subjects. The customer base covers more than 60 state, Tribal, and OSMRE office locations throughout the country.

Demand for TIPS tools and support continues to increase, especially for geospatial data and mobile computing tools for field use. TIPS is offering more onsite training for state, Tribal, and federal personnel to familiarize them with use of mobile computing devices by inspectors. Mobile computing increases efficiency in resolving state, Tribal, and industry issues. Below are additional details on the GeoMine Web Application and computing and mapping tools the TIPS program supports.

GeoMine Web Application. GeoMine provides authoritative data for surface coal mining operations across the country, merging data from numerous sources to create standardized, seamless layers that cross state and Tribal boundaries. It continues to support a diverse user base by providing several standardized, interoperable coal mining-related geospatial datasets, as well as high-resolution aerial imagery. Users include individuals, non-governmental organizations like Trout Unlimited and Appalachian Voices, educational institutions including the University of Washington, and other DOI bureaus.

A new user survey implemented at the end of FY 2022 is providing more detailed insight into GeoMine's usage through FY 2023. Most users access the app as a reference tool for geospatial data, but many also note the importance of the imagery the app provides, particularly from the EagleView Pictometry widget, and are asking for coverage to be expanded. During FY 2022, the Pictometry widget (high-resolution birds-eye view) was accessed 183 times, resulting in 434 distinct image views. The GeoMine app overall has received over 2,000 visitors and provided over 181 geospatial data downloads. Taken collectively, the usage statistics demonstrate not only that GeoMine serves an important role in the SMCRA community due to the data it provides, but that there is a desire for even more information to be made available moving forward.

GIS Mobile Computing. In FY 2022, OSMRE continued the use of tablets and smartphones that can display and collect geospatial data while at mine or Abandoned Mine Land (AML) site investigations.

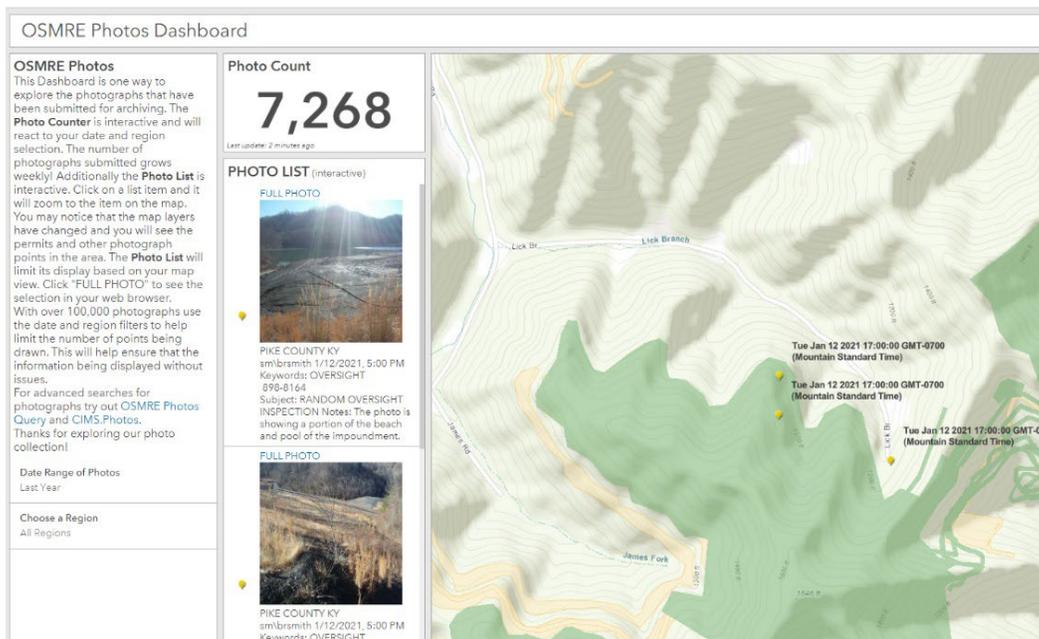
Mobile Applications Supported by Western Region GIS Branch (GIS Branch). Several of the mobile applications that are supported by the GIS Branch are listed below:

- Esri Survey123
- Esri Field Maps
- Avenza Maps
- Global Mapper Mobile

Survey123 and Field Maps are the primary mobile apps in use. Survey123 and Field Maps easily leverage enterprise level datasets hosted in ArcGIS Online. Consequently, they are the mobile apps most frequently configured for users that are heading out to the field.

Avenza and Global Mapper Mobile lend themselves to situations where enterprise data collection is not a priority. Several state programs take advantage of these applications, as do individuals who just need to see a map in the field, or who only need to store the data they collect on their own device.

OSMRE’s Enterprise Photo System. For most users, field photographs and notes (collected with Survey123 or Field Maps) enter a custom process that appends the data to a robust data base. Data collected in the field are synchronized to ArcGIS Online. Web applications configured in AGOL allow for searching and viewing of current and historical photographs. Currently over 100,000 photographs are available for viewing and have been made available to states and Tribal partners within OSMRE’s AGOL web platform. This information is critical to future investigations. The OSMRE Photos Dashboard allows for this enterprise GIS data to be easily viewed with a wide variety of client applications (see below).



OSMRE PHOTOS DASHBOARD, 4 MARCH 2022. THIS DATABASE ALLOWS USERS TO EASILY FIND CURRENT AND HISTORIC PHOTOS OF SPECIFIC SITES, SUPPORTING SITE INVESTIGATIONS AND RECLAMATION OF FORMER MINED LANDS. SOURCE: OSMRE

Emerging Technology Testing (StoryMaps and Dashboards). The GIS Branch deployed the Esri Story Maps product, which is an incredibly versatile tool to leverage not only static and dynamic maps, but photos, video, text, and even audio recordings to create immersive, engaging platforms for presenting information. The GIS Branch collaborated with the Indian Programs

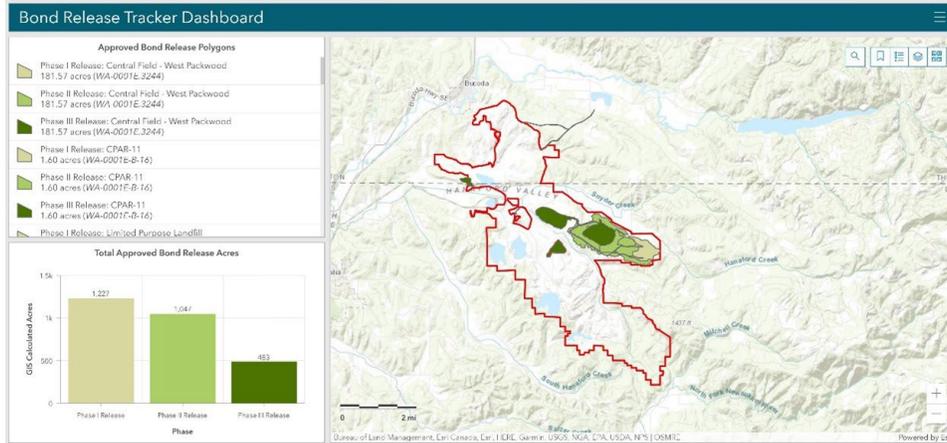
Branch and the Office of Communications to publish a [Story Map detailing the history and status of the Kayenta Mine Complex in Arizona](#).⁸ Using photos and video taken during inspections, documents from the original mine permit, geospatial data supplied by the operator, and satellite imagery, the Story Map presents the OSMRE perspective on the successful reclamation efforts at the Complex and its strong partnership with Tribal nations.



TITLE PAGE FOR THE KAYENTA MINE STORYMAP. STORYMAPS SUCH AS THIS ONE ARE AN IMMERSIVE, ENGAGING WAY TO INFORM THE PUBLIC ABOUT A FOCUSED TOPIC. SOURCE: OSMRE

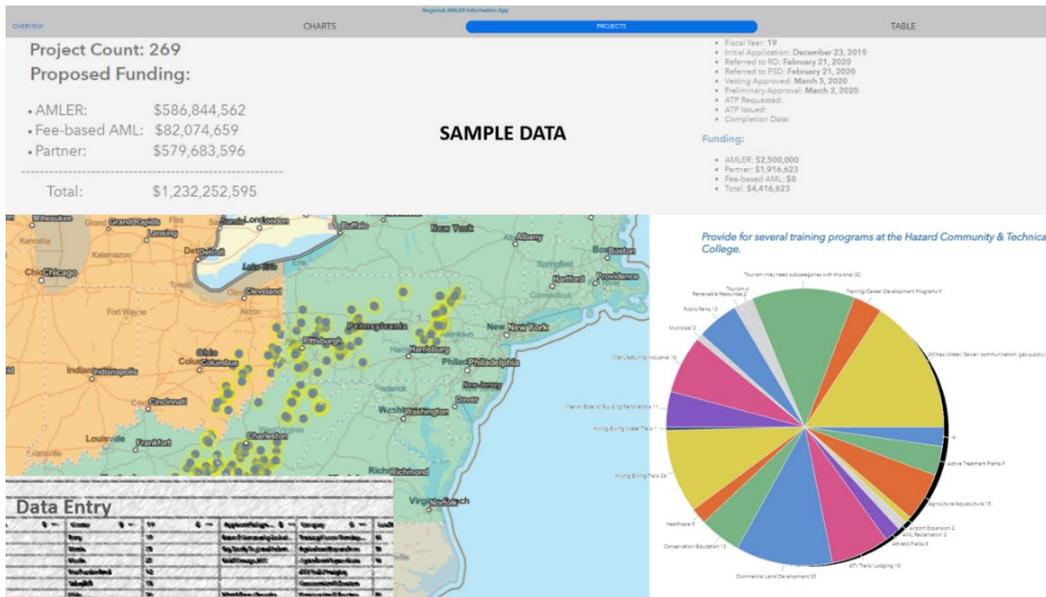
Bond Release Visualization Dashboard. In FY 2022-23, the GIS Branch is developing web applications to support Indian Programs mine teams and the Field Operation Branch's Federal Reclamation Abandoned Mine Land Program (FRP). One dashboard covers seven large Western mines, allowing mine team leads and managers to view lists of approved bond releases with pertinent project information, visualize areas at the mine by release phase, and easily see approved bond release acreage totals. This work will supplement tabular bond release reports and assist in ensuring that all areas in need of reclamation are accounted for. A second web application is modernizing project data management for the FRP program by leveraging cloud GIS capabilities. Specialists can access the application from any web browser and incorporate geospatial layers from state departments of natural resources and other federal and regional sources to contextualize emergency reclamation project data. They can view project locations overlaid on top of historic coal mine maps, measure proximity to parks and other public infrastructure, and plot new citizen complaints to determine if previous project work has been completed in the vicinity.

⁸ URL: <https://storymaps.arcgis.com/stories/eb1a9eaa0db1467dabfe616f02c1a53c>



SAMPLE SCREENSHOT OF THE BOND RELEASE TRACKER DASHBOARD. THIS TOOL HELPS MANAGERS KEEP TRACK OF THE AREAS RELEASED FROM RECLAMATION BONDS, ENSURING FINANCIAL ACCOUNTABILITY FOR RECLAMATION. SOURCE: OSMRE

Abandoned Mine Lands Economic Revitalization (AMLER) Dashboard. The [AMLER dashboard](#)⁹ was constructed by the Western Region GIS Branch to overhaul data input and display into a new centralized location that allows the data to be displayed in a geographic format. Users can now easily filter the data, drill down into individual attributes or projects, and produce reports and photos of AMLER projects.



SAMPLE SCREENSHOT OF THE AMLER DASHBOARD, WHICH PROVIDES EASY ACCESS TO DATA ON AMLER PROJECTS, FACILITATING ECONOMIC RESTORATION. SOURCE: OSMRE

⁹ URL: <https://experience.arcgis.com/experience/f47ca390a04c4e2aa3c8bf938d023e02>

Remote Sensing Direct Program Support and Coaching. Remote sensing data allows OSMRE and its partners to monitor reclamation, ensuring that former mined lands are safely and thoroughly restored. GIS Branch staff announced a contract with Planet Labs to deliver satellite data and access to Planet Labs' suite of products, which will provide inspectors the ability to examine specific features such as vegetation, impoundments, and geologic features. This contract also includes the ability to task a satellite to collect imagery over an area with higher resolution that can then be used to create elevation data. It will also allow OSMRE the ability to monitor reclamation over a long period of time, daily, or in some instances multiple times per day to help view an area before and after an event such as a highwall failure. This is on top of our ability to process Synthetic Aperture Radar (SAR) satellite data that enables users to see through clouds and smoke, as well as process CRSSP-Imagery Derived Requirements (CIDAR) requests. These requests allow us to deliver satellite-based observations to internal OSMRE users (e.g., mine team leaders) and our state and tribal partners. The impact includes accurate and timely remotely sensed imagery for monitoring and helping prepare teams for future mine site inspections (e.g., at Centralia, John Henry, McKinley, Kayenta, Navajo, and Absaloka mines).

In addition, the GIS Branch staff provided more than 20 group and in-person related training to advance remote sensing capabilities as they relate to SMCRA applications. This includes over 700 attendees at various events, with the goal of demonstrating comparisons of LiDAR collections for McKinley Mine reclamation areas, methane detection using thermal hyperspectral imaging, surface disturbance changes to help monitor active coal mines, and how to use various remote sensing applications (NEPAssist, and GeoMine).

ArcGIS Online. The ArcGIS Online web mapping system allows access to OSMRE and shared geospatial data. When mine inspectors conduct field work this system allows them to collaborate with SMCRA partners in near-real time. In 2022 the system continues to show increased usage, with over 360 state and Tribal members, and more than 500 total active users. Two new security enhancements were recently added into the ArcGIS Online environment including multi-factor authentication, and a new Standard Operating Procedure (SOP) allowing ArcGIS Online administrators to more effectively manage inactive or abandoned accounts. This resulted in nearly 200 accounts identified as inactive and scheduled for removal.

TIPS Training Program. The TIPS Training Program is a collaborative effort among OSMRE, states, and Tribes. 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. Although most of the TIPS tools are off-the-shelf applications, TIPS training is tailored exclusively to mining and reclamation uses. TIPS courses are delivered onsite at the customer's request and in training centers in

OSMRE's Regional Offices in Alton, Illinois; Pittsburgh, Pennsylvania; and rental training facilities in Denver, Colorado.

In FY 2022, the TIPS training program received a customer satisfaction rating of 97 percent, exceeding the annual Government Performance and Results Act (GPRA) goal of 96 percent. TIPS had not fully re-established in-person classes as transitioning out of the COVID-19 pandemic continues; therefore, 31 virtual vendor-instructed classes were scheduled. TIPS only held 19 of the 31 virtual classes and received 1 in-person special training session request from Kentucky. For FY 2022, there were 120 students trained, which was a 174% decrease from FY 2021.

National Technical Training Program (NTTP). Established in 1985, NTTP is an ongoing training program designed to increase the technical competence and professionalism of state, Tribal, and OSMRE regulatory and reclamation staff, keeping them abreast of changing technologies, evolving methodologies, and policies to ensure the training reflects the best protection and land restoration practices. The NTTP provides comprehensive training in the skills needed to carry out the mandates of SMCRA. The program, which identifies training needs through course development and presentation, is a cooperative effort between state, Tribal, and OSMRE offices. The NTTP utilized the experience and expertise of 46 subject matter expert instructors from state, Tribal, and OSMRE offices in FY 2022 to deliver both online and in-person classes. The instructors are experts in mining regulatory and reclamation practices.

NTTP has developed and maintains a library of 15 online self-paced courses. The online courses are now added to the NTTP training portfolio and will continue to be offered as options for in-person course offerings. In addition, in 2021, the Biden Administration signed the Infrastructure Investment and Jobs Act into law. This bill injected funds into OSMRE to support SMCRA reclamation projects. In response to this new legislation, NTTP developed the Introduction to SMCRA and BIL training curriculum, which explains changes to SMCRA, NEPA, eAMLIS, and Reclamation Planning. Currently, these courses are offered on DOI Talent in an online, self-paced format. One hundred and ten students have completed the Introduction to SMCRA and BIL training curriculum, with over another one hundred students enrolled in the courses.

The courses NTTP provide cover a wide variety of technical areas for several practical applications, including the design of abandoned mine land restoration, proper inspection tools and techniques, soils and revegetation, identification and handling of toxic/acid-forming materials, water-quality assessments, legal aspects of enforcement procedures, and preparation of evidence and testimony. In FY 2022, there were 195 in-person and 332 online course completions. The program achieved an overall effectiveness rating of 95 percent, based on student survey responses regarding the usefulness of the training for their current positions.

National Technology Transfer Team (NTTT). The OSMRE NTTT manages and promotes the Applied Science Program (ASP), whose goal is to develop, demonstrate, and share improved technologies to address environmental issues related to the mining of coal and subsequent reclamation of the land. The program accomplishes this by funding studies conducted by universities, nonprofit 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, rare earth elements, and other topics relevant to environmentally responsible mining and reclamation. These projects go beyond theoretical research and investigate application of existing theory to on-the-ground mining and reclamation issues.

The team brings together members of OSMRE, state and Tribal SMCRA programs, as well as representatives from the Interstate Mining Compact Commission and the National Association of Abandoned Mine Land Programs, to coordinate understanding of mining-related issues across the country. In FY 2022, the ASP team managed 8 projects that were selected through FY 2020 funds and selected another 8 projects using FY 2021 funds. The proposals were evaluated based on scientific and technical merit. The projects have a two-year term, but a no-cost extension can be granted if warranted. Quarterly programmatic reviews for each funded project are being conducted by assigned Project Technical Representatives. Reports and findings of completed projects are available on the [OSMRE Applied Science website](#).¹⁰

In late FY 2020, OSMRE issued a Notice of Funding Opportunity (NOFO) for the ASP for approximately \$1.6 million, and the selection process will take place in FY 2023. NTTT continued to manage the interactive Applied Science GIS application that allows any interested party to access quarterly status reports for funded and ongoing projects. The GIS application can be accessed on the [ArcGIS dashboard for OSMRE Applied Science](#).¹¹

NTTT also hosts and participates in technology transfer activities such as workshops, forums, and symposia to collaborate with partners outside the SMCRA community. This aspect of the team's activities has been significantly impacted by the COVID-19 pandemic. Some of the nationally recognized conferences offered in-person attendance in FY 2022. NTTT participated and provided promotional displays at the American Society of Reclamation Sciences (ASRS) annual conference (Duluth, MN – June) and the 19th International Bat Research conference (Austin, TX – August) in FY 2022.

¹⁰ URL: <https://www.osmre.gov/programs/applied-science>

¹¹ URL: <https://experience.arcgis.com/experience/ff3243e737cc476da6ab1368f4836b9c>

Another program that OSMRE uses to award cooperative agreements is the Mine Drainage Technology Initiative (MDTI), which builds consensus among industry, federal, and state regulatory agencies on acidic and toxic drainage technology development and technology transfer issues. MDTI cooperative agreements, which are established under authorities other than the Federal Technology Transfer Act, provide a forum for collaboration and information exchange with the following goals: (1) developing an understanding of mine drainage (MD) to better predict, avoid, monitor, and remediate MD; (2) developing innovative solutions to MD water quality problems; (3) identifying, evaluating, and developing “best science” practices to predict MD before mining; and (4) identifying successful remediation practices for existing MD sources, and describing the best preventive technologies.

In FY 2022, OSMRE had two MDTI cooperative agreements funding studies with universities that were in various stages of completion. Also in FY 2022, OSMRE issued another NOFO for an MDTI cooperative agreement, receiving 5 proposals in response and selecting one of the proposals to fund in FY 2022. Like the APS, MDTI cooperative agreements have a 2-year term that can be extended at no cost, if justified.

IX. 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. Most of these activities are undertaken at the level of each individual park unit, but service-wide networks, programs, and centers make related scientific contributions in areas such as inventory and monitoring and preservation technology.

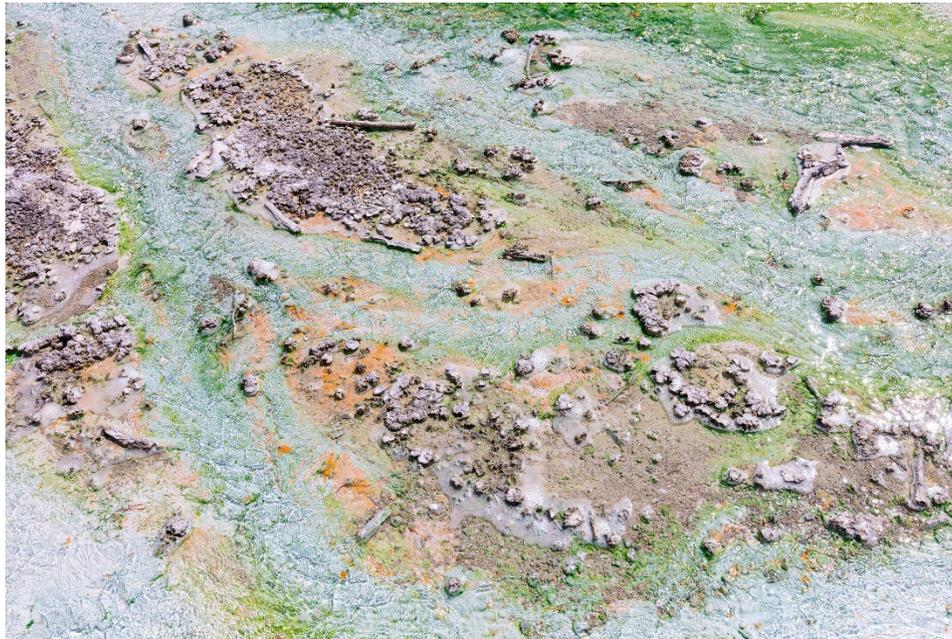
Scientific activities within NPS focus on improving the understanding and management of park natural and cultural resources. In cooperation with partners, NPS also works to preserve and interpret similar resources outside parks. The information generated by these activities is shared with park managers 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.

To expand the range of expertise and tools available to it, NPS participates in many collaborative ventures with universities and other governmental and nongovernmental organizations, including the Cooperative Ecosystem Studies Units Network.

NPS Cultural Programs include the National Center for Preservation Technology and Training (NCPTT), which Congress created to fill a fundamental need for research and technology transfer among federal, state, local, and tribal governments, Native Hawaiian organizations, educational institutions and other public entities with historic preservation programs. The NCPTT serves as a research and development laboratory for historic preservation and advances the application of science and technology to preservation issues. 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.

NPS encourages qualified scientists to undertake research on parks' 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 policies 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.¹²



THERMOPHILES OF WHIRLIGIG GEYSER’S RUNOFF CHANNEL, NORRIS GEYSER BASIN, YELLOWSTONE NATIONAL PARK. RESEARCH ON MICROORGANISMS FOUND IN THE EXTREME ENVIRONMENTS CREATED BY YELLOWSTONE THERMAL FEATURES HAVE LED TO SOME DISCOVERIES WITH PRACTICAL APPLICATIONS OF GLOBAL SIGNIFICANCE. NORRIS, ONE OF THE HOTTEST AND MOST ACIDIC OF YELLOWSTONE’S HYDROTHERMAL AREAS, HARBORS MICROBES OF INTEREST TO DIVERSE RESEARCHERS—FROM ASTROBIOLOGISTS TO FOOD SCIENTISTS. SOURCE: JACOB FRANK, NPS

Benefits-sharing Agreement. Yellowstone National Park has a nontraditional CRADA with a small business that is commercializing research results from a study of microbial mats collected from a thermal area in the park. Food products based on its research are currently available in 232 stores nationwide, including in Chicago, New York City, San Francisco, Houston, Los Angeles, Denver, and Dallas. The company is providing nonmonetary benefits related to a genetic monitoring program for the purpose of disease detection and conserving genetic diversity of park wildlife. The company will provide monetary benefits to the park upon successful commercialization of products or services it develops based on its discoveries.

¹² For further information on NPS benefits sharing, see [Benefits Sharing in the National Parks \(U.S. National Park Service\) \(nps.gov\)](https://www.nps.gov/nature/benefits-sharing.htm). URL: <https://www.nps.gov/nature/benefits-sharing.htm>

X. 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. Reclamation is the largest supplier and manager of water in the 17 western states and the Nation's second-largest producer of hydroelectric power. Reclamation manages water for agricultural, municipal, and industrial uses and provides flood risk reduction and recreation for millions of people.



HOOVER DAM ON THE COLORADO RIVER. RECLAMATION PROJECTS LIKE HOOVER DAM PROVIDE WATER, POWER, RECREATION, AND FLOOD PROTECTION TO MILLIONS OF AMERICANS. CREDIT: [BUREAU OF RECLAMATION](#)

Reclamation's activities, including hydropower, water deliveries, payroll, and recreation, contributed more than \$68.9 billion to the economy and supported 486,000 jobs.¹³ Most of this production was associated with water deliveries for irrigation (\$47 billion) and for municipal and industrial uses (\$11.7 billion). Reclamation provides western farmers with irrigation water for 10 million farmland acres that produce 60 percent of the nation's vegetables and one quarter of its fresh fruit and nut crops. Further, Reclamation delivers about 10 trillion gallons of water to 31 million people for municipal, residential, and industrial use. Through the process of

¹³ <https://doi.sciencebase.gov/doidv/doi-bureau.html>

providing water deliveries, Reclamation also generates hydropower through 78 owned power plants, 53 of which are operated and maintained by Reclamation. The latter 53 power plants account for 15 percent of the hydroelectric generating capacity in the United States and generate roughly 40 billion kilowatt hours of electricity annually (valued at \$2.7 billion in Fiscal Year 2019), which is enough to supply more than 3.8 million U.S. households.



HYDROPOWER TURBINES AT KESWICK POWER PLANT NEAR REDDING, CA. RECLAMATION FACILITIES PROVIDE HYDROPOWER FOR MILLIONS OF U.S. HOUSEHOLDS, AND ITS RESEARCH AND DEVELOPMENT WORK FINDS SOLUTIONS TO KEEP BOTH WATER AND POWER FLOWING. CREDIT: [BUREAU OF RECLAMATION](#)

Reclamation Research and Development (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 R&D Office manages two appropriated R&D programs: the Science and Technology (S&T) Program and the Desalination and Water Purification Research (DWPR) Program.

The S&T Program is the primary R&D program for Reclamation and funds intramural research that spans the spectrum of its water-related technical challenges. Its goals are to identify and develop cost-effective solutions to the technical and scientific problems affecting the 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. In addition to supporting internally led research, the program enlists crowdsourced innovation via technology prize competitions addressing some of Reclamation’s most difficult challenges in infrastructure, water availability, and environmental compliance.

The DWPR Program invests in extramural R&D that advances the capabilities of water treatment technologies to enable them to be used more broadly for the creation of new water supplies from non-traditional sources (e.g., seawater, brackish groundwater, produced waters from oil and gas, municipal and industrial wastewater), nationwide or even globally. Such new supplies can relieve water stress on western communities, tribes, western river basins supporting Reclamation projects, the Nation as a whole, and worldwide in water-constrained areas. The program also supports the operation and maintenance of the Brackish Groundwater National Desalination Research Facility, which hosts federal and non-federal R&D clients conducting bench-scale studies to pilot-scale demonstrations.

Reclamation Technology Transfer. Although Reclamation’s R&D focuses on developing solutions that address Reclamation technical mission needs, such solutions can also have broad applicability beyond Reclamation’s jurisdiction in the western United States. 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.

Most of Reclamation’s R&D reports, data, and information on technology advancements are transferred through public dissemination via the [R&D Office website](#)¹⁴ as well as through Reclamation’s new open data sharing platform, the [Reclamation Information Sharing Environment](#).¹⁵

Transfer of other technology advancements harnesses 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 U.S.C. § 3710(b).

Reclamation also works to increase awareness across U.S. industries and other nongovernmental organizations of the specialized research resources (people, lands, and

¹⁴ URL: www.usbr.gov/research

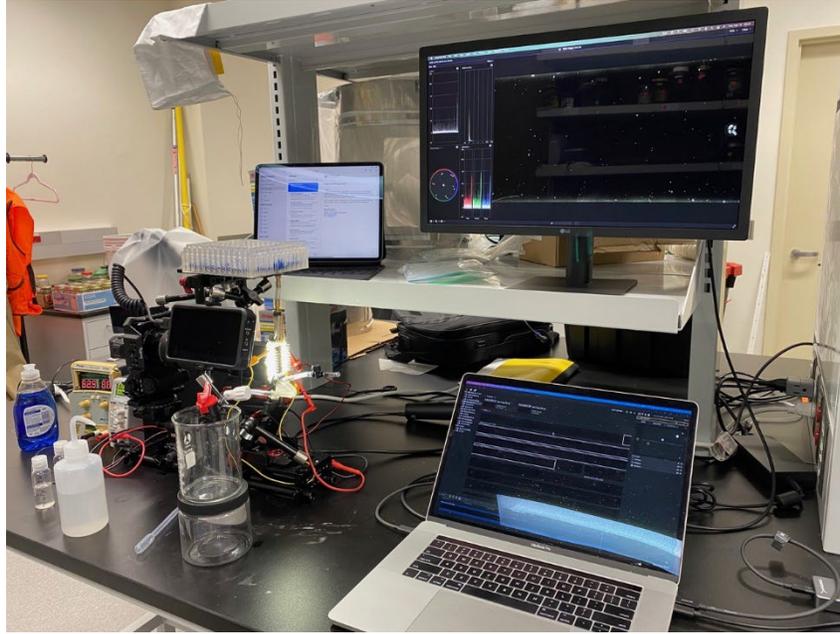
¹⁵ URL: <https://data.usbr.gov>

facilities) that they can access through technology transfer agreements authorized by 15 U.S.C. § 3710a. In addition to physical research laboratories, Reclamation's R&D assets include engineering and scientific expertise, 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 many of its R&D activities do not involve the 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 and help transfer technology more rapidly and broadly.

Highlights of Reclamation technology transfer activities during FY 2022 include the following:

Automated Image Analysis of Invasive Mussel Samples. Invasive quagga (*Dreissena rostriformis bugensis*) and zebra (*Dreissena polymorpha*) mussels pose a significant risk to natural habitats, recreation, and infrastructure like hydropower facilities, so controlling their spread is a priority for the Bureau of Reclamation, the Department of the Interior, and western states. The Reclamation Ecological Research Lab is one of the primary labs in the western United States that analyzes invasive zebra and quagga mussel early detection samples. Current early detection methods involve the collection of plankton tow net samples, which are preserved and sent to the lab where they are analyzed under a microscope to detect the larval stage (veliger) of the mussel. If veligers are detected, then quantitative polymerase chain reaction genetic analysis of the veligers is conducted to confirm species identification. Despite the accuracy of microscopy and DNA analysis methods, there are situations where more rapid and/or on-site detection of mussels is required, and there is a need to identify faster and more cost-effective methods of analyzing samples with large numbers of mussels.

A Material Transfer Agreement (MTA) was established with ScanLogX, which is in the process of developing an automated sampling device that incorporates machine learning to specifically identify dreissenid mussel veligers. The prototype device was of interest to Reclamation because it may be utilized both in-situ and in the lab and has the potential to process samples quickly and without filtration. The MTA allows for Reclamation to send ScanLogX water samples containing preserved veligers to determine if the device can accurately detect and enumerate veligers. ScanLogX has made progress with training the device and are working with Baylor University and the USGS to do in-situ testing with zebra mussel veligers. The collaborative work supported by this MTA will hopefully provide Reclamation another tool to effectively monitor mussel populations.



AUTOMATED IMAGING DEVICE FOR MONITORING OF INVASIVE MUSSELS. MONITORING THESE MUSSELS HELPS SCIENTISTS PROTECT ECOSYSTEMS AND KEEP WATER FACILITIES RUNNING. SOURCE: SCANLOGX

Characterizing Mechanical Behavior of Grouts with Ductile Recycled Material. With an increased awareness and dedication to sustainability, the unique testing capabilities of the Concrete and Structural Laboratory and the Geotechnical Laboratory and Field Support group of the Technical Service Center are supporting Reclamation design projects and exploring new applications for recycled materials in construction. The labs can test many types of cementitious materials, including special grouts or mortars for a variety of geotechnical applications.

Reclamation partnered with KM Materials, LLC to characterize grouts made with recycled materials to increase ductility. The hardened grout specimens were tested in an unconfined compression test as well as a variety of confined cyclic tests using advanced geotechnical testing equipment. Because of the specialized nature of the work, the Geotechnical Laboratory was the only known source with the unique equipment and specialized engineering expertise to perform this work. The hardened grout exhibited unique behavior during unload/reload cycles that are not characteristic of typical cementitious grouts. The results of the work can lead to further development or commercialization of the recycled materials and grout mixtures.



TO BETTER UNDERSTAND AND IMPROVE CEMENTITIOUS MATERIALS USED IN A VARIETY OF ENGINEERING PRODUCTS, NEW MIXTURES OF GROUT (LEFT) ARE TESTED FOR CHARACTERISTICS SUCH AS RESPONSE UNDER COMPRESSION (RIGHT).

SOURCE: BUREAU OF RECLAMATION

XI. 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 energy issues and activities. These activities primarily involve two offices: the Office of Offshore Regulatory Programs (OORP) and the Oil Spill Preparedness Division (OSPD).

OORP develops regulations and incorporates industry standards to enhance operational safety and environmental protection for the exploration, development, and production of offshore oil and natural gas, the development of renewable energy, and other energy activity on the U.S. OCS. OORP drives and supports continual improvement in safety, environmental protection, and offshore resource conservation through data and risk analysis, safety improvement initiatives, regulatory development and maintenance, standards and stakeholder engagement, policy development and oversight, and emerging technology evaluations to provide strategic guidance in support of BSEE's regulatory oversight and enforcement mission.

OSPD ensures that owners and operators of offshore facilities are ready to mitigate substantial threats of, and to respond to, oil spills that may result from their activities. OSPD performs numerous functions to improve oil spill preparedness and response capabilities, including comprehensive contingency planning, equipment testing and inspection, quality training, unannounced exercises, R&D, and engaging with the stakeholders of the National Response System.

BSEE R&D programs operate through OORP's Emerging Technologies Branch (ETB) and OSPD's Response Research Branch. The ETB is the agency's focal point on operational safety and pollution prevention research. Such research has been conducted within DOI since the late 1970's. OSPD's OSRR in its Oil Spill Preparedness Program contributes to the interagency collaborative efforts formalized in Title VII of the Oil Pollution Act of 1990.

OSPD also operates Ohmsett, the National Oil Spill Response Research and Renewable Energy Test Facility in Leonardo, New Jersey. The Ohmsett facility provides independent and objective performance testing of full-scale oil spill response equipment and marine renewable energy devices. In addition, the facility is available to help improve existing technologies through R&D. Domestic and international researchers from government, industry, academia, and oil spill removal organizations use Ohmsett to test and advance their technologies and train personnel on the use of advanced response equipment.

The majority of BSEE’s technology advances are shared with the public through reports that are publicly available on its [website](#).¹⁶ BSEE also shares its research results at conferences, workgroups, and other fora, such as the triennial International Oil Spill Conference, the annual Clean Gulf Conference, the Pacific States-British Columbia Oil Spill Task Force Annual Meeting, the National Response Team Science and Technology Committee, the Northern Oil and Gas Research Forum, the BSEE/U.S. Coast Guard (USCG) Response Work Group, BSEE/USCG Research Sharing meetings, industry meetings, and the Ocean Energy Safety Institute’s Public Research Forum.

BSEE’s primary research synergy is with state, Tribal, federal, and international government organizations, the offshore energy industries, and oil spill removal organizations. Research is typically in areas pertaining to critical equipment and technology, environmental impact, and risk reduction and assessment tools and techniques applicable to the U.S. OCS to ensure that the best available science is utilized in regulatory decision-making.¹⁷

BSEE is a member of the Interagency Coordinating Committee on Oil Pollution Research (ICCOPR) and its Executive Steering Committee. Comprised of 16 federal agencies, ICCOPR was established by Title VII 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.” ICCOPR publishes the Oil Pollution Research and Technology Plan (R&T Plan) that establishes the official federal priorities to address research gaps in preparedness, prevention, response, and injury assessment and recovery for oil spills. Throughout FY 2021, BSEE led efforts by the Executive Steering Committee to organize the ICCOPR to update the FY 2015-2021 R&T Plan.

BSEE is a member of the International Regulators’ Forum, which consists of members from 11 countries whose goal is to provide leadership on safety and safety-related regulatory matters for offshore energy activities. Other members include Norway, Canada, Brazil, and the United Kingdom.

The following are examples of FY 2022 completed or ongoing research projects that would, among other things, advance technological options and transfer knowledge about best technological practices to industries and regulators operating on the OCS.

¹⁶ URL: <https://www.bsee.gov/what-we-do/research/oil-spill-preparedness/oil-spill-response-research>

¹⁷ 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>.

Renewable Energy Fire Protection System. The purpose of this study is to evaluate the available options and performance of both passive and active fire protection and fire suppression systems (fire safety systems) on offshore wind facilities, ensuring that they are operated safely and reliably.

The offshore wind industry is relatively new in the U.S.; however, the international offshore wind industry is much more established and rapidly maturing, having the potential to serve as a significant energy source in the future. Currently DOI, to the extent feasible and unless otherwise known, has been accepting safety practices, standards, and regulatory practices used by other, more established programs outside the U.S. Accordingly, this study performed an assessment of the fire detection, protection, suppression, and explosion protection systems available for the offshore wind industry, and compared and contrasted the performance of passive and active fire protection/suppression systems available to the offshore wind industry.

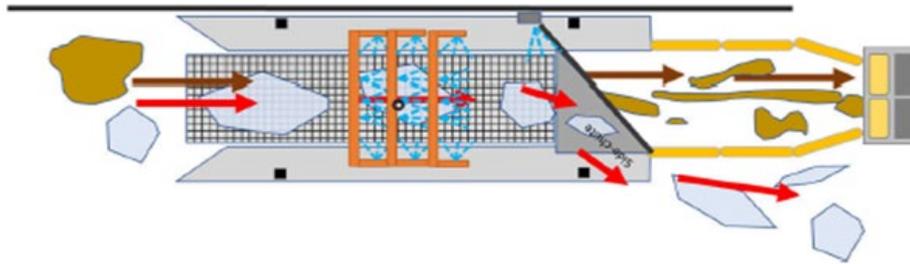
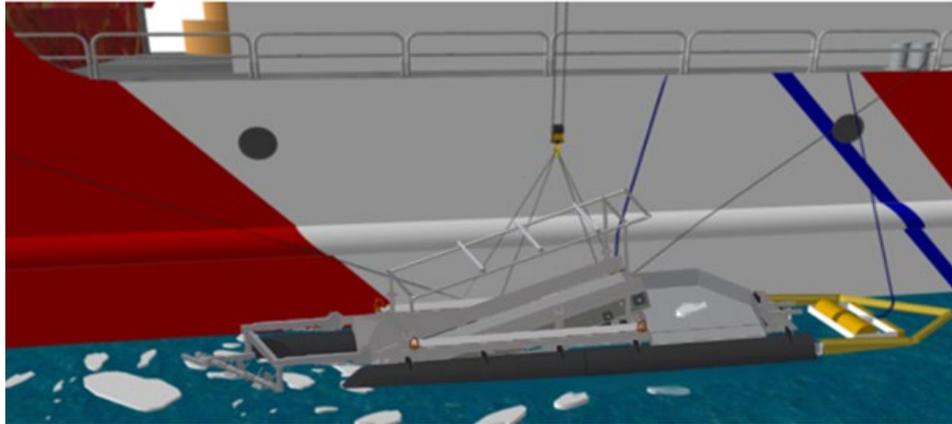
The study conducted a global review of current industry-standard systems and researched other options not currently used by the offshore wind industry. The project includes an assessment of:

- Fire protection philosophies
- Active and passive system technologies
- Fire zone layouts
- Fire insulation and barriers
- Fire integrity of walls and decks; insulation material specification and position; deck and surface coverings materials applications
- Ventilation system layouts and impacts to fire protection systems; penetration impacts
- Fire pumps, hydrants and hoses, sprinkler and spray systems, and other active fire protection systems
- Chemical considerations
- Fixed fire detection and alarm systems, including arc flash detection
- Specifications and optimum locations for detectors, equipment alarms and emergency call points.

Development of the BOWHEAD Vessel Ice Management System. BSEE contracted with Serco, Inc. to develop an ice deflection system called BOWHEAD to improve oil recovery in broken ice conditions, resulting in cleaner Arctic waters in the event of an oil discharge.

The BOWHEAD is deployed off the side of a vessel. As the vessel moves slowly forward, the BOWHEAD encounters oil and ice. Ice that enters between the pontoons is picked up by a conveyor belt. Oil remains in the water and is guided aft, where it is contained and recovered by a standard boom and oil skimmer. The ice is cleaned as it moves up the belt and is then

dumped out of the recovery area via an ice chute. Redirection of this ice allows the skimmer to operate in an ice-free zone. The BOWHEAD prototype was tested in 2021 in a simulated Arctic ice environment. BSEE OSPD plans to enhance the BOWHEAD prototype and conduct additional testing in 2023 to quantify its ability to improve oil recovery in ice over current oil-in-ice response tactics.



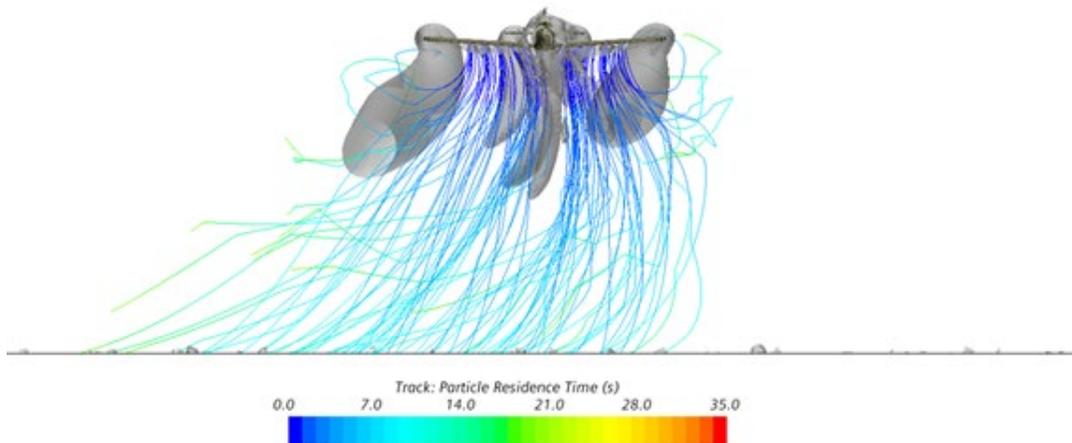
CONCEPT OF BOWHEAD SYSTEM OPERATING OFF THE SIDE OF A VESSEL. THE BOWHEAD SYSTEM CLEARS AWAY SEA ICE SO THAT OIL CAN BE MORE EFFECTIVELY SKIMMED OFF THE SURFACE OF THE WATER. SOURCE: SERCO, INC./BSEE, WITH PERMISSION



BOWHEAD ENCOUNTERING OIL AND ICE AS IT TRAVELS DOWN THE TEST TANK DURING **2021** TESTING. **SKIMMERS** REMOVE OIL FROM SEAWATER IN THE EVENT OF A SPILL; **BOWHEAD** IS DESIGNED TO MAKE THEM WORK BETTER IN ICY CONDITIONS, LEADING TO CLEANER OCEANS. SOURCE: BSEE/OHMSETT, WITH PERMISSION

Developing an Innovative Dispersant Spray Drift Model. Dispersants are chemicals that break up oil into smaller droplets, mitigating the effects of oil spills on the environment, but their effectiveness can vary based on the situation. BSEE funded a project with AMOG Consulting Inc. to develop a decision support tool to assist in applying oil dispersants, helping responders use them more safely and effectively.

The tool allows planners to identify operational windows and safety setback distances based on forecast meteorological conditions, spray drift patterns, aircraft types, and release rates. To create this tool, the contractor used Computational Fluid Dynamic (CFD) models to examine the forces and conditions experienced by a particular aircraft type during flight and how dispersants may behave as a result when released. The modeling created a library of data that informs predicted outcomes in an online display after the user inputs values for certain variables such as aircraft type, airspeed, and wind direction.



EXAMPLE OF DISPERSANT PARTICLE TRACK GENERATED FROM CFD MODELING FOR AN AT-802A MODEL AIRCRAFT EXPERIENCING A 90° MAXIMUM HEADWIND CONDITION. THESE MODELS MAY HELP MANAGERS USE DISPERSANTS MORE SAFELY AND EFFECTIVELY.

SOURCE: AMOG/BSEE, WITH PERMISSION

The final report and the online calculator have been delivered and the peer review completed. Based on the peer review comments, the calculator will be updated to include a new aircraft prior to the online tool being released to the public.

Ocean Energy Safety Institute (OESI). OESI is a collaborative initiative engaging the government, academia, industry, and scientific stakeholder communities. Its primary objective is to conduct cooperative research while building a collaborative model grounded upon principles of shared learning and promotion of dialogue and complementary research. The OESI was established in FY 2021 through a cooperative agreement between BSEE, the Department of Energy (DOE), and the Texas A&M Engineering Extension Service (TEES).

In support of OESI, TEES has assembled a consortium of industry, national labs, non-governmental organizations, and academia. The consortium includes 16 universities in 10 states, three national labs, and more than 20 stakeholders representing conventional and renewable energy. The OESI will support critical improvements for all offshore energy activities, including renewable and traditional energy, and support new offshore energy technology development.



CRANE INSTALLING AN OFFSHORE WIND TURBINE. BSEE IS COLLABORATING WITH ACADEMIA, INDUSTRY, SCIENTISTS, AND OTHER GOVERNMENT AGENCIES TO CONDUCT RESEARCH THAT MAKES OFFSHORE ENERGY PRODUCTION SAFER. SOURCE: BSEE

BSEE and DOE are substantially involved in the institute through a Joint Steering Committee (JSC), which includes representatives from each agency with expertise related to oil and gas, offshore wind, and marine energy technologies. The JSC provides input to OESI on its technology roadmaps and annual plans and reviews and approves its significant deliverables.

Renewable Energy Remote Inspections. Today's offshore wind turbines are developed with real-time remote monitoring technologies that aid turbine operators with performing preventative maintenance, optimization, and diagnostics. These technologies have been successfully implemented in parallel industries such as offshore oil and gas to satisfy various asset inspection and maintenance requirements. A study initiated in FY 2021 will evaluate the available options and economic benefits of conducting remote inspections and monitoring, maintenance, testing, and repairing offshore wind turbines above and below the waterline.



TWO EMPLOYEES WATCHING OFFSHORE WIND TURBINE INSTALLATION. BSEE IS RESEARCHING OPTIONS FOR REMOTE INSPECTIONS, WHICH COULD ENSURE SAFETY MORE EASILY THAN DIRECT INSPECTIONS. SOURCE: BSEE RENEWABLE ENERGY PROGRAM

Probabilistic Risk Assessment: Casing Shear Ram (CSR) + Dual Blind Shear Ram (BSR) Analysis.

This risk assessment evaluates the benefit of adding a second piece of equipment to allow a drill ship to escape in an emergency. The Deadman/Autoshear (DMAS) sequence activates in the event of the death or incapacitation of the driller who is operating the equipment. This application analysis aims to quantify and compare the benefit to the loss of containment risk of adding a second shear ram. This analysis applies to exploration and development wells drilled by rigs using dynamic positioning systems. This assessment was completed in FY 2021. Results will be released following peer review.

Probabilistic Risk Assessment: Surface Blow Out Preventer w/ Subsea Isolation Device Phase 1 vs. dual BSR/CSR Dynamic Positioning Rig Analysis.

BSEE undertook an analysis of a previously untried and complex configuration of equipment and compared it to a known implemented configuration, with the goal of understanding their relative risks. The analysis looked at the relative risk of a traditional dynamic positioning (DP) system drillship with a subsea blowout preventer (BOP) compared to that of a moored mobile offshore drilling unit with DP-assist with a surface BOP, high-pressure riser, and a Subsea Isolation Device. The risk analyzed pertains to uncontrolled hydrocarbon release during the completion of deepwater operations. This assessment evaluates the well-completion scenario. This assessment was completed in FY 2021. Results will be released following peer review.

XII. Bureau of Ocean Energy Management

The Bureau of Ocean Energy Management (BOEM) manages the Nation's offshore energy and mineral resources in an environmentally and economically responsible way. It ensures access to, and the fair return for, conventional and renewable energy and mineral resources of the U.S. OCS to help meet the Nation's energy and mineral needs while protecting the human, marine, and coastal environments and addressing climate change.

As the Nation's offshore energy and mineral resource manager, BOEM is committed to using the best available science and knowledge across a range of relevant disciplines that provide the scientific and technical foundation and the human capital needed to make sound decisions at all levels of the organization. Management of the energy and mineral resources of the OCS is governed by the Outer Continental Shelf Lands Act, which establishes procedures for leasing, exploration, and development and production of those resources, including oil, gas, renewable energy, and marine minerals such as sand and gravel used for coastal restoration projects.

BOEM conducts and publishes environmental reviews, including National Environmental Policy Act analyses and compliance documents, for each major stage of resource planning and development. These analyses are carried out by BOEM's [Office of Environmental Programs](#),¹⁸ [Office of Renewable Energy Programs](#),¹⁹ and [its regional offices](#). These analyses inform BOEM's decisions on its National OCS Oil and Gas Leasing Program and other energy and mineral leasing and development activities. In addition, BOEM's scientists conduct and oversee environmental studies to support 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—located in New Orleans, Louisiana; Camarillo, California; and Anchorage, Alaska—manage oil and gas resource evaluations; renewable energy development; environmental studies and assessments; leasing activities; reviews of required plans submitted by lessees; fair market value determinations; and geological and geophysical permitting.

BOEM Environmental Studies Program. BOEM manages the exploration and development of the Nation's offshore resources in a way that appropriately balances economic growth, energy development, and environmental protection. BOEM's ESP strives to apply the best science and knowledge available for informed decision-making. It plans, conducts, and oversees world-class scientific research to inform policy decisions regarding leasing and developing OCS energy and

¹⁸ URL: <http://www.boem.gov/Environmental-Stewardship>

¹⁹ URL: <http://www.boem.gov/renewable-energy>

mineral resources. 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 and mineral 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, and cooperative or other agreements with other federal agencies, Tribes, state institutions, and universities. 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 disseminating information, knowledge, and technologies to commercial entities and other stakeholders with interests in the OCS. Virtually all these activities are undertaken using authorities provided to BOEM other than the FTTA. Studies undertaken or funded by BOEM are available to the public through the [BOEM environmental studies website](#).²⁰ The website includes more than 150 ongoing and 2000 completed BOEM-sponsored environmental research projects and provides online access to more than 3,900 research reports. In 2022, ESP completed 30 studies that accounted for approximately \$34 million in BOEM-funded ocean research.

BOEM also partners with BSEE to select and fund renewable energy research to facilitate industry development, promote operational safety, and prevent pollution through BSEE's Technology Assessment Program.²¹

BOEM also participates in and funds interdisciplinary projects, including partnerships with other federal agencies, academic institutions, and the private sector. These projects are directed toward offshore ecosystem studies that utilize state-of-the-art technologies, such as autonomous underwater vehicle (AUV) surveys, deep-water human-occupied submersibles, and remotely operated vehicles. These partnerships leverage expertise and technologies to meet common management goals.

The following are a few examples of BOEM's ongoing scientific R&D activities, including some conducted in cooperation with other parties.

²⁰ URL: <https://www.boem.gov/environment/environmental-studies/environmental-studies-information>

²¹ More information on this research is available at <https://www.boem.gov/Technology-Assessment/>.

Atlantic Deepwater Ecosystem Observatory Network (ADEON). BOEM deployed the Atlantic Deepwater Ecosystem Observatory Network (ADEON), a multi-year, year-round, integrated, deep-water observing system for the U.S. mid- and south Atlantic Outer Continental Shelf. The new network gave BOEM better tools to manage the Outer Continental Shelf ecosystem to protect marine life and assess the impacts on related ecosystem components that may be affected by BOEM's energy and mineral development activities. During its period of operation, the network used advanced bottom-mounted acoustic technology to monitor human, biological, and natural abiotic factors that describe the ecology and soundscape of the Outer Continental Shelf offshore the U.S. east coast.

Air Quality Measurements. In 2022, BOEM expanded its partnership with the National Aeronautics and Space Administration (NASA) to study Gulf of Mexico regional air quality through remote sensing platforms. BOEM will use NASA's data in the Gulf of Mexico region to better monitor emissions from energy and mineral sources, including oil, gas, and renewable energy activities and sand and gravel projects. This data also will inform activities in BOEM's Atlantic and Pacific regions. This study will use field measurements from NASA's 2021 TRACER-AQ mission²² and the TEMPO (Tropospheric Emissions: Monitoring of Pollution) satellite's hourly, high resolution data of offshore pollutants.

Automated Detection of Wildlife in Aerial Surveys. In 2022, BOEM started the second phase of its partnership with USGS to develop automated detection algorithms to analyze aerial survey imagery. The imagery analysis promotes wildlife conservation by making it easier to track and identify animals. BOEM and other agencies are collecting large volumes of aerial survey data to monitor wildlife populations, but years of manual labor are required to derive useful wildlife information from these images. Instead, BOEM and USGS will develop a transferrable computer vision algorithm to automatically classify images of seabirds, turtles, and marine mammals. This new capability will enable automated detection of these animals to support many ongoing scientific projects, including BOEM's AMAPPS III - Photogrammetric Aerial Surveys to Improve Detection and Classification of Seabirds, Cetaceans, and Sea Turtles study.

Pacific VHF Nanotags Network Expansion. Inexpensive VHF nanotags and the associated tower network can help BOEM track the migration and flight patterns of birds and bats along the coast of the Southern California Bight. BOEM is working to expand the [Motus wildlife tracking network](#)²³ to the U.S. Pacific coast, replicating success for renewable energy studies on the U.S.

²² TRACER-AQ is an interagency mission led by NASA to collect air quality data using a combination of air- and ground-based measurements, along with modeling and analysis.

²³ Motus is a collaborative international wildlife tracking system that uses automated radio telemetry to collect data on the movement of birds, bats and insects across vast distances. URL: <https://motus.org>

East Coast. Towers will be deployed to better understand bird and bat forays into the airspace above the OCS. The network will include sensors at stations located on the mainland, offshore islands, and oil platforms up to 20 miles offshore. In the future, following network infrastructure proof of concept, networked VHF tracking could be scaled up to include Trinidad Head near the Humboldt Wind Energy Area and the entire U.S. Pacific Coast, including offshore waters. BOEM and others will have the ability to fill critical data gaps for small-bodied, high-vulnerability species and allow for new research in the future by increasing the capacity for large-scale, regional tracking.

XIII. Bureau of Land Management

The Bureau of Land Management (BLM) manages approximately 245 million surface acres and 700 million subsurface acres in the United States. BLM's multiple-use and sustained yield mandate directs the management of public land resources for a variety of uses, such as recreation, wildlife conservation, energy and minerals development, wilderness, livestock grazing, clean water, and timber harvesting, while also protecting a wide array of natural, cultural, scientific, and historical resources for the use and enjoyment of present and future generations. To support this dual mission, the BLM annually conducts and supports hundreds of research and development projects with diverse entities such as Cooperative Ecosystem Studies Units; colleges and universities; scientific societies and institutes; national laboratories; museums; botanic gardens and arboreta; federal, state, and Tribal government agencies; non-governmental organizations; and the private sector. These projects advance the state of knowledge and technology concerning all aspects of BLM resource management and transfer of those advances to entities and persons outside the BLM through publication of reports, technical references, scientific journal articles, data releases, fact sheets, presentations, web-based products, books, and more. Examples of FY 2022 technology transfer activities include the following bureau-wide and program-specific efforts.

BLM Library and Publishing. BLM provides essential support to technology transfer by offering a full range of publication services encompassing research support, consultation, and planning; writing and editing; design and layout; external publication; and coordination of printing and distribution. Librarians, writer/editors, visual information specialists, and printing specialists work in concert to provide publication assistance for a broad spectrum of BLM communication products. The [BLM Library](https://www.blm.gov/learn/blm-library)²⁴ helps the public find BLM publications and a wide array of other publications and information.

Quality Data. BLM regularly gathers, maintains, and publishes various types of data to inform the public about its resources and stewardship responsibilities. These data include detailed information on the commercial uses of the public lands, recreational activities, wild horse and burro management, cadastral (mapping) surveys, the extent and quality of BLM managed resources, and data for units of the BLM's 35-million-acre National Conservation Lands system. These data also include information on the socioeconomic impacts and benefits of public land management.

²⁴ URL: <https://www.blm.gov/learn/blm-library>

Much of these data are synthesized and published annually as tabular data in BLM's [Public Lands Statistics Report](#),²⁵ and as graphics and summaries in [The BLM: Sound Investment For America](#).²⁶ These data are also often published as [geospatial data](#).²⁷ [The Geospatial Business Platform](#)²⁸ is the source for public geospatial data, maps, models, and reports produced by the BLM. The BLM also provides data to clearinghouses maintained by the federal government, such as [data.gov](#) and [recreation.gov](#), and provides historic and newly acquired imagery to the public via the U.S. Geological Survey's Earth Resources Observation and Science Center ([USGS-EROS](#)).²⁹

Joint Fire Science Program (JFSP). The [JFSP](#)³⁰ is a joint agency and interdepartmental research, development, and science partnership between the U.S. Department of the Interior and the U.S. Department of Agriculture Forest Service. The JFSP provides funding for studies associated with managing wildland fire, fuels, and fire-impacted ecosystems to prepare for the emerging needs of managers, practitioners, and policymakers from local to national levels. The program provides leadership to the fire science community by identifying high-priority fire science research to meet management objectives. Transferring research findings to managers, practitioners, and policymakers is one of the main objectives of the program. The JFSP accomplishes most of its science delivery through an organized, national network of regional fire science exchanges named the [Fire Science Exchange Network](#).³¹ The Fire Science Exchange Network brings together fire managers, practitioners, and scientists to address common needs and challenges and provides access to the latest science through publications, webinars, workshops, field tours, discussion forums, and other activities that promote interactions between resource managers and researchers.

In FY 2022, BLM employees contributed to research projects funded by the JFSP as collaborators or partners. In addition, BLM landscapes were used in on-going JFSP research projects. The JFSP program manager, Tech Transfer Specialist, Program Analyst, and one Governing Board member are all BLM employees.

²⁵ URL: <https://www.blm.gov/about/data/public-land-statistics>

²⁶ URL: <https://www.blm.gov/about/data/socioeconomic-impact-report-2022>

²⁷ URL: <https://www.blm.gov/services/geospatial>

²⁸ URL: <https://gbp-blm-egis.hub.arcgis.com/>

²⁹ URL: <https://eros.usgs.gov/>

³⁰ URL: <https://www.firescience.gov/>

³¹ URL: https://www.firescience.gov/JFSP_exchanges.cfm

BLM's National Conservation Lands and Community Partnerships. BLM's [National Conservation Lands](#)³² are an outdoor laboratory and demonstration center for new and innovative management and business processes that aid in conservation, protection, and restoration. The BLM initiated a public pilot of an online system for permitting and tracking paleontological and scientific research in FY 2022, while expanding the pilot for Special Recreation Permits. Such a system facilitates the use of all public lands for scientific inquiry into natural and cultural resource issues as well as into the broader societal uses of public lands. The BLM supported research in FY 2022 which furthered development of effective management practices, both improving our understanding of resources and areas designated for protection as well as strengthening management techniques. For example, researchers are developing tools to identify existing versus desired recreation activities, experiences, and benefits of public lands. Both approaches, use of National Conservation Lands as outdoor laboratories and research to further effective management practices, benefit from diverse participation ranging from citizen science to institutional research by public and private entities.

Cultural Heritage. The [BLM Cultural Heritage Program](#)³³ manages archaeological sites, cultural landscapes, historic sites and structures to ensure cultural and scientific values are preserved, and their spiritual, scientific, recreational and economic benefits are realized appropriately for today's communities and future generations. Core program activities include locating and documenting cultural heritage sites on public lands; monitoring for natural and human-caused impacts; stabilizing and protecting resources; facilitating public access through recreation and education programs; and supporting academic research that explores the importance of archaeological and historic sites in American history.

Paleontology. Paleontological research on public lands is vital to the discovery of new types of organisms and new revelations about the history of ecosystem diversity and climate change on planet Earth. The BLM [Paleontology](#)³⁴ Program preserves paleontological resources for the benefit of current and future generations, assesses the presence and importance of paleontological resources prior to making land use decisions, facilitates insightful research into the geology and paleobiomes that preserve extinct organisms, and works to increase the public's awareness and appreciation of these important resources. There are approximately 80,000 recorded localities on BLM-administered lands, with thousands of resources yet to be discovered.

³² URL: <https://www.blm.gov/programs/national-conservation-lands>

³³ URL: <https://www.blm.gov/programs/cultural-resources>

³⁴ URL: <https://www.blm.gov/paleontology>

Visual Resources. The Federal Land Policy and Management Act (FLPMA) of 1976, as amended, requires public lands to be managed in a manner that will protect scenic (visual) quality while managing for multiple uses and sustained yield. The application of a single-color paint treatment to facilities on BLM lands is the most conventional best management practice for reducing visual impacts from proposed projects on BLM-administered lands. The BLM’s Standard Environmental Color Paint Tool (PC01-PC10) was developed to assist with color selection to minimize the visual contrast of a facility in the landscape.

Assessment, Inventory, and Monitoring (AIM). High-quality data are essential to keeping public lands healthy. BLM’s [AIM strategy](#)³⁵ is a standardized process to collect quantitative information on the status, condition, trend, amount, location, and spatial pattern of the terrestrial vegetation and soils, wadable streams and rivers, and riparian areas, floodplains, and wetlands of the Nation’s public lands. [AIM data](#)³⁶ are used by the BLM and a wide variety of federal and state agencies, universities, nongovernmental organizations, private industry, and the public. Approximately 8,909 AIM data points in upland, river & stream, and riparian & wetland systems were sampled in 2022.

The BLM AIM team was honored with a [2022 Esri Special Achievement in GIS \(SAG\) Award](#)³⁷ at the Esri User Conference in July 2022. Out of over 100,000 Esri customers worldwide, only 193 SAG awards were given out this year. The award recognizes the outstanding use of, and leadership in, the field of Geographic Information System (GIS) technology which AIM uses to collect, store, and share data.

National Aquatic Monitoring Center (NAMC). Monitoring aquatic ecosystems helps scientists, managers and regulators keep them healthy. The [National Aquatic Monitoring Center](#)³⁸ is a cooperative venture between Utah State University and the BLM. NAMC’s primary foci are the use of aquatic macroinvertebrates as bioindicators of freshwater biological integrity under the Clean Water Act and the development of scientifically defensible aquatic monitoring and assessment tools. NAMC processes macroinvertebrate and water samples for more than a dozen state and federal agencies and supports [web-based interfaces to publicly share](#)

³⁵ URL: <https://www.blm.gov/aim/strategy>

³⁶ URL: <https://gbp-blm-egis.hub.arcgis.com/pages/aim>

³⁷ URL: <https://events.Esri.com/conference/sagList/?fa=Detail&SID=7374>

³⁸ URL: <https://namc-usu.org>

[monitoring data](#).³⁹ NAMC also identifies and documents the distribution of aquatic invasive invertebrates to help control or ultimately prevent their spread.

³⁹ URL: <https://namc-usu.org/data>

XIV. Joint Fire Science Program

The [Joint Fire Science Program \(JFSP\)](#)⁴⁰, initiated in 1998, provides funding and science delivery for scientific studies associated with managing wildland fire, fuels, and fire-impacted ecosystems to respond to emerging needs of managers, practitioners, and policymakers from local to national levels. The JFSP work is managed through an internal program office hosted by the BLM and overseen by a 12-member Governing Board representing the Departments of the Interior (BIA, BLM, FWS, NPS, and the USGS) and the U. S. Department of Agriculture Forest Service. In FY 2022, the JFSP managed a \$6 million budget available from appropriated funds provided by the Department of the Interior (DOI) and the U.S. Forest Service (FS). Funds are distributed via an annual cycle of open, competitive, peer-reviewed proposal solicitations for current wildland fire research priorities in three categories – science delivery, primary research, and graduate research innovation.



MAP OF THE REGIONAL FIRE SCIENCE EXCHANGES THAT MAKE UP THE FIRE SCIENCE EXCHANGE NETWORK. THESE EXCHANGES BRING TOGETHER FIRE MANAGERS, PRACTITIONERS, AND SCIENTISTS TO ADDRESS REGIONAL FIRE MANAGEMENT NEEDS AND CHALLENGES, IMPROVING FIRE SAFETY AND ECOLOGICAL HEALTH. SOURCE: OFFICE OF WILDLAND FIRE

⁴⁰ URL: <https://www.firescience.gov/>

Science Delivery and Knowledge Exchange. The JFSP provides leadership to the fire science community by identifying high-priority fire science research to meet management objectives. Transferring research findings to managers, practitioners and policymakers is a key focus area for the program, and that is managed through the JFSP's fifteen regional fire science exchanges called the Fire Science Exchange Network (FSEN). The networks are successful in sharing, synthesizing, interpreting, demonstrating, and validating science products to facilitate science integration with on-the-ground land management. The network is a national collaboration that provides the most relevant, current wildland fire science information to stakeholders. The exchanges bring together fire managers, practitioners, and scientists to address common needs and challenges. Technology transfer is delivered through a variety of means, including webinars, training, field trips, research syntheses, workshops, social media, newsletters, etc.

FY 2022 highlights include:

- Produced 230 newsletters
- Published 185 blog posts
- Hosted 119 webinars
- Developed 14 syntheses
- Hosted 79 conferences/workshops
- Developed 58 short courses and continuing education units
- Created 139 video productions

Approximately 21,000 individuals participated in FSEN organized wildland fire science delivery activities in FY2022.

Primary Research. In FY 2022, JFSP focused limited research dollars on key scientific needs; in particular, social, and ecological recovery of communities impacted by wildfire and collaborative development of ecosystem mapping products for fire and fuels management.

FY2022 highlights include:

Social and Ecological Recovery of Communities Impacted by Wildfire. This research informs the development or improvement of strategies, tools, and resources used for post-fire community recovery, such that they facilitate recovery efforts that increase the resilience of social-ecological systems to future wildfires.

Collaborative Development of Ecosystem Mapping Products for Fire and Fuels Management. This research uses a collaborative framework, prototype mapping protocols and products that capture current ecosystem condition, desired condition,

and departure from desired condition at spatial and temporal resolutions relevant to fire and fuels management decisions.

Also in FY 2022, JFSP initiated 11 research projects with signed agreements and 31 research projects pending final agreements; it completed 28 research projects and 13 refereed publications.

Graduate Research Innovation. Graduate Research Innovation (GRIN) awards are meant to supplement already approved thesis or doctoral work by adding a component that addresses the management or policy relevance of the research. The JFSP funded 20 GRIN projects in FY2022. Funded projects focused on:

- Fuel management and fire behavior,
- Changing fire environment,
- Emissions and air quality,
- Fire effects and post-fire recovery,
- Relative impacts of prescribed fire versus wildfire, or
- Human dimensions of fire.

XV. Conclusion

During FY 2022, DOI's technology transfer activities provided critical information and technologies to improve our understanding of and ability to address key issues such as climate change, drought, wildland fire, and threatened and endangered species. During FY 2022, DOI's technology transfer activities included the following activities:

- Engaged in 32 Cooperative Research and Development Agreements (CRADAs) and at least 1,034 other collaborative R&D relationships.
- Disclosed 3 new inventions, filed 3 new patent applications, and received 1 new patent.
- Managed 72 active licenses for inventions and other intellectual property, which collectively earned \$108,761.
- Published over 3,600 reports, books, papers, fact sheets, and other documents.

XVI. Data Appendix

The following tables provide cumulative data for DOI from FY 2018 through FY 2022. Data for individual bureaus are available [online](#).⁴¹

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

Table 1: Disclosures and Patents

		FY 2018	FY 2019	FY 2020	FY 2021	FY 2022
	Invention Disclosures					
1	Invention Disclosures Received	9	8	4	2	3
2	Total Patent Applications Filed	7	3	4	1	3
3	<i>US</i>	1	0	2	1	3
4	<i>Foreign</i>	0	0	0	0	0
5	Total PCT Applications Filed. (NOTE: PCT = Patent Cooperation Treaty. See https://www.wipo.int/pct/en/)	0	0	0	0	0
6	Number of patents Issued	6	1	3	1	1
7	<i>US</i>	0	0	0	1	1
8	<i>Foreign</i>	0	0	0	0	0

⁴¹ URL: <https://www.doi.gov/techtransfer/annual-reports>

Table 2: Licenses

		FY 2018	FY 2019	FY 2020	FY 2021	FY 2022
9	Invention Licenses, Total Active	2	2	2	10	11
10	<i>New Invention Licenses</i>	0	0	0	2	2
11	<i>New Invention Licenses to Small Businesses</i>	0	0	0	1	2
12	Income bearing licenses, Total Active	15	16	14	9	10
13	<i>New Income Bearing Licenses</i>	0	0	0	1	2
14	<i>Exclusive licenses</i>	8	7	7	8	9
15	<i>Partially exclusive licenses</i>	0	0	0	0	0
16	<i>Non-exclusive licenses</i>	8	9	6	2	2
17	Other Licenses, Total Active	0	0	0	48	61
18	<i>New Other Licenses</i>	0	0	0	42	13
19	<i>New Other Licenses Granted to Small Businesses</i>	0	0	0	40	10
	Elapsed Amount of Time for Granting Invention Licenses					
20	Average (months)	7	7	7	30.5	7
21	Minimum (months)	7	7	7	29	5
22	Maximum (months)	7	7	7	32	9
23	Licenses terminated for cause	1	0	1	1	0

Table 3: License and Royalty Income

		FY 2018	FY 2019	FY 2020	FY 2021	FY 2022
24	Invention License Income	\$50,925	\$42,168	\$122,749	\$67,694	\$108,761
25	Other License Income					
26	Total Earned Royalty Income (ERI)	\$50,925	\$42,168	\$122,749	\$67,694	\$107,761
27	<i>ERI from top 1% of licenses</i>				\$53,630	\$98,356
28	<i>ERI from top 5% of licenses</i>				\$53,630	\$98,356
29	<i>ERI from top 20% of licenses</i>				\$53,630	\$98,356
30	Minimum Earned Royalty Income				\$3,195	\$25,000
31	Maximum Earned Royalty Income				\$53,630	\$98,356
32	Median Earned Royalty Income				\$10,925	\$19,302
	Disposition of ERI					
33	Percent of ERI distributed to inventors	62%	64%	39%	36%	33%
33A	Amount of ERI distributed to inventors	\$31,770	\$27,121	\$47,872	\$24,045	\$35,561
34	Percent of ERI distributed to the agency or laboratory	38%	36%	34%	37%	33%
34A	Amount of ERI distributed to the agency or laboratory	\$19,156	\$15,047	\$41,735	\$24,762	\$35,561

Table 4: CRADAs

		FY 2018	FY 2019	FY 2020	FY 2021	FY 2022
	CRADAs					
35	Total Active CRADAs	741	470	489	429	32
36	New CRADAs	422	352	237	139	5
37	New CRADAs Involving Small Businesses		2	2	1	1
	Other collaborative R&D relationships					
38	Other Collaborative Agreements, total active in the FY	249	269	353	625	1,034

XVII. Acronyms

AADA	Aquatic Animal Drug Approval Program
AADAP	Aquatic Animal Drug Approval Partnership
ADTI	Acid Mine Drainage Initiative
AGOL	ArcGIS Online
AML	Abandoned Mine Lands
AIM	Assessment, Inventory and Monitoring
ASP	Applied Science Program
AquADat	Aquatic Assessment, Inventory and Monitoring Database
AUV	Autonomous Underwater Vehicle
BHA	Bottom Hole Assembly
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BOEM	Bureau of Ocean Energy Management
BOP	Blowout Preventer
BOR	Bureau of Reclamation
BSEE	Bureau of Safety and Environmental Enforcement
BSR	Blind Shear Ram
CadNSDI	Cadastral National Spatial Data Infrastructure
CESU	Cooperative Ecosystem Studies Units
CFD	Computational Fluid Dynamics
CO₂	Carbon Dioxide
ConOps	Concept of Operations
CRADA	Cooperative Research and Development Agreement
CSR	Casing Shear Ram
DOE	Department of Energy
DEMD	Division of Energy and Mineral Development (within BIA)
DOI	Department of the Interior
DMAS	Deadman/Autoshear
DP	Dynamic Positioning
DWPR	Desalination and Water Purification Research
EDNA	Environmental DNA
EDS	Energy Dispersive x-ray Spectroscopy
EPA	Environmental Protection Agency
ERDC	U.S. Army Engineer Research and Development Center
ERI	Earned Royalty Income
ESA	Endangered Species Act
ESP	Environmental Studies Program
ETB	Emerging Technologies Branch

EULA	End User License Agreement
FAC	Fisheries and Aquatic Conservation
FDA	Food and Drug Administration
Fed Tech	Hyperion Technologies LLC
FIAT	Fire and Invasives Assessment Tool
FLPMA	Federal Land Policy and Management Act of 1976
FO	Forward Osmosis
FTC	Fish Technology Center
FTTA	Federal Technology Transfer Act of 1986
FUSA	Facility Use/Service Agreement
FWS	Fish and Wildlife Service
FY	Fiscal Year
GHG	Greenhouse Gas
GIS	Geographic Information System
GRSG	Greater Sage Grouse
HAPS	High Altitude Platform Stations
ICCOPR	Interagency Coordinating Committee on Oil Pollution Research
IDM	Imagery Data Management
IRFMS	Integrated Rangeland Fire Management Strategy
IX	Ion Exchange
JAO	Joint Administrative Operations
JFSP	Joint Fire Science Program
JSC	Joint Steering Committee
K- 12	Kindergarten through 12th grade
Landsat	Land Remote-Sensing Satellite System
LiDAR	Light Detection and Ranging Scanners
MCL	Materials and Corrosion Laboratory
MD	Mine Drainage
MDTI	Mine Drainage Technology Initiative'
MTA	Material Transfer Agreement
NAMC	National Aquatic Monitoring Center
NCL	National Conservation Lands
NCPTT	National Center for Preservation Technology and Training
NCR	Natural and Cultural Resources
NCTC	National Conservation Training Center
NY Bight	New York Bight
NGA	National Geospatial Intelligence Agency
NGO	Nongovernmental Organization
NGP	National Geospatial Program
NIC	National Innovation Center
NIOGEMS	National Indian Oil & Gas, Energy and Minerals System
NOFO	Notice of Funding Opportunity

NPS	National Park Service
NTTP	National Technical Training Program
NTTT	National Technology Transfer Team
OCS	Outer Continental Shelf
OESI	Offshore Energy Safety Institute
OMB	Office of Management and Budget
OORP	Office of Offshore Regulatory Programs
OPA	Office of Policy and Analysis (within the USGS)
OSMRE	Office of Surface Mining Reclamation and Enforcement
OSPD	Oil Spill Preparedness Division
OSRR	Oil Spill Response Research
PAIS	Padre Island National Seashore
PG&E	Pacific Gas and Electric Company
PLSS	Public Land Survey System
Reclamation	Bureau of Reclamation
R&D	Research and Development
R&T	Research and Technology
R&T Plan	Oil Pollution Research and Technology Plan
S&T	Science and Technology
SMCRA	Surface Mining Control and Reclamation Act of 1977
SO	Secretarial Order
TAA	Technical Assistance Agreement
TEES	Texas A&M Engineering Extension Service
TerrADat	Terrestrial Assessment, Inventory and Monitoring Database
TIPS	Technical Innovation and Professional Services
TLS	Terrestrial Laser Scanning
uADS	underwater Acoustic Deterrent System
UAF	University of Alaska Fairbanks
USACE	U.S. Army Corps of Engineers
UAS	Unmanned Aircraft Systems
USCG	U.S. Coast Guard
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
USGS - EROS	United States Geological Survey Earth Resources Observation and Science Center
WGA	Western Governors' Association