

Program Changes

Program Changes

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Water Science for the 21st Century	14,521	26	C-3
WaterSMART	14,584	29	C-4
Science to Support Sustainable Water Use	-63	-3	C-14
Landscape Understanding	15,569	47	C-17
Critical Landscapes	6,650	24	C-18
Invasive and Declining Species	3,810	10	C-25
Coastal Resilience and Landscapes	5,109	13	C-28
Natural Hazards Science	6,618	10	C-33
Natural Hazards Science for Disaster Response	6,618	10	C-34
Foundations for Land Management	37,826	25	C-43
Landsat Ground System	24,300	0	C-44
Ecosystem Services	1,750	5	C-45
Big Earth Data	1,100	0	C-48
Landsat Science Products for Climate and Natural Resources Assessments	4,000	2	C-49
National Civil Applications Program	-1,000	-5	C-49
3D Elevation Program	3,709	3	C-50
Great Lakes Fisheries Assessments	250	0	C-52
Enhanced Cooperative Activities and Urban Waters	717	5	C-53
Outer Continental Shelf (OCS) Ecosystems Decisions	300	2	C-54
Enhanced Support and Scientists for Tomorrow	2,000	9	C-54
Emerging Contaminants and Chemical Mixtures	700	4	C-55
Climate Resilience	32,018	36	C-57
Carbon Sequestration	8,700	21	C-58
Adaptation and Resilience	6,818	13	C-60
Community Resilience and Partnerships	16,500	2	C-62
Energy and Minerals	9,548	44	C-67
All-of-the-Above Energy	8,549	30	C-68
Critical Minerals	999	14	C-75
Science Infrastructure	21,131	19	C-77
Infrastructure Capacity to Support the Science Mission	18,931	16	C-78
Science Coordination	500	1	C-82
Engaging the Next Generation: Building a 21st Century Workforce	1,700	2	C-83
Grand Total	137,231	207	

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Water Science for the 21st Century

Water Science for the 21st Century (\$ in Thousands)			
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WaterSMART	14,584	29	C-4
Water Use Information	3,000	5	C-5
Water Availability and Use Science Program	3,000	5	C-5
Ecological Flows	2,500	4	C-6
Fisheries Program	2,500	4	C-6
Streamflow Information	1,328	0	C-7
Groundwater and Streamflow Information Program	928	0	C-7
Water Availability and Use Science Program	400	0	C-7
Water Use Research	1,000	0	C-8
Water Availability and Use Science Program	1,000	0	C-8
Advancing the National Groundwater Monitoring Network	1,000	1	C-9
Groundwater and Streamflow Information Program	1,000	1	C-9
National Hydrography Database	1,000	3	C-9
National Geospatial Program	1,000	3	C-9
Remote Sensing	800	3	C-10
Land Remote Sensing	400	1	C-10
Land Change Science	400	2	C-10
National Hydrologic Model	750	1	C-11
Water Availability and Use Science Program	750	1	C-11
Science to Support Drought	3,206	12	C-11
Environments Program	300	2	C-12
National Climate Change and Wildlife Science Center/DOI Climate Science Centers (CSCs)	1,030	2	C-12
Climate Research & Development	1,125	5	C-12
Land Remote Sensing	250	1	C-13
Water Availability and Use Science Program	301	2	C-13
Science Synthesis, Analysis and Research Program	200	0	C-14
Science to Support Sustainable Water Use	-63	-3	C-14
Cycle 3 National Water Quality Assessment	881	0	C-14
National Water Quality Program	881	0	C-14
HR&D Monitoring and Assessments	-1,000	-4	C-15
Water Availability and Use Science Program	-550	-3	C-15
Groundwater and Streamflow Information Program	-100	0	C-15
National Water Quality Program	-350	-1	C-15
Model Development and Research	-444	-2	C-15
Water Availability and Use Science Program	-444	-2	C-15
Tribes	500	3	C-16
Groundwater and Streamflow Information Program	500	3	C-16
Grand Total	14,521	26	

Justification of 2016 Program Changes

(+\$14,521,000/+26 FTE)

WaterSMART

(+\$14,584,000/+29 FTE)

Science to Support Sustainable Water Use

(-\$63,000/-3 FTE)

Overview

Water is an essential ingredient for healthy communities, economies, and the ecosystems of the Nation. In 2016, the USGS is requesting an additional \$14.5 million to expand, enhance, and initiate science activities involving the quantity and quality of water used by or needed for competing water uses. This is especially important at a time when ensuring sustainable water supplies is increasingly challenged by changes in the frequency and magnitude of extreme hydrologic events, such as floods and droughts,

creating new uncertainty for water managers. Efforts will continue and expand under Interior's WaterSMART initiative. USGS scientists will provide water managers with science, monitoring, assessments and tools to understand, address, and plan for competing demands for water. The primary focus will continue to be on developing a National Water Census, better understanding of water budgets, and supporting sustainable and environmentally sound water management. Expertise across multiple disciplines enables a broader focus to provide water resource, ecosystem, and land use managers the decision-support tools to make informed decisions.

WaterSMART **(+\$14,584,000/+29 FTE)**

Water Use Information	(+\$3,000,000/+5 FTE)
Ecological Flows	(+\$2,500,000/+4 FTE)
Streamflow Information	(+\$1,328,000/0 FTE)
Water Use Research	(+\$1,000,000/0 FTE)
Advancing the National Groundwater Monitoring Network	(+\$1,000,000/+1 FTE)
National Hydrography Database	(+\$1,000,000/+3 FTE)
Remote Sensing	(+\$800,000/+3 FTE)
National Hydrologic Model	(+\$750,000/+1 FTE)
Science to Support Drought	(+\$3,206,000/+12 FTE)

Overview

Meeting the water resource needs of the Nation is an increasing challenge in the face of rapidly changing drivers of water availability, such as climate change. At a time when ensuring sustainable water supplies is more important than ever, change in the frequency and magnitude of extreme hydrologic events, such as floods and droughts, are creating uncertainty for water managers. As competition for water resources grows for irrigation of crops, cities and communities, energy production, and the environment, so does the need for information and tools to aid water and natural resource managers. WaterSMART is a Department of the Interior (Interior) initiative that leverages and directs existing expertise and resources within the USGS and the Bureau of Reclamation (Reclamation) toward addressing complex, national- and regional-scale water challenges. The USGS is providing the science to help water managers understand and address competing demands for water. The primary focus of this initiative includes developing a National Water Census, better understanding of water budgets, and supporting sustainable and environmentally sound water management. Leveraging expertise across multiple disciplines enables a broader focus to address these challenging issues in a time of growing competition for water resources. The USGS possesses the skills and foundational resources to provide water resource, ecosystem, and land use managers the decision-support tools to make informed decisions. The goal of this effort is to improve the data and understanding associated with groundwater, surface water, human water use, and the ways in which they influence water availability, and to develop tools that will allow managers to apply the new understanding and data. The USGS expertise in understanding hydrologic cycle effects on water, human water use, and the ways in which water quality and quantity affect the natural environment is critical to addressing this issue. The Nation will be well served through this effort, by gaining the ability to balance water resource sustainability through consideration of water quantity, quality, and uses, including ecological uses.

Program Performance

Water Use Information (+\$3,000,000/+5 FTE)

Water Availability and Use Science Program (+\$3,000,000/+5 FTE)

Since 1950, the USGS has been the primary Federal agency responsible for providing a comprehensive understanding of water use across the Nation, with consistent reporting every five years through the USGS series of circulars: Estimated Use of Water in the United States. As required under the SECURE Water Act (P.L. 111-11), and the President's Climate Action Plan, the USGS is working to expand its efforts and provide comprehensive, high-resolution water use information (on an annual basis and at a location) that will support a host of decision-support systems. This high-resolution water use information will allow resource modelers and managers to understand the influence that human water use has on the hydrologic cycle, the degree to which human consumptive uses influence the sustainability of water supplies, and allows comparison of human water demands to the sustainability of environmental water needs. The USGS has already begun work under the National Science and Technology Council's (NSTC) Committee on the Environment, Natural Resources, and Sustainability to coordinate activities with other Federal agencies and State agencies to scope the effort for providing this high-resolution water use information. The USGS is coordinating an effort with the Bureau of Reclamation, the U.S. Department of Agriculture (USDA), the Environmental Protection Agency (EPA), the U.S. Army Corps of Engineers (USACE), and the Department of Energy (DOE) to improve their ability to feed base data into the water use databases.

The 2016 requested increase would allow the USGS to participate in a new multi-agency, Open Water Data Initiative that will integrate water information that is fragmented among multiple agencies into a national water data framework on a geospatial platform, as a placebased database. The Open Water Data Initiative will leverage existing partnerships and infrastructure to allow for greater data accessibility and better tools and solution development.

The requested increase would also allow the Water Resources Mission Area to continue to provide grants to State Water Resource Agencies to improve their ability to provide the base data at the necessary resolution for effective decisionmaking. Comprehensive water use information would be provided on an annual and ongoing basis for the following sectors of water use: irrigation, public water supplies, thermoelectric cooling water, industrial self-supplied water, and aquaculture. In addition, water use would be estimated for the mining, livestock, and self-supplied domestic water use sectors. The data would be formatted to allow easy input of water use to the National Hydrologic Model, as well as other models utilized by the USGS and others. The USGS would coordinate these activities with other Federal agency efforts, provide grants to and coordination with State Water Resources Agencies on their data delivery, and maintenance of the comprehensive Site-specific Water Use Data System and Aggregate Water-Use Data System databases. Finally, this funding would support periodic comprehensive analysis of the data to report out on water use trends and provide national water-use indicator analysis, and maps of water stress indicators.

Ecological Flows (+\$2,500,000/+4 FTE)

Fisheries (+\$2,500,000/+4 FTE)

The delivery of water at the correct time, quantity, and quality is critical to society both economically and ecologically. Recovery and restoration of aquatic ecosystems are dependent on the proper balance among societal and ecological needs. Healthy watersheds and sustainable, secure water supplies are challenged by climate change, and record drought conditions. With increased demand for freshwater use for domestic supply, agriculture, manufacturing, and energy production, there is a growing need to understand and quantify water needs. Moreover, there is a need to understand and quantify the associated societal and economic values in order to allow water managers to evaluate tradeoffs in monetary and non-monetary costs of water allocation decisions. This type of information, coupled with an understanding of how flow variability is related to ecological response, is utilized by water management authorities to establish flow criteria (often-minimum flow criteria), and ultimately relate them to allocation decisions for water withdrawals from streams, rivers and basins. Scientific underpinnings and advancements are crucial for advancing sustainability of healthy watersheds and water supply.

Decisions made every day by Federal, State and local managers affect the quantity, quality, and timing of water flows required to sustain freshwater and estuarine ecosystems and the human livelihoods and well-being that depend on these ecosystems. With increased demand for consumptive freshwater use for domestic supply, agriculture, manufacturing, energy production, and ecological sustainability, there is a growing need to develop Decision Support Systems (DSS) that have the capacity to provide a diverse set of management options to water regulators and stakeholders including water for human use, including: maintenance of economically and ecologically important species; minimizing adverse impacts and vulnerabilities in floodplains or flood-prone areas; and protecting and restoring the functions of natural systems. These DSS tools enable managers to factor in the full range of values—both monetary and non-monetary—in decisions that attempt to balance human and ecosystem needs.

Although many useful DSS tools have been developed to help decisionmakers enhance the sustainability of water supplies, they are often not transferable to other basins and systems. The proliferation of these site-specific tools makes it difficult to conduct analyses at the regional and national levels to inform decisionmaking. In addition, because they often do not explicitly consider public benefits in terms of economic, environmental and social goals, including monetary and non-monetary benefits, they limit the range of resolution options of decisionmakers. Broadening existing decision support tools to other basins and systems will provide a more comprehensive understanding of future water needs and tradeoffs associated with various management options. This will reduce uncertainty in water availability estimates and optimize the information water managers use to make important water allocation decisions.

The USGS conducts research in collaboration with Federal agencies (Bureau of Reclamation [BOR], National Oceanic and Atmospheric Administration [NOAA], USACE, and the U.S. Forest Service [USFS]), State, academic, and private partners. This research supports better incorporation of consistent, broadly applicable DSS into national water management decisions:

1. Adapt existing ecological flow DSS to other United States aquatic systems. DSS's are important management tools to help water managers and stakeholders understand tradeoffs and risks for meeting water supply needs. Building off existing DSS platforms, such as the recently completed and highly successful Delaware River Environmental Flow DSS, to develop a broadly applicable "generic" suite of DSS tools, is an essential step in enhancing capacity for water regulators across the United States.
2. Use lidar, a remote sensing technology, to derive the detailed bathymetric coverages needed to assess the changes in riverine habitat that affect ecological flow requirements. There is a need to develop and more broadly apply lidar data for support of ecological flow analyses in United States river basins. This emerging technology shows great promise for providing the data necessary to develop the habitat suitability measures needed for assessing changes in economically and ecologically important aquatic species as part of a fully integrated DSS. Ideally, a fully integrated DSS will enable water managers to simultaneously evaluate water allocation scenarios while considering all facets of the water budget and facilitate more informed decisionmaking about living resources, habitat, and other values.
3. Incorporate DSS into existing and ongoing water availability efforts (e.g., Principles and Requirements for Federal Investments in Water Resources, National Water Census Focus Area Studies) and support the further collection of biological components. DSS tools assist with understanding the quantitative linkages between changes in flow process and response of aquatic organisms, riparian vegetation, and other values in order to provide water regulators with diverse water allocation scenarios. However, there is an imminent need to improve this linkage through the collection of ecological data at a space and time that allows for better quantification and modeling of biological response and to include other values in DSS model components. In addition, monetary and nonmonetary values should be incorporated into these tools to allow decisionmakers to assess the full range of tradeoffs associated with water allocation decisions.

In 2016, and beyond, the Ecosystems and Water Resources Mission areas will continue to collaborate on research efforts in the Delaware, Colorado, and Apalachicola, Chattahoochee and Flint (ACF) River watersheds in addition to taking lessons learned from these watersheds to an additional three watersheds, which will be identified through a request for proposal (RFP) process involving all USGS Mission Areas currently collaborating in the National Water Census.

Streamflow Information

(+\$1,328,000/0 FTE)

Groundwater and Streamflow Information Program

(+\$928,000/0 FTE)

Water Availability and Use Science Program

(+\$400,000/0 FTE)

Streamflow information is required for water-resources management, and changing streamflow conditions require continuity of information for flood and drought response and routine water allocations. This activity would have three elements:

1. Increase the number of streamgages: Approximately 35 streamgage sites would be supported within the Groundwater and Streamflow Information Program. These could include reactivation

of discontinued sites, construction of new sites, and support of sites currently supported through other, less stable funding sources.

2. Estimate streamflow in remote areas using remote sensing: In remote regions of the United States, such as Alaska, little streamflow information is available, so methods for estimating streamflow in ungaged basins are not applicable. Direct gaging of Alaska rivers poses substantial logistical difficulties. Remote sensing assets may be more viable for estimating streamflow than in the lower 48 States due to increased frequencies of over flight by polar orbiting satellites. The proposed activity would test the potential of estimating streamflow in the Alaska frontier during open flow seasons. The streamflow estimates derived from remote sensing would be compared to both observed and calculated streamflow estimates. This will be implemented through the Groundwater and Streamflow Information Program.
3. Estimate monthly streamflow statistics: A goal of the National Water Census effort is to provide estimates of streamflow statistics throughout the Nation. The USGS StreamSTATS decision-support tool allows the USGS and partners to develop these estimates. StreamSTATS would be implemented in three additional States, and improved methods for proving the estimates would continue to be investigated. This will be implemented through the Water Availability and Use Science Program.

Water Use Research

(+\$1,000,000/0 FTE)

Water Availability and Use Science Program

(+\$1,000,000/0 FTE)

Water use information that identifies the impacts of human water withdrawals and return-flows is critical for the National Water Census's water budget analysis. This information, which is mostly collected at State, tribal, regional, and local governmental levels, must be obtained on a site-specific scale in order to be fully useful in the National Water Census analyses. The Water Availability and Use Science Program would work directly with State, tribal, regional, and local cooperators to match this funding and make maximum use of their water use datasets in the water availability and use assessment. Directed work is required to develop better methods of sampling, estimating, aggregating, and presenting water use data. This includes research into new methods that use remote sensing and spatial datasets in water use estimation. The research and networks and analysis functions of the USGS would work together to advance the development of those methods for use within the WaterSMART initiative. The USGS would integrate this information with decision-support tools that facilitate use of that information in a manner that is relevant to water resource management decisionmaking.

USGS monitoring, assessments, and research would continue and expand related to WaterSMART and impacts on water use. Additional focus will be placed on tracking site-specific, public supply and other water use information; developing consumptive use measurements and methodology (particularly associated with irrigated agriculture); assessing watershed water budgets (including developing estimates for streamflow at ungaged sites for more accurate water budgets); developing water use/budget models to track long-term patterns in groundwater and surface water flow; and advancing evapotranspiration measurements and assessment techniques.

Advancing the National Groundwater Monitoring Network (+\$1,000,000/+1 FTE)

Groundwater and Streamflow Information Program (+\$1,000,000/+1 FTE)

Current USGS water-level networks, such as the National Groundwater Monitoring Network, do not provide adequate space and time monitoring for all the Nation's major aquifers, which is critical information for determining water availability. To address this national need, a framework was developed in 2009 for a National Groundwater Monitoring Network (NGWMN) in response to the SECURE Water Act (P.L. 111-11) Section 9507(b) to provide a systematic groundwater-monitoring program for each aquifer system in the United States. To date, the Advisory Committee on Water Information (ACWI) Subcommittee on Groundwater (SOGW), through a successful pilot program and a pilot information portal developed by the USGS Groundwater Resources Program, demonstrated that a collaborative NGWMN can be successfully implemented by taking advantage of existing monitoring done by Federal, State, tribal and local agencies (<http://acwi.gov/sogw/>).

The Water Resources Mission Area would enhance research activities to improve drought forecasting. This activity is consistent with the Committee on the Environment, Natural Resources, and Sustainability focus on improving groundwater data and understanding. Groundwater and surface water availability changes will be evaluated by improving internal and external coordination and enhancing monitoring activities and data delivery systems to create a stronger link among the surface water and groundwater monitoring networks of the USGS, groundwater networks of State agencies, and the soil moisture network of Natural Resources Conservation Service (NRCS). Links would be improved between the well-coordinated ground-based monitoring networks and remote-sensing products. Drought creates an increased demand for groundwater resources, and land subsidence from the increased groundwater withdrawals is a critical issue in some hydrogeologic settings. Land subsidence work would be enhanced to help characterize the potential impacts of drought on infrastructure.

National Hydrography Database (+\$1,000,000/+3 FTE)

National Geospatial Program (+\$1,000,000/+3 FTE)

The USGS has been working since 1998, through the National Geospatial Program (NGP), the former National Water Quality Assessment (NAWQA) program and StreamStats, to create and improve the National Hydrography Dataset (NHD). Along with the Watershed Boundary Dataset, the NHD is used to portray surface water on The National Map. The NHD represents the drainage network with surface water features such as rivers, streams, canals, lakes, ponds, coastline, dams, and streamgages. Efficiently tracking water use and the relationship between manmade diversions and stream flow, requires that the points of withdrawal and discharge be mapped within the stream network. Currently, hydrography datasets of differing functionality and scales are used by agencies including the USGS, the Environmental Protection Agency, the U.S. Forest Service, and the Bureau of Land Management. The water resource community, including Federal, State, tribal, and local water resource managers; and private and non-profit organizations would benefit from using a single, scalable hydrographic referencing system with robust functionalities.

With these funds, the NGP will complete national NHDPlus high-resolution (1:24,000 scale) coverage for the conterminous 48 States, Hawaii, and Puerto Rico. This achievement will create a revolutionary integrated elevation-hydrography dataset for water resource managers throughout the Nation. Future lidar-derived integrated elevation-hydrography data will fit into the same structure and use the same utilities. This full integration of elevation and hydrography provides the potential to radically simplify hydrography data and streamline the user experience, application development, and stewardship of the data. Taking this step now positions the USGS to be able to fully utilize lidar data as they become available through the 3D Elevation Program (3DEP). It will also support the Water Census and enable an initial step in delivering the Open Water Data Initiative. Developing a single, scalable hydrographic referencing system will integrate currently fragmented water information into a connected, national water data framework to underpin innovation, modeling, data sharing, and solution development.

Remote Sensing **(+\$800,000/+3 FTE)**

Land Remote Sensing (+\$400,000/+1 FTE)

Land Change Science (+\$400,000/+2 FTE)

The National Water Census already benefits from the use of remote sensing data and analysis, including Landsat data. In 2016, the USGS would expand work across its land use and water programs to support additional aspects of the National Water Census. The National Water Census is at a place in its development to access operational Landsat products, generated as frequently as every eight days. Several new Landsat-based science products (including estimates of surface water extent) are at the stage of development to integrate with the National Water Census.

In the United States, good information on the amount of water in large storage features such as reservoirs and lakes is available. However there is a significant gap in identifying and quantifying water storage in smaller storage features. These water storage features influence the flow characteristics of streams in each watershed. Understanding and reporting on these features could provide benefit for drought status monitoring, understanding climate variability, and streamflow estimation, particularly in areas without streamgages. Moreover, information on changes in surface water storage is essential in order to accurately estimate the total amount of water in a basin—a central need for the National Water Census.

The USGS proposes to locate surface water features that have either been built or naturally store water (i.e., act like reservoirs). Given estimates of over three million constructed impoundments in the country, ranging from numerous small farm ponds up to large monitored reservoirs, remote sensing methods are the only feasible method for improving estimates of the total amount of water in a watershed.

The proposal would develop these estimates in a nationally consistent manner, and track changes in the number and size of these surface features within a year and across decades. Many of these water features are unknown because they are temporary, only storing water after precipitation events. Detection, documentation and monitoring of these features is only feasible through the use of a remote sensing system such as Landsat, which frequently and routinely images the land surface over long periods of time.

In a watershed such as the Apalachicola Chattahoochee, and Flint (ACF) such monitoring would provide an objective and systematic methodology for comprehensively assessing the state of the watershed, allowing multiple political entities to coordinate water usage and management.

National Hydrologic Model (+\$750,000/+1 FTE)

Water Availability and Use Science Program (+\$750,000/+1 FTE)

The Committee on the Environment, Natural Resources, and Sustainability has recognized the need for a National Hydrologic Modeling Framework to advance understanding and forecasting of the water budget, to effectively manage water resources, and to adapt to a changing climate. The USGS currently has a national scale hydrologic model that addresses the major components of the water budget, but human water use is not addressed explicitly. Moreover, information needed to operate the model must be obtained in a labor-intensive method. There is a need to assemble community modeling resources (i.e., datasets, models, use cases) to economize and enhance model development and verification activities across the community. Model development assumes continued community use of legacy models and datasets rather than proposing a new model framework. Such an activity would improve and modernize access to resources that support development, verification, or model application for specific decision situations.

This work, conducted in collaboration with other Federal agencies with major modeling and data generation activities would accelerate collaborative development of a nationwide hydrologic model that accounts for all aspects of the water budget. Initially, the USGS would work to incorporate remote sensing, including lidar and geophysical data, to refine landscape-scale topography, landcover, geologic framework, soil moisture, evapotranspiration estimates, and changes in depression storage. The USGS would begin steps to improve linkages between surface and groundwater hydrologic models by accommodating variable grid sizes and time steps, nesting existing fine-scale models within coarse-scale regional models. Finally, initial steps would be taken to refine operation of surface water models in sub-daily mode to better forecast flood response in smaller basins.

Science to Support Drought (+\$3,206,000/+12 FTE)

Responding to drought and managing limited water resources are primary drivers for many land and water management agencies. Given the persistent drought in multiple regions of the United States, the USGS proposes to quantify streamflow for all areas of the country, make precipitation data readily available, and determine groundwater availability under drought conditions. Providing access to these data will allow managers to determine impacts of drought on ecological systems. The USGS will develop actionable science approaches, by convening regionally based working groups of decisionmakers and natural resource managers to develop coordinated adaptive management plans for the complex consequences of severe and prolonged drought. The funding requested for this work would provide tools for fish and wildlife managers as well as water resource managers.

Environments Program (+\$300,000/+2 FTE)

More frequent and prolonged drought will increase the need to support investigations focused on the effects of extended drought on long-term population viability and habitat as well as terrestrial freshwater quality. The Environments Program would use the requested funding increase to support regional investigations of how drought interacts with other environmental stressors such as invasive vegetation and wildfires to affect landscape composition, structure, and function. Information derived from these investigations will be provided to resource managers that can then evaluate the tradeoffs between land management strategies and determine which strategies will be most effective for managing their resources.

National Climate Change and Wildlife Science Center/
DOI Climate Science Centers (CSCs) (+\$1,030,000/+2 FTE)

Understanding thresholds and tipping points caused by droughts is critical in providing managers with early action options. The National Water Census Data Portal serves information on streamflow, precipitation, and water use that can be utilized by the National Climate Change and Wildlife Science Center (NCCWSC)/DOI Climate Science Centers (CSCs) Program to provide the foundational data needed to build decision support tools. The NCCWSC would use the requested funding increase to continue to develop a science-based decision process for understanding and managing the impacts of drought on various parts of the Central and Western United States, including California. Much research is available on the effects of drought on human systems, notably agriculture, but the ecological effects are not as well studied. The program proposes to bring a diverse group of stakeholders together to gain a science-based, integrative understanding of drought impacts to their resource management responsibilities, and of their potential adaptive management responses. The USGS's goal is to use one or two drought stricken regions as examples to understand the impacts and then develop a decisionmaking process for managing limited water supplies in places like central California and the South Central United States. The USGS would develop working groups in places impacted by drought, consisting of USGS scientists, partners, and regional stakeholder networks to identify the science needs. Scientists attached to these working groups will develop models that integrate the social and economic impacts from drought and the USGS will use the NCCWSC/CSC Program's visualization facility (located in the Fort Collins Science Center) to allow the working groups to analyze scenarios using different decision points. In the requested increase, the program would expand the actionable science approach to other regions of the country that are prone to drought. The program would integrate results from climate driven drought projection models into models of ecological flow and wildlife impact to understand which areas of the country are more vulnerable to drought impacts. By focusing on the ecological impacts of drought, this project complements ongoing activities focused on water availability/supply and the agricultural and municipal effects of drought such as those under the National Integrated Drought Information Systems, U.S. Bureau of Reclamation basin studies, and other partners' efforts.

Climate Research and Development (+\$1,125,000/+5 FTE)

The Climate Research and Development (R&D) Program would use the requested funding increase to document long-term and medium-term patterns of drought and water availability in the Western and

Southeastern United States. Understanding patterns of drought is critical to develop sustainable plans for use of limited water resources by management agencies. These efforts would focus on synthesizing long-term patterns of United States hydroclimate in the two regions, including amount of precipitation, seasonality of precipitation (rain vs. snow), and variability in water availability over annual, decadal, and longer time scales. This research would provide a context to assess the magnitude and regional impacts of current and future droughts, and provide information on how ecosystems of the Western and Southeastern United States have responded to past intervals of drought. These studies would provide resource managers with real-world results that could be used to test results from a range of climate and ecosystem models.

In the Pacific Northwest and Alaska, water availability and water quality also are influenced by glacier dynamics. Increased funding would be used to expand ongoing research on alpine glaciers. Development of new and improved techniques to measure changes in the amount of water contained in alpine glaciers would improve the understanding of long-term patterns of glacier change and their influence on water availability and the transport of carbon and nutrients to streams, estuaries, and oceans. Such evidence would provide data needed by resource managers to better forecast changes in streamflow and ecosystem function in watersheds fed by alpine glaciers. The data and information collected by the Climate R&D Program can be compared to the current data that is collected and served through the National Water Census. This type of comparison would allow resource managers to use past examples to help understand current conditions in their area.

Land Remote Sensing (+\$250,000/+1 FTE)

The Land Remote Sensing (LRS) program would use the requested increase to work with the NCCWSC and the North Central CSC to investigate the relationship between drought and climate change on wildlife populations and their food sources. Drought-related indices and land cover would be used to model and predict how drought and climate change are impacting the phenology of animal migration and the forage quality of Western habitats. Current land change datasets and drought products will be evaluated for their adequacy to support management decisions for wide-ranging ungulate (e.g., Mule deer, Big Horn Sheep) populations and key habitats. The LRS program, along with the NCCWSC and the North Central CSC, would collaborate to identify gaps in remote sensing data, collect new data for model validation, and recommend new methodologies to meet the needs of scientists and decisionmakers in the conservation and land management communities. VegDRI is an operational drought model and map created weekly. The information is used by numerous organizations for drought mitigation decision supports. This information will be integrated with the evapotranspiration outputs that the National Water Census is already delivering to the public via the National Water Census Data Portal. The use of these and related capabilities would be extended into the habitat modeling community.

Water Availability and Use Science Program (+\$301,000/+2 FTE)

The Water Availability and Use Science Program would use the requested increase to improve water data and forecasting for drought. The program would create actionable, science-based information and tools as called for under the President's National Drought Resilience Partnership (NDRP). The NDRP's goal is to make it easier to access Federal drought resources by linking information such as monitoring, forecasts,

outlooks, and early warnings with longer-term drought resilience strategies in critical sectors such as agriculture, municipal water systems, energy, recreation, tourism and manufacturing. More accurate information about the timing and duration of droughts can enable States, tribes, counties and cities to plan more effectively and reduce drought impacts. In addition, the program would enhance research activities to improve drought forecasting. Groundwater and surface water availability changes would be evaluated by improving internal and external coordination and enhancing monitoring activities and data delivery systems to create a stronger link among the ground-based surface water and groundwater monitoring networks of the USGS, groundwater networks of State agencies and the soil moisture network of Natural Resource Conservation Service (NRCS). Links would then be improved between the well-coordinated ground-based monitoring networks and USGS remote sensing products. These data and information would be served through the National Water Census Data Portal. Drought creates an increased demand for groundwater resources, and land subsidence from increased groundwater withdrawals is a critical issue in some hydrogeologic settings. Land subsidence work would be enhanced to help characterize the potential impacts of drought on infrastructure.

Science Synthesis, Analysis, and Research (+\$200,000/0 FTE)

The Science Synthesis, Analysis, and Research (SSAR) program would use the requested increase to build on existing capabilities in gap analysis and collaborations with the Land Change Science (LCS) Program to provide species modeling for specific habitats. These outputs will improve the USGS support to ecosystem conservation planners by providing maps and analyses of species and habitats of critical concern for drought effects and areas most promising for mitigation actions.

Science to Support Sustainable Water Use (-\$63,000/-3 FTE)

Cycle 3 National Water Quality Assessment	(+\$881,000/0 FTE)
HR&D Monitoring and Assessments	(-\$1,000,000/-4 FTE)
Model Development and Research	(-\$444,000/-2 FTE)
Tribes	(+\$500,000/+3 FTE)

Program Performance

Cycle 3 National Water Quality Assessment (+\$881,000/0 FTE)

National Water Quality Program –	
Support National Water Quality Assessment Cycle 3	(+\$1,881,000/+4 FTE)
National Water Quality Program – Water Quality Monitoring	(-\$1,000,000/-4 FTE)

The National Water Quality Program's Cycle 3 (2013-2023) would be a leading source of scientific information for the development of effective policies and management strategies to protect and improve water quality for human and ecosystem needs. National Water Quality Assessment data, water-quality models, and scientific studies will characterize where, when, why, and how the Nation's water quality has changed, or is likely to change in the future, in response to human activities and natural factors. In 2016, the National Water Quality Program requests to reduce lower priority water quality monitoring to refocus

on supporting the National Water Quality Assessment Cycle 3 monitoring activities. The 2016 proposed funding increase will help the National Water Quality Program address priority aspects of the strategic science plan endorsed by the National Research Council and stakeholders such as the Advisory Committee on Water Information (<http://water.usgs.gov/nawqa/pubs/fs-2013-3008/>). Specifically, the resources will be used to:

- Work with Federal, State, and tribal partners to fill long-term water-quality monitoring gaps in critical watersheds and aquifers by leveraging available resources and collaborating with other programs to build an expanded and sustainable national network. Monitoring approaches will emphasize rapid feedback on changing water-quality conditions so that managers can identify emerging problems.
- Develop capability to provide annual Web-based reporting of the concentrations, loads, and trends of nutrients, sediment, and other contaminants in rivers flowing into important coastal estuaries to meet stakeholder needs for more-timely reporting of water-quality information.
- Develop forecasting and scenario-testing tools that will enable timely evaluation of current water-quality issues as well as the possible effects of future scenarios of changing climate, land use, and management practices by stakeholders.

HR&D Monitoring and Assessments **(-\$1,000,000/-4 FTE)**

Water Availability and Use Science Program	(-\$550,000/-3 FTE)
Groundwater and Streamflow Information Program	(-\$100,000/0 FTE)
National Water Quality Program	(-\$350,000/-1 FTE)

As resources are refocused on high-priority research areas such as the Puget Sound, water-related effects of unconventional oil and gas development, and methods for enhancing streamgaging, the Water Resources Mission Area proposes a \$1 million redirection of funding towards these areas. The proposed redirection of funding would result in reduced efforts on development of methods to detect various human-use compounds in water. This would slow progress on data collection and publication of information products in specific areas related to contaminants, ecosystem restoration, and others.

Model Development and Research **(-\$444,000/-2 FTE)**

Water Availability and Use Science Program	(-\$444,000/-2 FTE)
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The proposed change is reducing lower priority efforts within the Water Availability and Use Science Program to refocus on supporting National Water Census efforts. This would delay the advancement in groundwater model development to improve predictions of water availability and research to better understand the fate of contaminants in the environment.

Tribes **(+\$500,000/+3 FTE)**

Groundwater and Streamflow Information Program (+\$500,000/+3 FTE)

In 2016, the Groundwater and Streamflow Information Program is requesting an increase to build upon a 2015 investment to strengthen technical information needed to support water rights settlement work. Monitoring, assessments, and research would continue and expand work related to water availability issues on tribal lands in order to address such topics as water rights, water use, hydrologic conditions, and water-quality issues. The Groundwater and Streamflow Information Program would continue development of quantitative models of water budgets, including groundwater and surface-water interactions, that provide information on how human and natural factors, such as groundwater pumping and climate change, affect streamflows so that tribal river managers can develop effective strategies to maintain water supplies and restore critical habitats and healthy ecosystems. Building on an increase for tribal cooperators in 2014 and 2015, funding would be allocated in coordination with the Secretary's Indian Water Rights Office and other bureaus (including the Bureau of Indian Affairs and Reclamation) that support the Federal trust responsibility for water in Indian Country.

Landscape Understanding

Landscape Understanding (\$ in Thousands)			
	2016 President's Budget Program Changes	2016 President's Budget Program Changes - FTE	Page #
Critical Landscapes	6,650	24	C-18
The Changing Arctic	4,200	16	C-19
Environments Program	700	5	C-19
National Climate Change and Wildlife Science Center/DOI Climate Science Centers (CSCs)	500	4	C-20
Land Remote Sensing	250	1	C-20
Coastal & Marine Geology	2,000	4	C-21
Water Availability and Use Science Program	750	2	C-22
Columbia River (Salmon)	600	1	C-22
Environments Program	150	0	C-22
Contaminant Biology	50	0	C-22
Toxic Substance Hydrology	50	1	C-22
National Geospatial Program	350	0	C-22
Puget Sound	750	1	C-23
Environments Program	200	0	C-23
National Water Quality Program	100	1	C-23
National Geospatial Program	450	0	C-23
Science for the Sage Steppe Landscape	1,000	5	C-24
Environments Program	1,000	5	C-24
Upper Mississippi River	100	1	C-25
National Water Quality Program	100	1	C-25
Invasive and Declining Species	3,810	10	C-25
Brown Tree Snakes - Detection and Control	250	0	C-26
Invasive Species	250	0	C-26
New and Emerging Invasive Species	2,000	4	C-26
Invasive Species	2,000	4	C-26
Pollinators	1,560	6	C-27
Status and Trends	1,210	6	C-27
Science Synthesis, Analysis and Research Program	350	0	C-27
Coastal Resilience and Landscapes	5,109	13	C-28
Climate Outputs	500	2	C-29
National Climate Change and Wildlife Science Center/DOI Climate Science Centers (CSCs)	500	2	C-29
Coastal Land Use Change and Sea Level Rise	200	1	C-30
Land Change Science	200	1	C-30
Contaminant Network Along the Northeast Coast	1,300	3	C-30
Toxic Substance Hydrology	1,300	3	C-30
Imagery Datasets and Analytical Tools for Coastal Analysis	500	2	C-31
Land Remote Sensing	500	2	C-31
Coastal Resilience and Vulnerability	2,109	3	C-31
Coastal & Marine Geology	2,109	3	C-31
Sea Level Rise Models	500	2	C-32
National Cooperative Geologic Mapping Program	500	2	C-32
Grand Total	15,569	47	

Justification of 2016 Program Changes

(+\$15,569,000/+47 FTE)

Critical Landscapes	(+\$6,650,000/+24 FTE)
Invasive and Declining Species	(+\$3,810,000/+10 FTE)
Coastal Resilience and Landscapes	(+\$5,109,000/+13 FTE)

Overview

Interior, along with many other Federal and State agencies, local communities, tribes and regional coalitions manage their resources at the landscape scale, which requires understanding of many complex relationships between environmental and manmade factors. Land uses are increasingly interconnected and competitive. To inform decisions on siting energy development, allocating water resources, recreational opportunities, conservation of habitat, mitigation of development activities, and other land uses requires an understanding of the components within the landscape and how to balance a variety of uses and maintain a sustainable and resilient ecosystem. In 2016, the USGS is requesting an increase of \$15.6 million to expand, enhance, and initiate science activities in several areas to increase the understanding of the Nation's landscapes and how they work. One component expands science efforts at specific locations—the Arctic, Columbia River, Puget Sound, Upper Mississippi River, Great Lakes, and sage steppe habitat. Adding to these efforts are science activities of invasive species and species in decline. Another component builds on Hurricane Sandy efforts and initiates new work in coastal resilience and emerging contaminants and chemical mixtures.

Critical Landscapes **(+\$6,650,000/+24 FTE)**

The Changing Arctic	(+\$4,200,000/+16 FTE)
Columbia River (Salmon)	(+\$600,000/+1 FTE)
Puget Sound	(+\$750,000/+1 FTE)
Science for the Sage steppe Landscape	(+\$1,000,000/+5 FTE)
Upper Mississippi River	(+\$100,000/+1 FTE)

Overview

Knowledge of ecosystems is critical to the well-being of the Nation because ecosystems supply the natural resources and other goods and services that humans require. The scope of science needed to improve conservation and restoration of ecosystems is complex. In many ecosystems, regional environmental resource issues challenge decisionmakers and place them at a critical juncture to balance human needs with ecosystem health. The multidisciplinary approach applied by the USGS is necessary to develop an understanding of both individual ecosystem processes and holistic ecosystem level evaluations of responses to actual and proposed restoration alternatives and plans. Science enables resource managers to make informed decisions, to help resolve and prevent resource management conflicts, and to support Interior's public trust stewardship responsibilities for the Nation's lands and waters. Increases in 2016, support research and development efforts focused in the Arctic, Columbia River, Puget Sound, Upper Mississippi River, and Sage Steppe Landscape. In addition to these increases, USGS research will continue to support other priority ecosystems such as Chesapeake Bay, Everglades, Great Lakes, California Bay Delta, and the Gulf Coast. These multi-disciplinary projects are designed to serve local ecosystem management needs and provide knowledge and approaches transferable to similar ecosystems across the Nation.

Program Performance

The Changing Arctic	(+\$4,200,000/+16 FTE)
Environments Program	(+\$700,000/+5 FTE)
National Climate Change and Wildlife Science Center/ DOI Climate Science Centers (CSCs)	(+\$500,000/+4 FTE)
Land Remote Sensing	(+\$250,000/+1 FTE)
Coastal and Marine Geology Program	(+\$2,000,000/+4 FTE)
Water Availability and Use Science	(+\$750,000/+2 FTE)

The USGS can contribute significantly to supporting communities and resource managers in understanding changes in the Arctic that impact ways of life and the long-term resilience of ecosystems and communities. The Arctic is warming faster than any other region on Earth. In areas such as Alaska, observations show that the vast majority of glaciers are losing mass at an astounding rate, while rapid permafrost loss can be seen from coastal areas to inland forests and tundra. In turn, shrinking permafrost and glaciers have brought a host of impacts to the broader physical environment, such as the formation of thermokarst lakes (land-surface configuration that results from the melting of ground ice in a region that creates the lake, sinkhole, tunnel, etc.), altered streamflow paths and regimes, disruption of ocean currents, and sea-level rise. Less well understood is how glacier and permafrost change alters downstream ecosystems and the resources they provide. The USGS will take a whole-system approach to study the many dimensions—physical, biological, social and economic—of permafrost and glacier loss. This approach will be driven by the near-term needs of stakeholders, and will build cross-disciplinary teams of scientists using a blend of measurements, conceptual modeling, and process modeling within a collaborative framework as a means to clarify the linkages between climate, glaciers and human impacts. This effort will build on a rich legacy of Federal science in the Arctic, while also capitalizing on capacity from the broader research community. Completion of this project will allow managers in the Arctic to understand the potential climate impacts to glaciers and determine potential changes in production of salmon and migratory waterfowl, wildfire regimes across Alaska and changes in permafrost.

Environments Program	(+\$700,000/+5 FTE)
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While the Arctic region has experienced warming and cooling cycles over millennia, the current warming trend is unlike anything previously recorded and is affecting the region faster than any other place on Earth, bringing dramatic reductions in sea ice extent, altered weather, and thawing permafrost. Implications of these changes include rapid coastal erosion threatening villages and critical infrastructure, changes to wildlife habitat, increased greenhouse-gas emissions from thawing permafrost, threats from invasive species, and potentially significant impacts on subsistence activities and cultural resources. Changing habitats and related impacts to species are of great importance to land and wildlife managers as well as indigenous peoples. Federal, State, and tribal managers need to understand how climate, in particular, is impacting the lands and species for which they are responsible, and what actions may be warranted to protect those resources for. As development continues to be proposed for many parts of Alaska, but especially the Arctic Slope, managers must understand the trajectories of change and attempt to forecast additional impacts from development both to honor commitments to Native Americans and to

help conserve these natural resources. The USGS is committed to applying assessment and analysis techniques to the species and habitats of Alaska, especially the North Slope, to help provide the information, models, and other tools that managers need to support difficult decisionmaking.

Climate changes have the potential to affect the outcomes of various resource management decisions such as those in energy development, wildlife disease management, and Native American subsistence harvests. The Environments program would use the requested funding to work with scientists from other parts of the USGS and partner agencies to analyze potential changes to distributions and condition of fish and wildlife populations and their habitats as a result of climate changes and human activities. Although it is fairly certain that climate-induced changes to animal populations and habitats will occur, predictions about the precise nature of those changes remain uncertain. Management strategies designed to offset these changes are hampered by uncertainty in how climate change will affect both species' occurrence (i.e., distribution) and within-season timing (e.g., growth, reproduction, migration). The program will seek to develop quantified methods to assess plant and animal responses simultaneously at species and community levels to explicitly incorporate shifts in species' responses to climate variables. Qualitative and quantitative methods would be useful for developing and testing monitoring approaches for fish and wildlife species of importance to Alaska. Such methods have application beyond taxa in Alaska and could be applied across systems where there is a desire to predict the species changes and shifts in life history timing in response to climate change or development.

National Climate Change and Wildlife Science Center/

DOI Climate Science Centers (CSCs)

(+500,000/+4 FTE)

The National Climate Change and Wildlife Science Center/Climate Science Center (NCCWSC/CSC) Program would use the requested funding increase to develop a process to estimate total glacier loss in Alaska and potential changes in freshwater input. These estimates would be used along with projections of future changes in climate, fire regimes, vegetation, and water flows, produced by the program's recently completed Alaska Integrated Ecosystem Model (AIEM). The AIEM is an ecosystem model for Alaska and Northwest Canada. This modeling tool is capable of forecasting how landscape structure and function might change in response to climate changes. This tool is capable of providing scenarios of changes in landscape structure and function that could be used by resource-specific impact models to assess the effects of climate change on natural resources. The information from the requested increase will be used by managers of high priority species such as goose and caribou to identify potential impacts and identify management options.

Land Remote Sensing

(+\$250,000/+1 FTE)

The Land Remote Sensing (LRS) program would use the requested increase to contribute to the development of predictive models, which support the evaluation of changes to the environment resulting from the conversion of permanently sequestered ice and snow to liquid and gaseous water. Multi-temporal and multi-resolution remote sensing data from satellites and airborne systems (Landsat, Classified Systems, Aircraft, and Unmanned Aerial Systems) would be used in combination with field level studies and in-situ observations to measure changes of ice and snow volumes and support the

development of predictive models of the impacts from climate-induced changes. This work would build on initial research being conducted in the development of an Essential Climate Variable for permafrost.

Coastal and Marine Geology Program

(+\$2,000,000/+4 FTE)

The proposed increase will enhance the capacity of the Coastal and Marine Geology Program (CMPG) to work with communities, the Bureau of Indian Affairs, and the Office of Insular Affairs (OIA), to deliver assessments of coastal vulnerability to storms, erosion, and sea-level rise for communities along the Alaskan Arctic and Bering Sea coasts and throughout U.S. Island Territories and Freely Associated States. The livelihoods of these remote communities are linked to their coastal landscapes, resources and infrastructure, and are threatened by impacts from storm-related flooding, permanent inundation and coastal change associated with climate change. Tools to assess vulnerability and anticipate future change, and to develop sustainable strategies to respond and adapt to change while preserving cultural, economic and environmental health are needed. Application of CMGP tools developed for the ocean coasts of the lower 48 States requires development of foundational data and enhancements to reflect the unique character and processes of these vulnerable landscapes. Through this effort, the CMGP will assess and address critical data and knowledge gaps and, for priority communities, begin to synthesize the data and knowledge into tools that will support development of effective and sustainable strategies to respond to changing conditions. Initial pilot assessment and forecast products will provide a widely accessible framework and strategy for a sustained and longer-term effort to address the requirements of the widespread communities throughout these regions. Resulting data and products will be delivered through the USGS Coastal Change Hazards Portal, which enables access through Federal ocean and climate data and toolkit services that facilitates broad access and application.

Consultation with tribes, State, and other entities Alaska and the Arctic, and with Interior resource managers, would guide systematic prioritization development of products for this region where vulnerable landscapes, ecosystems, and communities face impacts of coastal change in response to sea-level rise, changing ice-cover, storms, and increasing shoreline retreat associated with permafrost decline, inundation, and land subsidence. Substantial data gaps, including mapping of coastal landscapes and change, would be addressed to provide observational inputs to coastal vulnerability and change forecasts. Field programs would focus on development of coastal change assessments and forecasts reflecting processes and conditions unique to this region and of particular concern to native communities and Interior resource managers. Initial development in selected priority communities would establish the framework and requirements for broader development and provision of data, forecasts and decision-support tools. The CMGP will work with other Federal agencies (Interior: BIA, NPS, BLM, FWS, BOEM, USACE, NOAA), regional Climate Science Centers and LCCs, State agencies, and interagency Arctic/Alaska councils to define priorities and leverage efforts as is required to develop substantive products in these remote, unique, and operationally challenging regions.

Coastal communities throughout the Island Territories (including the Freely Associated States) are dependent on coral reef systems to buffer storm and coastal flooding impacts, to sustain fisheries and biodiversity, and for other economic and cultural benefits. Coral reefs are particularly vulnerable to sea-level rise, changing storm climate, ocean warming, and ocean acidification. The USGS will conduct research to enhance our understanding of the response of coral reef-associated shorelines to climate

change and other stresses. Research results will include updated data and development, and validation of physical models that predict vulnerability of coral reef seascapes and adjacent landscapes to climate change, sea-level rise, and storm impacts. The resulting data and models will assist resource managers and coastal communities in assessing the sustainability of infrastructure, food and agricultural, and groundwater resources. Assessment and forecast products will be developed to meet the requirements of island communities to design and evaluate sustainable and effective strategies to enhance coastal resilience and adapt to coastal change.

Water Availability and Use Science Program (+\$750,000/+2 FTE)

Permafrost has accelerated altering surface water and groundwater distribution, flow and quality; ice-jam flooding; land surface features; lake and wetland dynamics; health of aquatic and terrestrial ecosystems, ocean currents; and sea level. Permafrost thaw and the naturally accompanied changes in water flow and distribution is having important economic consequences on roads and other infrastructure. The Water Availability and Use Science Program would use the requested increase to address the most urgent scientific and social questions stemming from warming in the Arctic with input from Federal, State and tribal resource managers and collaborative efforts among cross-interdisciplinary teams of scientists. Among the issues to be addressed would be the effect of permafrost thaw on surface water and groundwater and carbon and mercury export to surface waters.

Columbia River (Salmon) **(+\$600,000/+1 FTE)**

Environments Program	(+\$150,000/0 FTE)
Contaminant Biology	(+\$50,000/0 FTE)
Toxic Substances Hydrology	(+\$50,000/+1 FTE)
National Geospatial Program	(+\$350,000/0 FTE)

The Columbia River is the largest river in the Pacific Northwest, and plays an important role in the region’s culture and economy through tribal fisheries, irrigation, power production, and recreation, among other goods and services. This system has been affected by a number of anthropogenic changes, including altered flows, environmental contaminants, and invasive species that have degraded the ecosystem. Managers and policymakers require scientific information to prevent the decline of critical species such as salmon, which are a valued tribal trust species; to manage ecological flows in this engineered river system; and to reduce risks from habitat degradation, changes in species composition, and climate change. With the proposed increase, the USGS would enhance documentation of the life history, habitat requirement, and population status and trends of forage fish, critical as a food source to other species, supporting fish, bird and mammals. The USGS would address invasive species, related climate impacts, chemical and physical habitat degradation, and effects on economic and trust species. USGS scientists would conduct research on the effect of altered flow regimes due to climate change and dam operations on habitats. A new Columbia River Treaty with Canada, which would take effect in 2025, could potentially affect flow regimes. USGS researchers would characterize ecological tradeoffs related to alternative flow regimes, as they affect physical habitat features, food webs, and ecological interactions influencing the sustainability of salmon, sturgeon, and other key species populations. The research results would help decision makers address flow regimes as required by the treaty. The USGS would combine

data acquisition efforts with the Science Application for Risk Reduction (SAFRR) project to better leverage multiple science uses for high-resolution lidar data, through 3DEP, over ecosystem and natural hazard projects in the Columbia River area. The SAFRR develops natural hazard disaster scenarios as a strategy to increase community resilience or a community's ability to cope with the effects of a disaster. This work builds upon what was started in 2015.

USGS researchers would continue to investigate the effects of endocrine-disrupting chemicals (EDCs) on fish and wildlife in the Columbia River through laboratory and field investigations in four critical areas: (1) investigations into adult onset immune suppression following early life stage exposure of EDCs; (2) development and application of fish models to better understand EDC-induced immune suppression and disease resistance; (3) characterization of fish and wildlife models for trans-generational effects of EDCs; and (4) studies to identify reproductive effects of chronic low-dose exposure in several species including endangered sturgeon.

In addition, research into contamination of the Columbia River and its wetlands with metals, including mercury, would investigate the potential biological effects of these metals on aquatic insects, including the potential to influence maturation of aquatic larva to terrestrial adults, contaminant bioaccumulation, and the movement of these metals through the food chain.

Puget Sound	(+\$750,000/+1 FTE)
Environments Program	(+\$200,000/0 FTE)
National Water Quality Program	(+\$100,000/+1 FTE)
National Geospatial Program	(+\$450,000/0 FTE)

Puget Sound, the second largest estuary in the United States, provides diverse benefits to a growing regional human population. It provides a home, recreation, and economic opportunity to millions of people. The Sound is a natural resource treasure, supporting hundreds of species of fish, sea birds, and marine mammals, many of which are of enormous economic and cultural importance to the region. Human development and land use changes will likely affect the future sustainability of the Sound, particularly watershed and shoreline alterations that are likely to reduce critical habitat for species and reduce water quality. More than 20 Native American tribes are protected in perpetuity in their uses of salmon. However, salmon are in decline due to reductions in habitat quantity and quality. The USGS is providing critical science to support priorities of a major ecosystem restoration effort involving tribal, local, State, and Federal entities. The proposed increase in 2016 would support managers and decision makers by developing process-based monitoring and models at the ecosystem scale to identify and address risks to salmon. These models, based on current and historic monitoring, help decisionmakers identify the key species and processes in the ecosystem for appropriate protections, controls, and monitoring. In addition, the USGS would investigate the status of forage fish populations—some of which are in decline—and identify linkages between population dynamics, bioenergetics, predation, habitat alterations, disease, and food availability. In support of the restoration, this work would result in new molecular tools and sampling methods. The USGS would combine data acquisition efforts with the SAFRR project to better leverage multiple science uses for high-resolution lidar data, through 3DEP over ecosystem and natural hazard project in the Puget Sound area. Finally, the recent removal of two major

dams on the Elwha River is one of the largest river restoration projects in history, requiring active management of former submerged reservoir lands; use of hatcheries to supplement wild fish populations; and monitoring of specific aquatic, terrestrial, and near-shore marine responses of the ecosystem. This work builds upon what was begun in 2015. USGS science would provide managers with information on ecosystem responses to specific post-removal restoration actions to ensure that restoration is effective.

The remarkably diverse and resilient habitats of the Puget Sound estuary provide a wide range of ecosystem benefits, including significant current and potential carbon sequestration across the seagrass - marsh - tidal forest transect. The National Water Quality Program is proposing a funding increase to build upon an investment started in 2015 that focuses on carbon cycle modeling in the Nisqually National Wildlife Refuge, and other neighboring field sites (Snohomish Estuary to the north). These areas in the Puget Sound need greater accounting of carbon stocks and fluxes in order to comply with statutory and regulatory requirements. Carbon accounting is needed in a changing world in order to support management decisions that can maximize estuarine resilience and ecosystem services, from carbon sequestration to wildlife support.

Science for the Sage Steppe Landscape

(+\$1,000,000/+5 FTE)

Environments Program

(+\$1,000,000/+5 FTE)

The North American sage steppe landscape covers about 120 million acres, extending across 11 Western States and parts of 2 Canadian provinces. Sixty percent of the sage steppe landscape is in public ownership, with the Interior managing 51 percent of these lands. Sage steppe provides the primary habitat for greater sage-grouse, a species that the FWS is considering for Federal listing in a determination due in September 2015. The sage steppe landscape has been significantly altered by multiple stressors, including increasing incidence of large wildfires, rapid spread of invasive cheatgrass that alters natural fire regimes, expanding energy development, and other human land uses. These changes have resulted in significant loss, fragmentation, and conversion of landscapes once dominated by sage steppe, and they have had a resulting negative effect on greater sage-grouse, a species that now occupies less than half of its historic range. The USGS is conducting research to understand the changes in the sage steppe landscape, and how these changes impact species, like greater sage-grouse, which depend on this habitat for survival. A significant portion of this research is focused on understanding changes at a large, multi-jurisdictional landscape scale, developing the tools and techniques that State and Federal managers need to respond to these changes. With this initiative, the USGS would expand its fire and restoration research to better understand the effects of repeated fires on the sage brush ecosystem and the efficacy of restoration activities by Interior partner agencies. Research projects include development of models to predict the effect of a changing fire regime and habitat fragmentation on the persistence of sage grouse populations, understanding the significance of climate change in the sage steppe landscape, and developing and testing alternative sage steppe restoration/rehabilitation strategies.

This information will help inform restoration, rehabilitation, and mitigation practices for greater sage-grouse habitat within the context of ecosystem management to increase resilience. These evaluations will span the entire range of the greater sage-grouse, and will provide decision-makers the information to make landscape-scale decisions. This unprecedented, landscape-level study will provide critical

information on (1) implementation strategies (equipment, methods, seed sources and transfer guidelines, site prioritization) that maximize habitat restoration for greater sage-grouse, and (2) rates and likelihood of sage steppe establishment given to losses from fire and other activities. This information is relevant to State and Federal agencies, including but not limited to State land, fish and wildlife agencies, the USFS, BLM, NPS, and FWS.

This initiative provides a direct link to the Secretary's priority on Landscape Level Understanding by focusing on a high priority landscape and providing the science needed for managers to make landscape-scale decisions. All the research will be planned and implemented in close collaboration with Interior Bureaus (BLM, NPS, and FWS).

Upper Mississippi River **(+\$100,000/+1 FTE)**

National Water Quality Program (+ \$100,000/+1 FTE)

The National Water Quality Program would build upon a 2015 investment into Upper Mississippi River Basin (Basin) with a requested increase in 2016 to perform more data collection and interpretative studies on water quality in the Upper Mississippi Region. The Basin contains a wide diversity of landscape types that include major agricultural operations and headwaters with major urban landscapes. Both landscape types can have negative impacts on aquatic ecosystem health of the Mississippi River and connecting rivers downstream resulting in maintaining or expanding hypoxia conditions in the Gulf of Mexico. Existing USGS programs in this region are developing a better understanding of water resources through critical streamflow measurement stations that characterize water quality. The proposed increase would be used to support additional monitoring of nutrients and sediment used to develop water quality models that would help States and local agencies prioritize their efforts towards the largest sources of nutrients in the Basin. Data and interpretive studies addressing water quality concerns are shared with State and local partners in this five State region (Minnesota, Wisconsin, Illinois, Iowa and Missouri).

Invasive and Declining Species **(+\$3,810,000/+10 FTE)**

Brown Tree Snakes – Detection and Control (+ \$250,000/0 FTE)

New and Emerging Invasive Species (+ \$2,000,000/+4 FTE)

Pollinators (+ \$1,560,000/+6 FTE)

Overview

Nonindigenous invasive plants and animals cause significant economic losses and diminishing opportunities for beneficial uses of forests, croplands, rangelands, and aquatic resources. Costly effects include clogging of water facilities and waterways, wildlife and human disease transmission, threats to commercial, native, and farmed fisheries and increased fire vulnerability and adverse effects for ranchers and farmers. Across the Nation, the USGS partners with States, tribes, other Federal agencies, businesses, agriculture, natural resource managers, and the private sector to help solve problems posed by all significant groups of invasive organisms in terrestrial and aquatic ecosystems. Increases in 2016

would continue research and development efforts focused on the brown tree snakes in Guam and new and emerging invasive species of national concern.

Insects, birds, and mammals, that are pollinators, are critical to agriculture and the economy. The USGS and other scientists are documenting alarming declines in pollinators. In 2016, the USGS, in collaboration with the U.S. Department of Agriculture, will study land use, land condition, and land cover as they relate to pollinator habitat needs, including restoration efforts; study the use of pesticides; and provide data and tools to the American people to promote healthy habitats across the country.

Program Performance

Brown Tree Snakes – Detection and Control

Invasive Species (+\$250,000/0 FTE)

Shortly after World War II, the brown tree snake (BTS) was accidentally transported from its native range in the South Pacific to Guam. Because of abundant prey on Guam and the absence of natural predators and other population controls, BTS populations reached extraordinarily high numbers. Snakes have caused the extinction of most of the native forest vertebrate species; thousands of power outages affecting private, commercial, and military activities; and widespread loss of domestic birds and pets. The highest priority needs for control and management of BTS are the development of landscape-scale methods to suppress or eradicate snakes on Guam, and to detect and eradicate incipient populations of snakes accidentally transported to other islands such as Hawaii and the Northern Mariana Islands. The military expansion on Guam will raise the profile of these issues because military construction will result in mitigation actions that include snake suppression in areas of high ecological value, and because increased military cargo transport and off-Guam training exercises will increase the odds of transporting snakes to other islands, such as Hawaii. With the increased funding, the USGS would build on continuing work focusing on high-priority research to validate the efficacy of aerially-delivered toxicants for snake control at landscape-scales; predicting the results of snake suppression on Guam and the increase of potentially problematic species (such as non-native rats); increasing the number of trained snake rapid responders in Hawaii and other islands at risk of receiving BTS transported from Guam; and conducting a thorough assessment of the possibility that scattered reports of snakes sighted in the U.S. Commonwealth of the Northern Mariana Islands represent an established population.

New and Emerging Invasive Species (+\$2,000,000/+4 FTE)

Invasive Species (+\$2,000,000/+4 FTE)

The introduction, establishment, and spread of invasive species will be important drivers of biodiversity loss over the next century and will pose substantial risks to native species, valued ecosystem services, and human and wildlife health. Ongoing global changes such as more-frequent transcontinental and transoceanic trade and tourism, land and water use changes, and climate change are facilitating ever-faster rates of establishment and spread of harmful, invasive plant and animal species around the world. Challenges for scientists will be to determine which newly established nonnative species might cause

significant impacts and become high priority invaders, and accurately estimate their potential spread throughout the country. While many invaders cause little or no observed change in the invaded ecosystem, a small percentage of species that become established alter ecosystem structure and function in detectable and deleterious ways. USGS research on current high priority invasive species such as tamarisk in the Southwest, nutria in the Gulf of Mexico, Burmese pythons in the Everglades, and Asian carp in the Mississippi River Basin provides information to identify the next generation of invaders and to forecast their impacts. Assessing the factors influencing known invasions improves the national ability to predict invasions and to take preventative measures early enough to better address new invasive species.

This increase would allow the USGS to enhance ongoing efforts focused on the development, evaluation, and improvement of tools for early detection and control of existing and emerging invasive species. The USGS would develop and improve the power of advanced molecular detection tools (such as eDNA and fecal source tracking) to detect invasive species at very low densities in the field, such as sea lamprey. These USGS research endeavors would provide information for assessments of risk and predictions; determine effects of invasive species; develop tools and innovative methods for control and management; and deliver information management tools to more effectively integrate and use available data on invasive species. In addition, the USGS Nonindigenous Aquatic Species database (<http://nas.er.usgs>) would be expanded to provide information and data on aquatic invasive plants, information needed by our Interior and other partners to manage new and emerging plant invaders. The end result would be a collection of early detection tools for invasive species to enhance capability for early detection and control of currently established and emerging invasive species and to ensure that the Nation is better prepared for the next—yet unknown—generation of invasive species. This research would address invasive species and ecosystems of concern for our Interior partner agencies and would be coordinated with the National Invasive Species Council.

Pollinators

(+\$1,560,000/+6 FTE)

Status and Trends

(+1,210,000/+6 FTE)

Science Synthesis, Analysis and Research

(+\$350,000/0 FTE)

The Pollinators Initiative will address research priorities identified through the 2014 Presidential Memorandum on Pollinator Health, through the development of studies, monitoring programs, and decision tools for land and resource management agencies, such as the National Protocol Framework for the Inventory and Monitoring of Bees, and pollinator habitat models. The USGS would expand the small group of researchers who work directly on pollinators. The USGS would support scientists who work on habitat characteristics, ecosystem services, disease and pesticides toward pollinator issues.

USGS scientists work closely with the U.S. Department of Agriculture (USDA), which is interested in ensuring that honeybees have adequate forage throughout their lifespan. The initiative would support increased interaction between the USGS and Interior bureaus to support management of lands to support pollinators, and ensuring that populations of native species are maintained. Partnerships would also be expanded, including the Pollinator Partnership, a consortium comprised of local, regional, tribal and national governments, corporations, universities and others that work to protect the health of managed and native pollinating animals vital to our North American ecosystems and agriculture, and the Monarch Joint

Venture, a partnership of Federal and State agencies, non-governmental organizations (NGO), and academic programs that are working together to support and coordinate on-the-ground conservation efforts to protect the monarch migration across the lower 48 United States.

The proposed increase would allow the USGS to significantly augment its interdisciplinary pollinator science program to:

- Expand existing collaborations with the USDA to study the patterns, processes, and consequences of changes in land use, land condition, and land cover as they relate to pollinator habitat needs including forage, nesting, and other requirements.
- Work with land management agencies to translate habitat needs into effective restoration strategies and monitor effectiveness of restoration activities.
- Expand science in support of FWS efforts to conserve and restore healthy monarch butterfly populations.
- Conduct research on the cumulative impacts of pesticides.
- Collaborate with the FWS to refine and test the National Protocol Framework for the Inventory and Monitoring of Bees.
- Build capacity for identification and taxonomy of native bees, in partnership with USDA and non-federal partners.
- Provide information and tools in support of other Federal agencies' outreach and education activities to promote healthy habitats across the country.
- Create maps and analyses for habitats of critical concern for pollinators with areas of greatest potential for mitigation and restoration activities.
- Enhance existing online repositories of pollinator occurrence data to capture national distributions, ranges and potential ranges for important pollinator species including predicted ranges in light of climate change.

Coastal Resilience and Landscapes **(+\$5,109,000/+13 FTE)**

Climate Outputs	(+\$500,000/+2 FTE)
Coastal Land Use Change and Sea Level Rise	(+\$200,000/+1 FTE)
Contaminant Network Along the Northeast Coast	(+\$1,300,000/+3 FTE)
Imagery Datasets and Analytical Tools for Coastal Analysis	(+\$500,000/+2 FTE)
Coastal Resilience and Vulnerability	(+\$2,109,000/+3 FTE)
Sea Level Rise Models	(+\$500,000/+2 FTE)

Overview

U.S. populations, critical infrastructure, and economies, are concentrated in coastal regions and are at substantial risk from coastal hazards and long-term change. Major storms impact lives and livelihoods

with economic costs in the billions, and unquantified but equally consequential social and environmental costs. The security, vulnerability, and resilience of the physical, ecological, and human components of coastal systems are intimately linked. Enhancing resilience and reducing vulnerability as change accelerates due to increasing development and the consequences of climate change requires data, knowledge, and tools to assess coastal vulnerability; to develop effective and sustainable strategies to enhance resilience; and to forecast the impacts of future conditions and processes on environmental and economic health and public safety. This initiative engages numerous USGS programs to develop and integrate their proven capabilities to provide the foundational data, methods, and knowledge to enhance our ability to assess and forecast coastal vulnerability and the efficacy of strategies to increase resilience and adapt to change.

The activities will improve understanding of the vulnerability of coastal resources and communities and will inform strategies to enhance coastal resilience and adapt to coastal change. In meeting immediate needs, they will also establish and demonstrate the effectiveness of a more comprehensive effort to provide and apply the breadth of USGS science capabilities to the diverse and widespread coastal settings of the Nation. As a result of this effort the USGS will provide data, understanding and tools that advance our understanding of coastal vulnerability to storms and sea-level rise including: (1) data, tools, and forecasts that will enable coastal resource managers to anticipate future consequences of coastal change and to assess the efficacy and sustainability of alternative management strategies, including “green” or “nature-based” approaches; (2) information to assess the potential for storm-driven dispersal of contaminants and the short-term and persistent consequences of resulting human and environmental exposure to support effective mitigation and response; (3) geospatial characterization of the landsurface and landcover, including post-event mapping of change, required to assess ecological and human vulnerability and for modeling of impacts and change; (4) enhanced records of past sea-level and storm impacts to improve models and understanding of the potential scale and extent of future change; and (5) methods to characterize and communicate risk and vulnerability so that communities can design strategies based on consistent, comparable, and meaningful estimates of costs and benefits.

Program Performance

Climate Outputs

(+\$500,000/+2 FTE)

National Climate Change and Wildlife Science Center/

DOI Climate Science Centers (CSCs)

(+\$500,000/+2 FTE)

The National Climate Change and Wildlife Science Center/DOI Climate Science Centers (CSCs) Program, working closely with the Coastal and Marine Geology Program (CMGP), would use the requested increase to bring structured decision making approaches that integrate the latest sea-level rise projections to refuge and other land managers in the Southeastern United States, the Hawaiian Islands, and the west coast. Specifically, the program would identify management endpoints for land managers in coastal zones and develop approaches that link climate outputs with models to inform the decisionmaking process. The land managers would then use this information in decisionmaking in areas such as restoration of habitat or protection or conservation of species.

Coastal Land Use Change and Sea Level Rise (+\$200,000/+1 FTE)

Land Change Science (+\$200,000/+1 FTE)

The requested increase would develop tools for estimating the risks and potential benefits and costs of various sea-level rise and storm surge mitigation measures. Program researchers would assess the impacts and risks stemming from coastal land use change on communities and their potential vulnerability. In order to mitigate, prepare for, and recover from disasters, public officials and at-risk communities need a clear understanding of societal risk to create strategies for increasing resilience to both to sea-level rise and storm surges.

Contaminant Network Along the Northeast Coast (+\$1,300,000/+3 FTE)

Toxic Substances Hydrology (+\$1,300,000/+3 FTE)

Enhanced dispersal and concentration of contaminants (including chemicals and pathogens) from a wide array of municipal (wastewater), industrial (chemical storage and processing facilities), and residential sources in coastal regions due to storm-induced disturbances could decrease the health and resilience of coastal communities and ecosystems in coming years throughout the United States. As part of the Hurricane Sandy supplemental, the USGS received \$2.0 million in 2014, and is establishing a contaminant vulnerability assessment network based on a prioritized monitoring and modeling infrastructure supported with extensive landscape-scale assessments of potential contaminant sources. The requested increase would augment that ongoing effort by: (1) enabling the establishment of real-time water quality monitoring capabilities in key locations associated with the network along the northeast coast, and (2) supporting the development of standard operating procedures to prioritize areas vulnerable to contaminant impacts based on the real-time monitoring network and other factors, as well as (3) the rapid deployment and mobilization of field crews for environmental sample collection (including water, soils, and sediment). This will be developed in close collaboration with local, State, tribal, and other Federal partners, including public health agencies commonly engaged in first response actions.

Network monitoring sites will be collocated where possible in partnership with a separate USGS effort led by the Water Mission Area, and funded by the Hurricane Sandy supplemental, which is establishing a Surge, Wave, and Tide Hydrodynamics (SWaTH) network along the northeast coast. The requested increase will enable real-time water quality sensors to be sited on a subset of SWaTH sites. Interpretation of these data in context with the associated landscape-scale assessments of contaminant sources and modeling will provide supporting information required to mitigate those sources in the short term and minimize their impact for future events. Lessons learned from the establishment of this network can be applied to other coastal areas of the United States. The data would be used to mitigate contaminant threats and could also be used to help design more extensive networks of a similar nature.

Imagery Datasets and Analytical Tools for Coastal Analysis (+\$500,000/+2 FTE)

Land Remote Sensing (+\$500,000/+2 FTE)

The Land Remote Sensing (LRS) Program would use the requested funding increase to work with the Land Change Science (LCS) Program and other USGS and interagency partners to develop new datasets to support dynamic coastal land change analysis for improved coastal resource management and resilience planning. The LRS program would support more frequent National Land Cover Database (NLCD) based sources of land change information including interim and ongoing monitoring especially after significant storm events. The LRS program would primarily develop datasets that exploit new elevation technologies (to augment 3DEP), hyperspectral capabilities, and various platforms to include Unmanned Aerial Systems. The LRS program would provide analytical tools for integrating repeat elevation and spectral data to characterize the impacts of coastal change and severe weather events on terrestrial and aquatic vegetation health, and other features that play a role in coastal resilience and flood inundation. Prototype datasets would be developed for one or two priority areas and made available for peer-review evaluation and for use in sea-level rise modeling exercises that will occur within the CMGP and NCCWSC/CSC program.

Coastal Resilience and Vulnerability (+\$2,109,000/+3 FTE)

Coastal and Marine Geology Program (+\$2,109,000/+3 FTE)

This requested increase will enable the Coastal and Marine Geology Program (CMGP) to build upon datasets, regional geologic studies, and models of coastal change and vulnerability developed and enhanced with supplemental funding in the aftermath of Hurricane Sandy. Activities will focus on Interior and other Federal lands and managed resources in the mid-Atlantic region and, in collaboration with established USFWS, NPS, and other Federal partners, lead to improved assessments and forecasts of the vulnerability of coastal lands and resources to future extreme storms and sea-level rise. Data, tools and models will be developed to assess the effectiveness and sustainability of existing and alternative strategies for enhancement of natural system resilience and the associated benefits in terms of reduced vulnerability of coastal infrastructure and communities. Field studies will address specific resources at management-relevant scales to assess coastal vulnerability and resilience to extreme events and persistent change across the entirety of barrier-island, bay/estuary, and wetland systems. Data, tools, and forecasts will enable coastal resource managers to anticipate future consequences of coastal change and to assess the efficacy and sustainability of alternative management strategies, including “green” or “nature-based” approaches. Updated assessments will be provided after extreme events, and as changes occur due to persistent change or management actions. Tools will be provided to enhance resource resilience, reduce vulnerability of adjacent infrastructure and communities to future storms and sea-level rise, and to assess the success of management actions and the science on which they were based. Resulting data and products will be delivered through the USGS Coastal Change Hazards Portal which enables access through Federal ocean and climate data and toolkit services that facilitate broad access and application.

Sea Level Rise Models **(+\$500,000/+2 FTE)**

National Cooperative Geologic Mapping Program (+\$500,000/+2 FTE)

The National Cooperative Geologic Mapping Program (NCGMP) would use the increase to build upon regional geologic studies to better understand climate extremes in the geologic record; to understand the footprint that large storms leave on the landscape (both onshore and offshore) in California; and to better understand climate signals in the Coastal Plain formations of the Atlantic Coastal Plain (e.g., Paleocene-Eocene Thermal Maximum). These paleoclimate indicators are generally discovered through careful examination of sediment core samples involving sediment description, geochronology, paleontology, and geochemistry. The information gathered would enable coastal resource managers to design resiliency strategies for future storms, and longer-range trends such as sea-level rise.

Natural Hazards Science

Natural Hazards Science (\$ in Thousands)			
	2016 President's Budget Program Changes	2016 President's Budget Program Changes - FTE	Page #
Natural Hazards Science for Disaster Response	6,618	10	C-34
Expanding Use of Flood Inundation Mapping and Rapid Deployable Streamgages	700	4	C-34
Groundwater and Streamflow Information Program	700	4	C-34
Rapid Response to Volcano Unrest and Eruption, and Associated Hazards	0	0	C-35
Volcano Hazards	0	0	C-35
Earthquake Early Warning and Rapid Event Characterization	-1,502	-2	C-36
Earthquake Hazards	-1,502	-2	C-36
GSN Primary Sensor Deployment	4,920	2	C-37
Global Seismographic Network	4,920	2	C-37
Improved Geomagnetic Monitoring to Support Space Weather Nowcasting	1,700	3	C-37
Geomagnetism	1,700	3	C-37
Landslide Response	500	2	C-38
Landslide Hazards	500	2	C-38
Rapid Wildfire Science Response	500	2	C-39
Environments Program	500	2	C-39
Building Sinkhole Hazard Response Capability	200	0	C-40
National Cooperative Geologic Mapping Program	200	0	C-40
Disaster Scenarios and Strategic Science Crisis Response	300	1	C-40
Land Change Science	300	1	C-40
Precision Monitoring for Non-Seismic Fault Activity	-700	-2	C-41
Earthquake Hazards	-700	-2	C-41
Grand Total	6,618	10	

Justification of 2016 Program Changes

(+\$6,618,000/+10 FTE)

Overview

Every year the United States faces disasters that threaten the Nation through loss of life and property, degradation of human health and the environment, and impacts to national security and economic vitality. In domestic and global events, the Nation's emergency managers and public officials look to USGS science to inform them of the risks hazards pose to human and natural systems and how to reduce losses and improve response. Major events in the last several years include the Napa, California earthquake; landslides in Washington State and Colorado; Midwest flooding; Hurricane Sandy; Japan's Great Tohoku earthquake and Pacific-wide tsunami; and volcanic eruptions in Alaska and Hawaii. In 2016, the USGS is requesting an increase of \$6.6 million to strengthen its capabilities both before and after disasters strike. Included in the request is funding to continue earthquake early warning development, continue volcano monitoring, expand the streamgage network, support solar storm monitoring, expand the Global Seismic Network, improve landslide and sinkhole understanding and response, develop a rapid response capacity for wildfires, and undertake scenario planning for disaster response. Faced with rising expectations for rapid, robust information, in response to these events, the USGS will strengthen its capabilities—both before and after disasters strike—while harnessing new technology and promoting partnerships. Efforts in 2016 will deliver science to support disaster response, provide enhanced situational awareness, provide our Nation with greater resilience to natural hazards, build on investments enacted in 2015, and significantly advance the goals outlined in the USGS Natural Hazards Science Strategy.

Natural Hazards Science for Disaster Response **(+\$6,618,000/+10 FTE)**

Expanding Use of Flood Inundation Mapping and Rapid Deployable Streamgages	(+\$700,000/+4 FTE)
Rapid Response to Volcano Unrest and Eruption, and Associated Hazards	(\$0/0 FTE)
Earthquake Early Warning and Rapid Event Characterization	(-\$1,502,000/-2 FTE)
GSN Primary Sensor Deployment	(+\$4,920,000/+2 FTE)
Improved Geomagnetic Monitoring to Support Space Weather Nowcasting	(+\$1,700,000/+3 FTE)
Landslide Response	(+\$500,000/+2 FTE)
Rapid Wildfire Science Response	(+\$500,000/+2 FTE)
Building Sinkhole Hazard Response Capability	(+\$200,000/0 FTE)
Disaster Scenarios and Strategic Science Crisis Response	(+\$300,000/+1 FTE)
Precision Monitoring for Non-Seismic Fault Activity	(-\$700,000/-2 FTE)

Program Performance

Expanding Use of Flood Inundation Mapping and Rapid Deployable Streamgages **(+\$700,000/+4 FTE)**

Groundwater and Streamflow Information Program **(+\$700,000/+4 FTE)**

Effective flood-damage mitigation and flood response requires timely, reliable, and real-time information about river levels, flood flows, and geospatial understanding of the extent and timing of potential flood inundation, all of which the USGS is uniquely positioned to provide. From its creation, the former National Streamflow Information Program (now a component of the Groundwater and Streamflow Information Program) included provisions devoted to improve streamflow data delivery and to provide the data in context tailored to specific events and rapid assessment of streamflow conditions. The USGS, the National Oceanic and Atmospheric Administration, the Federal Emergency Management Agency, and the U.S. Army Corps of Engineers are engaged in joint efforts to standardize new flood-inundation mapping processes, enabling emergency management officials at the Federal, State, tribal, and local level to assess, in both real time and in advance, the threat that flooding poses to public facilities, businesses, and homes. For the first time, emergency officials and the general public can know the forecasted height of floodwaters, and can see on a street-by-street basis, the expected extent of a flood hours or even days before it occurs. However, these maps require extensive field data-collection to develop and calibrate. The requested increase would be used to develop and pilot such procedures and to expand the present library of flood-inundation maps based on present technologies.

Useful real-time information about flood levels can be acquired at existing USGS streamgages; however, there is an urgent need to develop the means for providing the same information to flood-threatened communities that lack a permanent USGS streamgage. Rapid-deployable streamgages (RDS) can be installed, rated, and ready to broadcast data within hours to monitor flood heights and approximate flood flows, especially as the water levels approach elevations requiring careful management of reservoir releases or close scrutiny of levee performance. The requested increase would support a focused, expansion to further test and operationalize this new technology. Implemented together, the flood-

inundation and RDS systems will provide crucial flood data needed to help manage flood response activities.

Rapid Response to Volcano Unrest and Eruption, and Associated Hazards (\$0/0 FTE)

Volcano Hazards Program (\$0/0 FTE)

Roughly half of the Nation's 169 volcanoes are potentially dangerous because of the manner in which they erupt and the communities within their reach. Volcano monitoring, early warning systems, and pre-crisis planning are crucial in reducing risks to aviation, communities, and infrastructure.

While no additional funding is requested in 2016, the VHP will continue 2015 investments and work to expand the development of ash-fall modeling that would give responders and the public information on when and how much ash will accumulate by continuing to expand the use of satellite-based remote sensing and infrasound detection of eruptive activity, particularly at remote volcanoes lacking ground-based instrumentation. This effort is in partnership with the National Weather Service, Air Force Weather Agency, and NASA for rapid and coordinated response to ash forming eruptions and improved delineation of ash clouds and ash fall forecasts. The VHP will continue to upgrade and improve the monitoring network at Mount Hood, a very-high-threat volcano, including installation of three more seismic monitoring stations near its summit. Mt. Hood is near Portland, OR, and is a very-high-threat ash-producing volcano.

The VHP will grow and improve the Nation's volcano monitoring infrastructure (NVEWS) and begin efforts to install a real-time monitoring network at Glacier Peak, 70 miles northeast of Seattle, WA, with installation of ground-based instruments anticipated in 2015, and additional installations in 2016. The VHP will also complete the high-resolution lidar (3DEP) survey of Glacier Peak in support of ongoing geologic field investigations and preparation of a new geologic map of the volcano and hazard assessment. The VHP will establish permits for modern monitoring network to be installed at this volcano over the next four years. The VHP also plans to improve monitoring networks at Baker in Washington, and at Mt. Shasta and Lassen Peak in California. The VHP will repair monitoring networks on two High-Threat Alaskan volcanoes that failed due to deferred maintenance and will repair failed monitoring networks on high-threat volcanoes in the Commonwealth of the Northern Mariana Islands.

The VHP will continue long-term efforts including restoring monitoring networks on high-threat Alaskan volcanoes and redesigning networks for improved performance where possible; geologic investigations at Glacier Peak in support of a new hazard assessment; geologic investigations leading to a new hazard assessment for Mt. Shasta, a very-high-threat volcano in California; prioritizing new mapping projects in support of volcanic hazards assessments focused on very-high-threat and high-threat volcanoes; and establishing new criteria for USGS volcano hazards assessments and delivery of hazard information in digital form that is easily accessible by end users.

Earthquake Early Warning and Rapid Event Characterization (-\$1,502,000/-2 FTE)

Earthquake Hazards Program (-\$1,502,000/-2 FTE)

Rapid response for earthquakes and tsunamis requires improvements to the capabilities of USGS monitoring networks. These networks improve public safety and better serve the needs of decisionmakers by supporting emergency response, including the protection of critical infrastructure. The goal is to implement an earthquake early warning system along the U.S. west coast. The system will be similar to the one that has been operating successfully in Japan since 2008, and performed successfully in the 2011 M9 Tohoku earthquake. The USGS system will eventually extend to incorporate real-time deformation data from existing Global Positioning System (GPS) networks.

USGS R&D efforts in earthquake early warning (EEW) began in 2004, and a pre-prototype EEW system called *ShakeAlert* has been operating in California since January 2012. This system, which is not yet public but serves dozens of test users, was made possible by recent investments in the California Integrated Seismic Network within the USGS Advanced National Seismic System (ANSS). The USGS used American Recovery and Reinvestment Act funding to upgrade seismic and GPS networks in the State, homeland security (UASI) funds were used to upgrade the seismic network in southern California, and the Gordon and Betty Moore Foundation provided research funding to USGS partner universities. These investments have enabled earthquake detection and evaluation within seconds in some parts of the State.

Before public warnings can be issued routinely, the current *ShakeAlert* test system must meet quality, speed and reliability standards. Those standards include having enough sensors to ensure coverage near earthquake sources. Currently there are not enough ANSS sensors to provide fast and reliable alerts uniformly across the U.S. west coast. Although the Los Angeles and San Francisco Bay areas have better sensor coverage than other parts of California, it is estimated that several hundred additional stations are needed to cover all of the earthquake source regions. The USGS will work with partners, including State partners and private-sector utilities, to improve the monitoring of critical pipelines, power, and communications infrastructure systems that cross major faults.

In 2015, Congress enacted an increase of \$5.0 million to the USGS, “to transition the earthquake early warning demonstration project into an operational capability on the west coast.” These funds will be used to further the ShakeAlert development effort, including the expansion of seismic network coverage that is needed to ensure accurate earthquake alerts and the integration of real-time GPS data. In 2016, at the requested funding level, USGS will work with the partners to further the development effort, with the goal of implementing a limited public warning system by 2018. These efforts will also serve to improve the ANSS as a tool to support emergency management and response by leveraging existing investments into new capabilities, including implementing and integrating response capabilities, partnering with end users to create the products they need, and building the support structure for rapid emergency response. The request for 2016 will support operational costs, providing a Federal cost share for the program. The USGS will continue to work with State partners in 2015 to identify opportunities for cost sharing agreements to support the system in their states.

GSN Primary Sensor Deployment (+\$4,920,000/+2 FTE)

Global Seismographic Network (+\$4,920,000/+2 FTE)

The Global Seismographic Network (GSN) provides high-quality seismic data needed for earthquake alerts and situational awareness products, tsunami warnings, national security (through nuclear test ban treaty verification and research), hazard assessments and earthquake loss reduction, as well as research on earthquake sources and the structure and dynamics of the Earth. The network, which the USGS jointly supports with the National Science Foundation, operating through the IRIS Consortium of universities, currently consists of more than 150 globally distributed seismic stations, installed over two decades. Network operation is accomplished in cooperation with domestic and international partners who may provide facilities to shelter the instruments, and personnel to oversee the security and operation of each station. Because of its real-time data delivery, the GSN has become a critical element of USGS hazard alerting activities, as well as of the tsunami warning system operated by the National Weather Service of NOAA.

In 2012, Congress provided \$5.7 million to the Department of Energy's (DOE) National Nuclear Security Agency for the replacement of aging GSN sensors. The DOE subsequently transferred most of those funds to the USGS for the development and purchase of new borehole seismic sensors. However, under the agreement with the DOE, all of the funds were specified for procurement of the new sensors and none for installation or site improvements. Besides needing installation, one-fourth of the GSN's seismic station sites also need vault repairs to improve data quality. Until the aging sensors are replaced and vaults repaired, GSN data quality will continue to decline—as the borehole sensors fail, they are replaced by noisier surface sensors—which slowly erodes the capability of the network. Because GSN data are used for earthquake alerting (USGS), tsunami warning (NOAA), nuclear treaty verification research (DOE, DOD) and basic research on the Earth (NSF), there are many stakeholders who rely on, and have a vested interest in, the network and are anxiously awaiting this final stage of its upgrade. The requested increase covers the installation of the DOE-funded borehole sensors and repairs to 25 vaults. The resulting improvements will help ensure that the Global Seismographic Network (GSN) remains the core global system for earthquake and tsunami monitoring, nuclear treaty research and verification, Earth science and research and education.

Improved Geomagnetic Monitoring to Support Space Weather Nowcasting (+\$1,700,000/+3 FTE)

Geomagnetism Program (+\$1,700,000/+3 FTE)

Large magnetic storms (solar flares) represent a potential hazard for the activities and infrastructure of our modern, technologically based society, particularly due to impacts to the electrical grid. A recent study sponsored by the National Academy of Sciences estimated that the largest storm could have an economic impact of one to two trillion dollars on the United States economy. The long-term monitoring and real-time reporting of geomagnetic storms that is provided by USGS geomagnetic observatories has significant potential to advance space weather impact forecasting and research. The two most needed enhancements are in electrical field (E-field) monitoring—the direct measurement of currents in the Earth's crust—and the gathering and integration of existing global magnetic field data.

Electrical currents are induced in the Earth's crust by geomagnetic storms, which can in turn induce currents in the electric power grid that can cause the grid's massive transformers to overheat and fail or burn. Routine collection of E-field measurements are important for modeling the hazardous currents that are induced in the grid, and for assessing compliance by the electrical power industry with a recent ruling by the Federal Energy Regulatory Commission.

There is also tremendous potential represented in the global magnetic field data collected by other countries, but acquiring and managing these data and bringing the data collection efforts of many countries into the 21st century has been essentially an unfunded, volunteer effort. The interagency National Space Weather Program has given the USGS the mandate to acquire these data, and this initiative would provide the funding needed to do so. Support for one full-time technician with a travel and equipment budget could have a significant impact on global data availability. The return on that investment would be compounded in terms of both operations and research.

The USGS proposes the following investments to provide enhanced monitoring of geomagnetic- and E-field activity at ground-level:

- Expanded monitoring: Improve magnetic and electrical field monitoring by installing new observatories and variometer stations in the continental U.S., adding a Wake Island and South Pole observatory, providing support for the existing Samoan observatory, and monitoring the crustal electric field at every observatory.
- E-field monitoring: Begin a national project for detailed geographic and depth-dependent mapping of U.S.-regional lithospheric electrical conductivity, based upon magneto-telluric (MT) methods that exploit known geological structures, the existing USGS magnetic observatory network, and the network expansion proposed above.
- INTERMAGNET: Work in collaboration with academic and government institutes worldwide to integrate global observatory data with statistical and dynamical models of the magnetosphere and ionosphere to improve regional predictions of hazardous geomagnetic-field activity.
- Scenario testing: Work in collaboration with electric-power companies, the oil and gas drilling industry and the US Air Force to compile information on magnetic-storm effects and make assessments of geomagnetic hazard vulnerability and risk to technological systems and continuity of operations.

The result of these investments will be a national capability for mapping time-dependent geomagnetic hazards for assessing national space weather vulnerability and risk, with the potential for significantly improving forecasts of space weather and its impacts.

Landslide Response

(+\$500,000/+2 FTE)

Landslide Hazards Program

(+\$500,000/+2 FTE)

As the population moving into potentially hazardous areas grows, the overall exposure to landslide impacts rises. Changing land-use patterns and increasing wildfire frequency also contribute to an increase

in the exposure to landslide hazards. Recent landslide disasters in Colorado and Washington are stark reminders that USGS science is needed to assist State and local agencies in response efforts and to provide assistance, assess hazards, and alleviate impacts from landslides. The requested increase would build on investments in 2014 that are being used to expand post-wildfire debris flow hazard assessments and grow capability to respond to landslide crises. The USGS product for situational awareness for post-fire debris flows is comprised of two components: debris-flow hazard assessments and debris-flow warnings issued by NOAA's National Weather Service based on rainfall criteria developed by the USGS. The hazard assessment component has been expanded from southern California to the nine States of the intermountain West. However, additional resources are needed to develop rainfall criteria to support debris-flow early warning for areas beyond southern California, which requires expanded monitoring of post-wildfire landscapes. Additional funding would be used to monitor rainfall and post-fire debris-flow activity in as many as six wildfires in Arizona and Colorado. These data would support two systematic studies of rainfall conditions for post-wildfire debris-flow initiation and would be used to develop early-warning criteria for these two States. Expansion of the capability of the USGS to respond to landslide crises, such as the SR530 landslide near Oso, WA, is also needed. Additional resources would be used to develop an integrated system to monitor landslide movement and processes combining in-situ and remote-sensing observations with topographic and geologic data. This system could be deployed in response to a landslide crises in the first year of development. Results and lessons learned would be documented in a systematic study used to improve the system. Partners include NOAA, Burned Area Emergency Response teams, Federal, State and local emergency management, State geological surveys, and the private sector.

Rapid Wildfire Science Response

(+\$500,000/+2 FTE)

Environments Program

(+\$500,000/+2 FTE)

Wildfires continue to be an expanding natural hazard across the United States that affect human safety, landscape resilience, and infrastructure and often overwhelm effective response capacity. Accurate and timely scientific information is critical to ensure appropriate management response to wildfires and effective investments in stabilization, rehabilitation, and restoration of landscapes immediately after wildfires occur.

Currently, fire management organizations lack information to prioritize burned regions for mitigation activities. These activities focus on post-fire effects on water quality and supply, critical wildlife habitat, invasive species, and ecosystem services such as livestock grazing, timber production, and recreational value. Having this information during a wildfire allows fire managers to employ wildfire suppression strategies that result in long-term resource benefits such as reducing hazardous fuels. Demands for strategic preparation and rapid science delivery during and immediately after wildfires are increasing, and frequently surpass the current capacity for the USGS to adequately provide science for a cohesive wildfire response by Federal, State, tribal, and local organizations.

The requested increase would provide a unique opportunity for the USGS to develop a proactive rapid science response capacity for wildfires. This new capacity represents an integrated landscape-level approach that will bring together scientists from the fields of information technology, water science,

climate dynamics, ecology, geomorphology, remote sensing, risk assessment, and decision analysis. Activities will take place across scientific disciplines to ensure that consistent and comprehensive information and data products are available and that scientists are prepared, qualified, and certified to immediately respond to wildfires.

USGS scientists would develop a set of science response protocols, relevant databases, and monitoring equipment that will be easily deployed when required by wildfire response organizations, especially Federal land management agencies in the Interior and the USFS. This will fill a direct need for the USGS to support Federal wildfire-management policy by providing the scientific information and tools to ensure that fire management response planning and activities are based on the best available science. Further, this new capacity will allow real-time science support elements of the Federal Land Assistance, Management and Enhancement (FLAME) Act related to ensuring appropriate management response to wildfires and determining the most-cost effective means for allocating post-fire response investments.

Building Sinkhole Hazard Response Capability (+\$200,000/0 FTE)

National Cooperative Geologic Mapping Program (+\$200,000/0 FTE)

USGS expertise is repeatedly sought by State and local governments faced with sinkhole hazards. The requested increase would build a partnership with State geological surveys to deliver technical assistance in response to what is a widespread and at times deadly phenomenon. Recent events in Florida and elsewhere have underscored the threat that sinkholes pose in terms of loss of life and property as well as the direct and indirect costs associated with sinkhole formation. The requested increase builds on existing research activities that are making advances in understanding the geologic and hydrologic controls in sinkhole-prone landscapes, known as karst. In order to better inform and support rapid response to sinkhole formation and effective mitigation measures, this new work would focus on the short- and long-term mechanisms that trigger sinkholes, including extreme storm events, prolonged droughts leading to shifts in water management practices as well as ongoing aquifer depletion, and other major changes in water use. This work would increase areas mapped in karstic terrains. The USGS National Landslide Information Center would develop a Web portal and virtual clearinghouse for critical data needed by community planners and emergency managers.

Disaster Scenarios and Strategic Science Crisis Response (+\$300,000/+1 FTE)

Land Change Science (+\$300,000/+1 FTE)

Planning and preparing for hazard events before they strike improves response. In support of pre-event planning and preparation, the USGS will develop fully realized scenarios of disaster events in collaboration with Federal, tribal, State, local and university partners. These scenarios will improve the Nation's resilience to natural hazards, biological epidemics (e.g., epidemic avian influenza), and human triggered disasters (e.g., industrial accidents). These scenarios would apply integrated science across multiple mission areas to the intersection of community decisionmaking and emergency response. The requested increase would both expand scenario generation and fund the science gaps identified through the scenario development process. Science-based scenarios would also be developed during a crisis

response in order to reveal the impacts of alternative response strategies. Scenario development would be undertaken in partnership with the other bureaus within Interior, in consultation with the Landscape Conservation Cooperatives and the Climate Science Centers. This initiative would support a standing Interior capacity for rapidly implementing strategic science working groups, similar to what was done during the Deepwater Horizon Oil Spill disaster.

Precision Monitoring for Non-Seismic Fault Activity (-\$700,000/-2 FTE)

Earthquake Hazards Program (-\$700,000/-2 FTE)

To support higher priority efforts, the USGS will reduce efforts using two techniques for assessing fault-specific earthquake hazard: precision geodesy and active-source seismic profiling. Between the occurrences of large earthquakes, precision geodetic monitoring is used to track non-seismic fault movement. Data from this monitoring helps assess the buildup of energy along a fault, and can affect assessments of earthquake probabilities and large-earthquake recurrence times. Researchers will have to rely on less precise data, such as GPS, for fault-specific assessments. In addition, fault slip and earthquake potential are also assessed through geophysical profiling, especially seismic profiling such as is used in the oil and gas industry. Such capabilities can be used to assess fault-specific earthquake hazard. Without these data, USGS researchers will rely on geologic studies alone, significantly diminishing the understanding of individual fault geometry and slip history.

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Foundations for Land Management

Foundations for Land Management (S in Thousands)			
	2016 President's Budget Program Changes	2016 President's Budget Program Changes - FTE	Page #
Landsat Ground System	24,300	0	C-44
Land Remote Sensing	24,300	0	C-44
Ecosystem Services	1,750	5	C-45
National Ecosystems Framework	450	0	C-46
Environments Program	450	0	C-46
Biological Carbon Sequestration	400	2	C-46
Carbon Sequestration	400	2	C-46
Landscape and Climate Conditions	200	1	C-46
Land Change Science	200	1	C-46
Evaluating Green Infrastructure Investments	250	1	C-47
Energy Resources	250	1	C-47
Enhancing Resilience in Coastal Infrastructure	150	1	C-47
Energy Resources	150	1	C-47
Decision Support Tools	300	0	C-47
Science Synthesis, Analysis and Research Program	300	0	C-47
Big Earth Data	1,100	0	C-48
Data Cube	600	0	C-48
Land Remote Sensing	600	0	C-48
Observations and Measurements	500	0	C-49
Science Synthesis, Analysis and Research Program	500	0	C-49
Landsat Science Products for Climate and Natural Resources Assessments	4,000	2	C-49
Land Remote Sensing	4,000	2	C-49
National Civil Applications Program	-1,000	-5	C-49
Land Remote Sensing	-1,000	-5	C-49
3D Elevation Program	3,709	3	C-50
National Enhancement	1,387	0	C-51
National Geospatial Program	1,387	0	C-51
Alaska Mapping and Map Modernization	1,322	3	C-51
National Geospatial Program	1,322	3	C-51
NHD/Landscape Level Assessments - Chesapeake Bay	500	0	C-51
National Geospatial Program	500	0	C-51
Coastal Lidar	500	0	C-52
National Geospatial Program	500	0	C-52
Great Lakes Fisheries Assessments	250	0	C-52
Fisheries Program	250	0	C-52
Enhanced Cooperative Activities and Urban Waters	717	5	C-53
National Water Quality Program	717	5	C-53
Outer Continental Shelf (OCS) Ecosystems Decisions	300	2	C-54
Environments Program	300	2	C-54
Enhanced Support and Scientists for Tomorrow	2,000	9	C-54
Cooperative Research Units	2,000	9	C-54
Emerging Contaminants and Chemical Mixtures	700	4	C-55
Toxic Substance Hydrology	700	4	C-55
Grand Total	37,826	25	

Justification of 2016 Program Changes

(+\$37,826,000/+25 FTE)

Landsat Ground System	(+\$24,300,000/0 FTE)
Ecosystem Services	(+\$1,750,000/+5 FTE)
Big Earth Data	(+\$1,100,000/0 FTE)
Landsat Science Products for Climate and Natural Resource Assessments	(+\$4,000,000/+2 FTE)
National Civil Applications Program	(-\$1,000,000/-5 FTE)

3D Elevation (3DEP) Program	(+\$3,709,000/+3 FTE)
Great Lakes Fisheries Assessments	(+\$250,000/0 FTE)
Enhanced Cooperative Activities and Urban Waters	(+\$717,000/+5 FTE)
Outer Continental Shelf (OCS) Ecosystems Decisions	(+\$300,000/+2 FTE)
Enhanced Support and Scientists for Tomorrow	(+\$2,000,000/+9 FTE)
Emerging Contaminants and Chemical Mixtures	(+\$700,000/+4 FTE)

Overview

Foundational to all work in landscapes and across the other science themes are data and tools. These data and tools help land and resource managers make informed decisions across the landscape and provide data and information to the public for use in a wide variety of applications. This component expands efforts in lidar collection for 3D elevation, Big Earth Data, development of Landsat science products, ecosystem services, and building the next generation of natural resource scientists and managers.

Continuing the Landsat data stream by initiating the next Landsat ground system for the Thermal Instrument Free Flyer, Landsat 9, and to receive and disseminate Sentinel-2 data is also requested. The Foundations for Land Management component supports implementing the Administration's Open Data Initiative including the Open Water Initiative and Big Earth Data Initiative and makes tools available to communities and government entities which support the Secretary's Mitigation Strategy. These data and their access are required to support Presidential and Secretarial priorities for Building a Landscape Level Understanding of Our Resources.

Program Performance

Landsat Ground System **(+\$24,300,000/0 FTE)**

Land Remote Sensing (+\$24,300,000/0 FTE)

In 2016, the USGS Landsat satellite program is requesting to be funded at \$77.6 million, \$24.3 million above 2015, and includes funding for the maintenance and operation of ground systems and satellite operations. Following extensive study, the Administration has established a plan for a long-term Sustainable Land Imaging program that would extend the four-decade long Landsat series of measurements of the Earth's land surfaces for another two decades. The plan includes three simultaneous activities: a new U.S.-built small satellite with a thermal imager that would launch as soon as feasible, likely in 2019, and would operate either in conjunction with a European Sentinel-2 satellite or with the Landsat 8. The second activity would be the initiation of Landsat 9 as a rebuild of Landsat 8, with a target launch date in early 2023. The third activity is ongoing investment in technology development and systems innovation to reduce risk in next generation missions, including Landsat 10.

The requested increase in 2016 is the first time the USGS will be requesting new funding to build capacity to operate the satellites and collect, archive, process and distribute the data for the Sustainable Land Imaging program. Additional funding requests will be made in future fiscal years. In 2016, the USGS would document the space and ground segment requirements and define specifications for instrument procurements, provide engineering support and technical assistance in the evaluation and

selection of NASA's spacecraft, and in evaluating competitive contract proposals for needed functionality. The USGS will work with NASA to carry out this program. During 2016, the USGS will support NASA mission systems engineering activities, including: space-to-ground interface design, mission operations concept establishment, system component integration definition, development of verification plans for system testing, instrument calibration and validation engineering, support of instrument specifications and requirements definition, and building and evaluating requests for proposals. Finally, the USGS will develop and refine ground-system operations concepts and requirements, perform ground system design activities with an emphasis on the space-to-ground interface, and formulate acquisition strategies for ground network, data processing, and mission operations center (flight systems and software) capabilities.

Additionally in 2016, the USGS would establish the capability to acquire, store, and disseminate data from the European Space Agency's Sentinel-2 satellites (Sentinel 2A is expected to launch in 2015 and Sentinel 2B in 2016). Sentinel-2 data may partially mitigate the risk of losing the eight-day revisit coverage during the period between the decommissioning of Landsat 7 and the launch and operations of a Landsat 8 Rebuild mission.

Ecosystems Services **(+\$1,750,000/+5 FTE)**

National Ecosystems Framework	(+\$450,000/0 FTE)
Biological Carbon Sequestration	(+\$400,000/+2 FTE)
Landscape and Climate Conditions	(+\$200,000/+1 FTE)
Evaluating Green Infrastructure Investments	(+\$250,000/+1 FTE)
Enhancing Resilience in Coastal Infrastructure	(+\$150,000/+1 FTE)
Decision Support Tools	(+\$300,000/0 FTE)

Overview

Land and resource management agencies are increasingly being called upon to understand the effects of their actions in an economic context. Tools, data systems and methods must be developed to achieve a comprehensive understanding of the effects of management actions so that decisions factor in effects on essential environmental benefits. Once these tools are readily available, a formal mechanism or capability to routinely integrate these sources of information into valuation assessment products for land and resource management is needed. Data from multiple monitoring programs are being gathered in EcoINFORMA and other data hubs. Tools are being gathered and developed and their uses standardized. The framework for using those tools and data in decisionmaking contexts are being developed in the National Ecosystem Services Framework and the National Map of Areas of Concern. Information for particular services and stressors such as carbon sequestration and climate are also included in this group of initiatives.

Program Performance

National Ecosystems Framework (+\$450,000/0 FTE)

Environments Program (+\$450,000/0 FTE)

Many services of natural systems are difficult to quantify and therefore are not well considered in decisionmaking. As part of a multiagency assessment of biodiversity and ecosystem services trends, the USGS evaluates data, information, methods, and tools that contribute to the identification, assessment, valuation and use of ecosystem services for policy and management scenarios. In 2015, the USGS will support cross-government leadership, coordination, and studies that focus on integrating ecosystem services assessment into Federal decisionmaking to ensure that benefits to society are fully considered. The 2016 increase will allow the USGS to expand this work. The USGS will assess and fill additional information gaps; test protocols for integrating interagency information in natural resource assessments, and refine interagency practices for applying information in natural resource decisionmaking. This activity contributes to the goals of the Committee on Environment, Natural Resources and Sustainability's Subcommittee on Ecological Systems and other cross-government efforts to develop policy-relevant information on ecosystem services for Federal decisionmaking.

Biological Carbon Sequestration (+\$400,000/+2 FTE)

Carbon Sequestration (+\$400,000/+2 FTE)

The biological carbon sequestration project (LandCarbon) develops tools to analyze how land management actions may be affecting rates of carbon sequestration and other ecosystem services. With additional funding, an existing pilot study with the U.S. Fish and Wildlife Service at the Great Dismal Swamp and Pocosin Lakes National Wildlife Refuges will be expanded to include a study in the Pacific Northwest with the National Park Service (e.g., Olympic National Park), where park managers and other stakeholders can explore alternative management strategies and their potential impact on services such as carbon sequestration, water quality, and biodiversity. Various mitigation scenarios would be explored, including expanding conservation areas and management practices; increasing intensive forest management; and enhancing ecosystem resilience to reduce emissions of carbon dioxide. USGS scientists have developed methods to incorporate Landsat satellite data, collect stakeholder input, and develop models and tools. Interagency agreements and partnerships would be developed to ensure practical uses in day-to-day land management decision making.

Landscape and Climate Conditions (+\$200,000/+1 FTE)

Land Change Science (+\$200,000/+1 FTE)

The Land Change Science (LCS) Program proposes to develop decision-support tools that could be used to help synthesize, visualize, and analyze ecosystem services. The LCS Program would establish methodologies for the assessment and mapping of ecosystem goods and services, and contributing to their valuation, with an emphasis on understanding how they respond to changing landscape and climatic

conditions. These tools translate knowledge gained through a variety of case studies into standardized thematic information, metrics, models, and tools that facilitate improved decisionmaking by natural resource managers. The LCS Program will develop these tools for some of the USGS priority landscapes: the Everglades; San Francisco Bay-Delta; Sage steppe Biome; Colorado River; Puget Sound; Great Lakes; and Chesapeake Bay, which require tools supporting critical management decisions.

Evaluating Green Infrastructure Investments (+\$250,000/+1 FTE)

Energy Resources (+\$250,000/+1 FTE)

The issue of valuing ecosystem services is critical to our Nation's ability to make informed decisions in managing biological, water, and geologic natural resources. Since many ecosystem services are public goods, markets do not provide meaningful indications about the value of these services. The USGS Science and Decisions Center proposes to refine and apply methods of valuing ecosystem services, and evaluating green (nature based) infrastructure investments, especially in Critical Landscapes. These activities focus on methods of applying ecosystem service valuations to inform decisions and will support implementation of the President's Council on Science and Technology Advisors (PCAST) report, "Sustaining Environmental Capital: Protecting Society and the Economy."

Enhancing Resilience in Coastal Infrastructure (+\$150,000/+1 FTE)

Energy Resources (+\$150,000/+1 FTE)

An ecosystem services approach provides an analytical framework for considering the impacts of climate change on services provided by nature as well as manmade. The Science and Decisions Center would use the requested funds to build on a multiagency effort to advance the use of an ecosystem services approach in informing climate change adaptation and decisions. The effort would address issues related to metrics, valuation and institutional factors in order to inform adaptation decisions.

Decision Support Tools (+\$300,000/0 FTE)

Science Synthesis, Analysis, and Research (+\$300,000/0 FTE)

The USGS would use geospatial analyses and synthesis of existing data to identify regional areas of conservation concern, quantified through ecosystems services, to produce a national-scale map highlighting areas of concern. The USGS would identify possible mitigation strategies for each regional area of concern by aligning management actions to policy outlined in law or regulation. Spatial output would be quickly revised to adapt to changing policy concerns. The national-scale map of areas of concern would be a key tool for managers to successfully evaluate at-risk resources and enhance mitigation success. The Wyoming Landscape Conservation Initiative Integrated Assessment (<https://www.wlci.gov/wlciIA/>) provides a multifactorial index identifying watersheds where conservation actions may be more or less-effective; provide building blocks for this approach toward a national scale capability.

Big Earth Data **(+\$1,100,000/0 FTE)**

Data Cube	(+\$600,000/0 FTE)
Observations and Measurements	(+\$500,000/0 FTE)

Overview

The overall goal of the Big Earth Data Initiative (BEDI) is to increase discoverability, accessibility, and usability of high value Earth observations with a particular focus on the Climate Data Initiative and other national science and decisionmaking priorities. In 2013, strategic direction was established by developing the National Plan for Civil Earth Observations, the BEDI Common Framework, and coordinated implementation plans in the USGS, the National Oceanic and Atmospheric Administration (NOAA), and NASA. These plans directly support the Office of Science and Technology Policy's Open Data initiatives on open access to research, the Executive Order and OMB Memorandum 13-13.

An increase of \$2.0 million was enacted in 2015 to support BEDI and Interior-wide coordination efforts, continuing to improve Earth science data discovery and begin efforts to improve accessibility. In 2016, the USGS will continue to lead the USGEO to advance BEDI; implement and populate the USGS Science Data Catalog; apply USGS science data management policies to datasets; implement tools that make it easier for scientists to document their data; integrate individual datasets into larger portal platforms (e.g., the National Geospatial Platform, EcoINFORMA, etc.); and begin to develop Web services for high-priority datasets.

Program Performance

Data Cube	(+\$600,000/0 FTE)
Land Remote Sensing	(+\$600,000/0 FTE)

The Land Remote Sensing (LRS) Program would initiate the development of a pilot study for Landsat data access that would allow the user to define a geographic area of interest, timeframe, and specific parameters derived from the data (e.g., vegetation index) rather than the pre-determined geographic extent and digital numbers currently provided by the USGS. The USGS currently requires users to perform the framing, subsetting, and computing of derived information on their own. The LRS program would prototype these streamlined data access capabilities to demonstrate the utility and efficiency of direct access to "pixels of interest." The prototype capability would allow the USGS to demonstrate the ability to extract and create a multi-temporal remote sensing based value-added product(s), or "data cube(s)," which will be "applications ready" for use in support of scientific analysis.

Observations and Measurements (+\$500,000/0 FTE)

Science Synthesis, Analysis, and Research (+\$500,000/0 FTE)

As a contribution to the Climate Data Initiative, the USGS would develop Web services that will apply the Observations and Measurements Data Model, an International Standards Organization standard, on priority climate data. This effort would provide an application that makes it easier for scientists and others to access, integrate, and apply their information. Leveraging the National Geospatial Platform, this effort would increase the availability of USGS climate data that is required to support more informed landscape level decisionmaking. The USGS has requested an increase in 2016 for the Community Resilience Toolkit. The Toolkit creates a clearinghouse where BEDI data and information could be made available.

Landsat Science Products for Climate and Natural Resources Assessments (+\$4,000,000/+2 FTE)

Land Remote Sensing Program (+\$4,000,000/+2 FTE)

The requested increase will be used to increase the usability and impact of Landsat science products for climate studies and land management. The Interior bureaus rely on Landsat as a data source on wildfires, consumptive water use, land cover change, rangeland status, wildlife habitat, and other Interior responsibilities. Landsat 8 is a \$1.0 billion Federal investment and has improved data quality, particularly for snow- and ice-covered land surfaces, water resources monitoring and resource management. The requested increase would allow the LRS Program to accelerate the development of Landsat-based science information products. The LRS Program has identified a set of Landsat-based science products that will improve applications used by natural resource managers, and will contribute to the international and interagency climate monitoring community's initiative to develop consistent Climate Data Records (CDRs) and related Essential Climate Variables (ECVs). The CDRs are long-term time-series measurements such as surface reflectance that support a variety of ECVs, including measures of fire disturbance, snow cover, permafrost, surface water extent, land cover, and biomass. The CDRs and ECVs will provide an authoritative basis for regional- to continental-scale identification of historical change, monitoring of current conditions, and predicting future scenarios. The requested increase would drive a focus on augmenting computing and online storage resources, generation of CDR and ECV products from the historical archive for the conterminous United States and Alaska, and implementation of enhanced continuation of the CDR and ECV product generation to include near real time processing of current acquisitions and completion of enhanced data access and delivery services.

National Civil Applications Program (-\$1,000,000/-5 FTE)

Land Remote Sensing Program (-\$1,000,000/-5 FTE)

The National Civil Applications Program (NCAP) uses data from classified systems and commercial satellites to investigate climate change and other Earth dynamics, ecosystems, natural hazards, and

manmade disasters (such as wildland fires), and improve land and resources management. In 2016 the Land Remote Sensing Program will begin to decrease lower-priority, outdated, or duplicative functions of the NCAP. The USGS will maintain its civil science leadership of the Civil Applications Committee and assess ways to use classified assets for hazards, environmental, and natural resources applications strategically. In addition, USGS NCAP funding for research will be leveraged to maximize cost-sharing with other agencies. The acquisition, archive, and dissemination of classified remotely sensed data to support science programs of the USGS, Interior, and other Federal civil agencies would be continued.

3D Elevation Program **(+\$3,709,000/+3 FTE)**

National Enhancement	(+\$1,387,000/0 FTE)
Alaska Mapping and Map Modernization	(+\$1,322,000/+3 FTE)
NHD/Landscape Level Assessments – Chesapeake Bay	(+\$500,000/0 FTE)
Coastal Lidar	(+\$500,000/0 FTE)

Overview

Prompted by a growing appreciation for the wide applicability and inherent value of lidar, a USGS-led consortium of Federal agencies commissioned a National Enhanced Elevation Assessment (NEEA) study in 2010 to quantify the costs and benefits of a national lidar program. A 2012 NEEA report documented a substantial return on such an investment, defined five Quality Levels (QL) for elevation data, and recommended an 8-year collection cycle of Quality Level 2 (QL2) lidar data as the optimum balance of benefit and affordability. In response to the study, the USGS–NGP established the 3D Elevation Program (3DEP) in 2013 as the interagency vehicle through which the NEEA recommendations could be realized.

3DEP activity responds to growing needs for high-quality and high-resolution elevation data to capture change in the Nation's natural and constructed features. New and accurate data are constantly in demand to improve aviation safety, understand and mitigate the negative effects of coastal erosion and storm surges, provide infrastructure for Arctic shipping and resource extraction, identify landslide hazard areas, protect biodiversity and habitats, and to support hundreds of other mission critical activities within Interior and other Federal, State, and tribal partners. The 3DEP initiative will systematically collect and make available 3D elevation data using lidar (light detection and ranging) over the United States. Ifsar (Interferometric Synthetic Aperture Radar) data would be collected in Alaska. These data would directly contribute to the Secretary's priorities for Landscape Scale Understanding, improving the lives of Native Americans, WaterSMART, and America's Great Outdoors.

Potential benefits of \$1.2 billion to \$13.0 billion would accrue annually to the Nation from 3DEP data. The current project-by-project Federal approach to acquire these data yields fewer than 10 percent of these benefits. The 3DEP replaces the current approach with a coordinated data acquisition campaign to provide national data coverage and related products and services. This effort would increase the benefits realized from 10 percent to as much as 58 percent. Key activities include: (1) a national Federal and State partnership data acquisition campaign to lower acquisition costs per square mile and to increase data collection coverage from 5–12 percent of the United States annually; (2) increasing the quality of data acquired to benefit a larger number of business needs; and (3) providing application ready products and

services for lidar point-cloud and bare-Earth elevation data and derived products that support the most common business applications.

Program Performance

National Enhancement (+\$1,387,000/0 FTE)

National Geospatial Program (+\$1,387,000/0 FTE)

The USGS would accelerate its collection by 4,140 square miles of QL2 lidar per year over the remaining States, Puerto Rico, and District of Columbia, with expectations to leverage with other State and Federal sources, resulting in 12,420 square miles per year. The requested increase would expand the current coverage rate of data collection from approximately 5 percent of the Nation per year to about 5.5 percent per year.

Additional 3DEP Efforts:	
Columbia River	+\$350,000
Puget Sound	+\$450,000
Chesapeake Bay	+\$500,000

Alaska Mapping and Map Modernization (+\$1,322,000/+3 FTE)

National Geospatial Program (+\$1,322,000/+3 FTE)

The requested increase would enable the USGS to collect 6,100 square miles of new ifsar over Alaska each year, with expectations to leverage those funds from other State and Federal sources up to three times, for a resulting combined 18,300 square miles per year. The requested increase would allow for new tools to integrate elevation data with surface water information, transportation, boundaries, and manmade structures and provide easier access and downloading capabilities, and improved Web services.

NHD/Landscape Level Assessments – Chesapeake Bay (+\$500,000/0 FTE)

National Geospatial Program (+\$500,000/0 FTE)

The USGS would systematically collect and manage high-quality lidar over the eastern shore of the Chesapeake Bay. This 65,000 square mile drainage basin is the largest estuary in the United States and touches six States and the District of Columbia. New and accurate baseline elevation data are required to understand landscape level processes at a parcel and local level scale and to develop strategies that allow for the Bay's sustainable development and management of natural resources. To achieve this objective, the USGS will need to increase its commitment to elevation data collection and management and to the National Hydrographic Dataset. Ongoing Federal and State lidar acquisition partnerships throughout the Chesapeake Bay watershed would be leveraged and expanded.

Coastal Lidar (+\$500,000/0 FTE)

National Geospatial Program (+\$500,000/0 FTE)

The National Geospatial Program would use the requested increase to collect enhanced elevation data using lidar in coastal zones over the United States. New and accurate baseline elevation data is required to understand and mitigate the negative effects of coastal erosion and storm surge, to map existing and potential landslide hazards, and to monitor biomass in a changing world. The 3DEP within the NGP responds to growing needs for high-quality and high resolution topographic data to capture change in the Nation's natural and constructed features and would be used for sea-level rise modeling projects in the Coastal and Marine Geology Program.

Great Lakes Fisheries Assessments (+\$250,000/0 FTE)

Fisheries Program (+\$250,000/0 FTE)

As recognized by the President's Great Lakes Restoration Initiative, the Great Lakes are a key strategic resource and driver of economic vitality that are threatened by multiple stressors that include invasions of exotic mussels and fishes, habitat degradation, and harmful algal blooms. The USGS is hard-pressed to meet the information needs of our regional management partners due to the sheer scope of imposed ecological changes. Spatially comprehensive and resolute information through time is needed about the drivers of changes to deep-water fisheries, coastal ecosystems, and beach health to guide the implementation of effective interventions. The rapid advancement of 21st century tools, technologies, and science presents our best hope for gathering information that matches the scope of the challenges. The USGS proposes to further the use of advanced technologies in the Great Lakes in the following areas:

- Understanding lake-scale implications of invasive mussels for deepwater fish production by understanding how mussels affect biomass and size spectra of lower trophic levels
- Developing a mechanistic understanding of how climate, nutrients, and lake morphology interact to affect harmful algae blooms
- Piloting an early warning system for detection of human pathogens that cause millions of dollars in annual economic losses to the U.S. coastal tourism industry

Long Range Autonomous Underwater Vehicles (LR AUVs) would be used to assess biomass size spectra over large spatial scales to enable extensive estimation of total fish biomass in the Great Lakes. LR AUVs are unmanned and untethered vehicles that help remove the high personnel costs of scientific sampling in very deepwater environments. These platforms are low cost as compared to ships but can be directed as to where, when, and what they sample to full lake or ocean depth. This work will provide new insight into impacts of invasive mussels on Great Lakes fish production, as well as new information that could impact critical annual decisions by fisheries managers. The work will be carried out in collaboration with the Monterey Bay Aquarium Research Institute (MBARI), a privately funded NGO, and the Michigan Technical University (MTU).

Sample Processors (ESP) would provide onsite (in situ) collection and analysis of water samples from the subsurface Great Lakes. The instrument is an electromechanical/fluidic system designed to collect discrete water samples, concentrate microorganisms or particles, and automate application of molecular probes that identify microorganisms and their gene products. The ESP also archives samples so that further analyses may be done after the instrument is recovered from the lake or ocean floor. Specifically, the ESP will be used to automatically monitor phycocyanin concentrations in Great Lakes waters, exploring the role of those organisms in the development of Harmful Algal Blooms (HABS). The recent explosion of HABS in the Great Lakes is linked to significant environmental, economic, and health concerns across the Great Lakes basin and communities.

A pilot project using ESPs offshore from Chicago, IL, beach sites would provide an early warning system for health decisionmaking. Major human health threats are arising from naturally occurring toxicants and anthropogenically derived environmental contaminants at those very heavily used public beaches.

Enhanced Cooperative Activities and Urban Waters (+\$717,000/+5 FTE)

National Water Quality Program (+\$717,000/+5 FTE)

The requested increase for the National Water Quality Program would enhance cooperative activities related to energy and water; enhance local cooperative studies related to regional drought; enhance data collection related to tribal water issues. The National Water Quality Program would be able to support monitoring streamgages, groundwater levels, and water-quality observations at 2015 levels.

In addition, the National Water Quality Program would fund activities in the Urban Waters Federal Partnership (UWFP). Urban waters in rivers and lakes commonly have degraded water quality that is not suitable for drinking, swimming, or fishing. Contaminants, habitat destruction, and increasing streamflow flashiness (rate of change of stream discharge) resulting from urban development have been associated with the disruption of biological communities, particularly the loss of sensitive biota. Every stream is connected downstream to other water bodies, and inputs of contaminants and/or sediments to streams can cause degradation downstream with adverse effects on biological communities and on economically valuable resources, such as fisheries and tourism. In addition, stormwater runoff is a major problem in urban areas, increasing contaminant loads in local streams and rivers and costing cities millions of dollars to mitigate. Economic revitalization and economic development through urban water restoration is an important component of the UWFP. Through the National Water Quality Program, localities and States are engaged as they are concerned with similar issues to better protect their urban watersheds, resulting in jointly planned and jointly funded activities that align with and leverage the national goals for the programs. Funding would provide new streamgages or upgrade existing streamgages; enhance water quality, water quantity, and habitat monitoring; support studies to understand the use of nature based infrastructure to reduce the impact of stormwater runoff; and to develop modeling tools to simulate water quality, biological conditions, and to describe stream health. New multi-stressor models would provide insight on how management actions can improve water quality, flow characteristics, habitat, and biological conditions.

Outer Continental Shelf (OCS) Ecosystems Decisions (+\$300,000/+2 FTE)

Environments Program

(+\$300,000/+2 FTE)

The coastal and offshore environment is increasingly being seen as an opportunity for renewable resource development, substantially ramping up the need for biological science to support decision needs of Interior bureaus. USGS research has a unique role in marine waters to support, in particular, BOEM mission-critical research priorities focused on Interior trust resources (sea birds, marine mammals, aquatic ecosystems) and potential impacts of energy development on wildlife, their habitats, and the coastal ecosystem resilience. Continued long-term research, supported by short-term focused research, is needed across multiple disciplines. This includes investigations as diverse as predicting the response of polar bears and walrus to sea ice declines, mapping of seabird abundance and distribution, understanding benthic resources and microbial ecology, determining acoustic effects on marine animals, and charting deep sea coral distributions and function. The proposed increase would provide the USGS with resources to develop a comprehensive geographic dataset on the pelagic distribution and movements of seabirds in the U.S. Pacific Ocean using methodology developed for the Atlantic, to design long-term research and monitoring strategies to understand ecosystem changes in relation to wildlife resources, and to expand investigations on offshore wind energy and wildlife on the Atlantic coast. Research will be coordinated closely with BOEM to identify the most effective science projects. This will result in improved study planning and implementation mechanisms to enhance the Outer Continental Shelf (OCS) program results overall.

Enhanced Support and Scientists for Tomorrow (+\$2,000,000/+9 FTE)

Cooperative Research Units

(+\$2,000,000/+9 FTE)

Youth Scientists for Tomorrow— The Cooperative Research Units (CRU) involvement in youth programs has traditionally been focused on graduate education. CRU will apply the requested increase to implement two initiatives that provide undergraduate students, from groups under-represented in the conservation workforce, with mentoring and hands-on experience designed as a pathway to Interior recruitment. The CRU Program will use its existing cooperative network to work with Interior partners to improve and increase youth involvement in Interior science and resources management.

- The first initiative will be in collaboration with the Doris Duke Foundation. Undergraduate students at five CRU host universities will be mentored by CRU supported graduate students and research scientists. Students will attend leadership training programs, work with scientists and graduate students on selected research projects, and complete paid internships with local, State, Federal, and tribal agencies or Nongovernmental Organizations (NGOs). Increase will be used to support internships and staff time.
- The second initiative will be in collaboration with the FWS. Funding will support graduate and undergraduate students conducting research on National Wildlife Refuges as a means to develop and recruit Federal scientists and natural resource managers. Students will address research topics of importance to the USGS and the National Wildlife Refuge System including landscape connectivity, fish and wildlife health, human uses, and wildlife population management.

The proposed increase would enhance opportunities to provide advanced scientific training and professional mentorship leading to Masters and PhD. Funding will focus on the training of students on contemporary research topics including the application of science and analytical tools for decisionmaking, energy development, fire ecology, ecosystem sustainability, threatened and endangered species, invasive species, and water quality and use. Student support includes safety training and equipment in addition to financial and research support. Implementation will be through enhancement of existing partnerships with universities and NGOs serving Native American and Hispanic communities and other underrepresented groups.

Science, technology, engineering, and mathematics (STEM) - The CRU program engages in scientific research, technical assistance to natural resource managers, and training of future natural resource professionals. The CRU will apply the requested increase towards training, mentoring, and support of STEM graduate and post-doctoral associates from under-represented groups. Unit scientists are particularly poised to advise and mentor STEM graduate students, and the requested increase will expand capacity and provide focus on minority recruitment. Students will address thematic science of importance to the USGS and Interior bureaus including the application of science and analytical tools for decisionmaking, energy development, fire ecology, ecosystem sustainability, threatened and endangered species, invasive species, and water quality and use.

Emerging Contaminants and Chemical Mixtures (+\$700,000/+4 FTE)

Toxic Substances Hydrology Program (+\$700,000/ +4 FTE)

The requested increase will support a national assessment of contaminant mixtures at stream locations affected by combinations of contaminant sources, including wastewater treatment plant discharges, industrial discharges, landfill leachate, crop agriculture, and animal agriculture. Samples of stream waters and sediments have been collected in 2014, will be analyzed in 2015, and using USGS analytical capabilities for approximately 800 common and emerging chemical contaminants. In addition, the USGS will employ extensive forensic analyses to identify unknown contaminants in these environmental samples. This project is being coordinated with the EPA and their capability to conduct *in vitro* bioassays of environmental samples. The information produced by these activities can provide a basis for toxicity testing for chemical mixtures and low-level exposures; help improve understanding groups of contaminant effects on organism health; and identify unidentified contaminants of emerging concern based their actual presence and their levels in the environment. A pilot project, completed in 2014, tested chemical mixtures and forensic methods in stream waters at a limited number of stream sites; scientists from the EPA National Exposure Research Lab, National Risk Management Research Lab, and National Health and Environmental Effects Research Laboratory are testing the same water samples for biological activity using bioassays. The expanded effort will enable interpretations of the existing chemical and bioassay data.

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Climate Resilience

Climate Resilience (\$ in Thousands)			
	2016 President's Budget Program Changes	2016 President's Budget Program Changes - FTE	Page #
Carbon Sequestration	8,700	21	C-58
Biological Carbon Monitoring and Tools	6,500	15	C-58
Carbon Sequestration	6,500	15	C-58
Biological Carbon Sequestration Land Management	200	1	C-58
Carbon Sequestration	200	1	C-58
Grand Challenge: Carbon Inventory and Decision Support Tools	2,000	5	C-58
Carbon Sequestration	2,000	5	C-58
Adaptation and Resilience	6,818	13	C-60
Climate Adaptation and Resiliency - Vulnerability Assessment Database	800	0	C-60
National Climate Change and Wildlife Science Center/DOI Climate Science Centers (CSCs)	800	0	C-60
Emerging Science Needs	2,268	6	C-60
Climate Research & Development	2,268	6	C-60
Grand Challenge: Climate and Land Cover Change Effects	1,500	3	C-60
Climate Research & Development	1,500	3	C-60
Interagency Coordination	2,250	4	C-60
National Climate Change and Wildlife Science Center/DOI Climate Science Centers (CSCs)	2,250	4	C-60
Community Resilience and Partnerships	16,500	2	C-62
Community Resilience Toolkit	11,000	0	C-63
National Geospatial Program	11,000	0	C-63
Translational Science Grants	3,000	2	C-65
National Climate Change and Wildlife Science Center/DOI Climate Science Centers (CSCs)	3,000	2	C-65
Tribal Climate Science Partnerships	2,500	0	C-66
National Climate Change and Wildlife Science Center/DOI Climate Science Centers (CSCs)	2,500	0	C-66
Grand Total	32,018	36	

Justification of 2016 Program Changes

(+\$32,018,000/+36 FTE)

Carbon Sequestration	(+\$8,700,000/+21 FTE)
Adaptation and Resilience	(+\$6,818,000/+13 FTE)
Community Resilience and Partnerships	(+\$16,500,000/+2 FTE)

Overview

The effects of changing climate are most profound in the frequency and intensity of extreme weather events. USGS scientists are conducting science to understand the impacts of these events and are building tools for communities and land and resource managers to use in building resilience to and adapting after these events. In 2016, the USGS will expand partnerships and collaboration, translate science into practical application-ready solutions, initiate new science activities in emerging areas such as integrating long historical records into climate modeling, establish a national carbon inventory and tracking system, and building a clearinghouse of data, tools, shared applications, and best practices for use by resource managers, decisionmakers, and the public.

Program Performance**Carbon Sequestration** **(+8,700,000/+21 FTE)**

Biological Carbon Monitoring and Tools	(+\$6,500,000/+15 FTE)
Biological Carbon Sequestration Land Management	(+\$200,000/+1 FTE)
Grand Challenge: Carbon Inventory and Decision Support Tools	(+\$2,000,000/+5 FTE)

Program Performance

Biologic carbon sequestration refers to both natural and deliberate processes by which carbon dioxide (CO₂) is removed from the atmosphere and stored as carbon in vegetation, soils and sediments. The President's Climate Action Plan (June 2013) notes the importance of biological carbon sequestration: "America's ecosystems are critical to our Nation's economy and the lives and health of our citizens. These natural resources can also help ameliorate the impacts of climate change, if they are properly protected." Congress, too, recognized its importance, mandating a national inventory of carbon sequestration and greenhouse gas fluxes under section 712 of the Energy Independence and Security Act of 2007.

Management of carbon stored in biological reservoirs has importance for both mitigation of climate change and for adaptation to such changes. The USGS has developed methods for evaluating biological carbon storage at a regional scale; however, these methods were developed for a broad national assessment and need refinement to be applicable to a specific site or decision. The development of an approach that identifies the scientific basis for carbon management decisions (such as ecosystem restoration) and a process to incorporate science information directly in management planning will be critical to ensure effective use of scientific results. While management activities have implications for carbon management, informed decisions are often hampered by the lack of tools for understanding or incorporating science into decisionmaking. The USGS will work directly with decisionmakers to understand their needs and timelines, and develop and apply refined geospatial models and estimation techniques for biological carbon sequestration, as well as decision-support tools supporting carbon management objectives and the tradeoffs involved with other ecosystem services. In 2016, the biological carbon sequestration project would develop methodologies for updating critical input data, streamline biogeochemical models for calculating carbon stocks and sequestration, and engage an interdisciplinary team of scientists for evaluating and documenting results. The project would also conduct research and development for reducing carbon stock and sequestration uncertainties. Further research into quantifying and reducing uncertainties in estimating carbon stocks and sequestration is needed to incorporate information on carbon stocks and sequestration into land management decisions and national and global policy development.

The biological carbon sequestration national assessment will be completed in 2015 for all 50 States. In 2016, the biological carbon sequestration project would initiate a grand challenge leveraging this initial assessment to implement a carbon inventory and tracking system for carbon stocks and flows on all Interior lands, complete with online tools to support regional natural resource decisionmaking.

Interior can be a leader in the Federal Government in establishing a national carbon inventory and tracking system. Interior manages one-fifth of the Nation's lands; on those lands, the BIA, BLM, FWS, NPS, and Office of Wildland Fire have a shared need to incorporate into their resource management decisions both current science and regional stakeholders' values for uses (ecosystem services) of the land, ranging from recreation to carbon management. These science and stakeholder inputs are needed to support resource managers in planning infrastructure investments for resilience to extreme weather and changing climate, in forest planning and supporting Tribal forest management, and in assessing the impacts of activities such as wildfire fuels treatments.

The implementation of the *Priority Agenda on Enhancing the Climate Resilience of America's Natural Resources*

(www.whitehouse.gov/sites/default/files/docs/enhancing_climate_resilience_of_americas_natural_resources.pdf) presents an opportunity to broaden and accelerate existing work to support these goals. Interior proposes to leverage multiple bureaus' expertise and authorities to:

- Improve inventory, assessment, projection, and monitoring systems for important carbon sinks.
- Develop estimates of baseline carbon stocks and trends to inform Federal natural resources management.
- Assess, restore, and protect coastal habitats to understand and enhance the storage of blue carbon.
- Incorporate carbon into natural resource management practices.

These efforts will be integrated into accelerated work on quantifying ecosystem services for Federal lands. The results will be used to enhance existing online decision support tools with new content, building on the USGS LandCarbon Viewer to develop a comprehensive resource for managers on the ground. Work will be conducted jointly with Interior's land management agencies (FWS, BLM, BIA, and NPS) to insure that results are readily incorporated into management decisions.

Interior and the US Department of Agriculture (USDA) share many resource management challenges and opportunities, and manage many acres of adjoining lands. Both Departments seek to collaborate on inventorying and monitoring carbon stocks, supporting routine annual updates, developing policies for carbon management on both Departments' lands, and developing mutually reinforcing carbon management and landscape resilience approaches with managers of non-Federal lands. In 2016, working with USDA, the USGS will integrate USDA's expertise in the economic drivers of land conversion and short-term predictions for agricultural and forest lands, with USGS expertise in long-term land and climate change, satellite-based assessment of land characteristics, and non-market drivers of change. The collaboration would support the development of varied long-term management scenarios incorporating a range of policies and climate conditions. This would increase the capacity of both Departments' land management bureaus to assess the impacts of potential actions on carbon sequestration, and improve the characterization of uncertainties.

Adaptation and Resilience**(+\$6,818,000/+13 FTE)**

Climate Adaptation and Resiliency - Vulnerability Assessment Database	(+\$800,000/0 FTE)
Emerging Science Needs	(+2,268,000/+6 FTE)
Grand Challenge: Climate and Land Cover Change Effects	(+1,500,000/+3 FTE)
Interagency Coordination	(+2,250,000/+4 FTE)

Program Performance

Climate change requires the Nation to prepare for an increasingly wide range of temperature and precipitation patterns, including longer and more intense droughts, heat waves and other climate-related environmental change. Adaptation and resilience planning are key components to help our Nation and economy thrive in the face of climate challenges that could affect our infrastructure, food supply and physical safety. Examples of adaptation and resilience measures include using water resources more efficiently; adapting building codes to future climate conditions and extreme weather events; building flood defenses; and developing drought and other weather tolerant crops. In order for decisionmakers and industry to know where to focus their efforts, they must first know which climate change issues are most pressing.

In early 2013, Interior released a policy that requires Interior bureaus and offices to incorporate climate adaptation into policies, programs, planning, and operations. Identifying which species, ecosystems, and regions are likely to experience negative effects from climate change is a crucial initial step in building a climate adaptation program. Many Federal, State, tribal and other entities are conducting vulnerability assessments. These entities need to be able to easily access the findings of completed or ongoing assessments learn from existing methods and data to develop new studies, and combine results to provide larger and more meaningful conclusions. In 2016, the USGS would work with an existing interagency/State coordination group and tribes to continue development of a public cross-agency database and field guide to vulnerability assessments. This project would support Interior and other agencies in establishing standards and best practices, tracking progress for such assessments, and strategically prioritizing adaptive management actions.

Assuring that Federal, State, and other scientific activities are efficiently and effectively devoted to high-priority needs requires an increased level of coordination. The requested increase would allow the USGS to develop and implement the technical means to track relevant climate change adaptation-science across Federal agencies and ensure the availability of this information in a Web accessible format at the regional and national scale. Additionally, the USGS Climate Science Centers (CSCs) would continue to work with regional partners to identify common priorities and develop multiagency strategies that ensure coordinated implementation of public science investments to target the most critical management needs. This cross-agency dialogue convened by the CSCs represents a critical component of an effective and efficient Federal response to the climate science needs of managers. Investment in better coordination allows the USGS to better leverage the capacity and expertise of existing institutions, eliminate redundancy, make maximum use of existing data, and better support the needs of decisionmakers.

Another important step in climate adaptation and resiliency is ability to provide identification and documentation for long-term patterns of drought, storms, and other hydrologic events that affect coasts, urban areas, agriculture and other sectors of our Nation. Instrumental monitoring of climate variables such as temperature and precipitation spans only the last century or so; it is critical to integrate the data with fossil and chemical indicators of past climate to understand the magnitude, frequency, spatial impacts, and drivers of droughts and megadroughts (events that lasted decades). The requested increase would allow the USGS to expand a research effort begun in 2015 to document historical baseline levels of variability in water resources across the United States, providing context and setting expectations for modern-day patterns of droughts, storms, and other hydrologic events that affect coasts, urban areas, agriculture, and other sectors in our Nation. A high concentration of the U.S. population lives along the Nation's coastline; therefore, rising sea level poses significant impacts on society, infrastructure, and coastal habitats that serve as buffers from storm surges and severe weather events. An increasing science need is to improve the ability to accurately forecast rates and magnitudes of future sea level rise. The requested increase would allow the USGS to conduct research to develop consistent methods to measure the amount of water contained in alpine glaciers. This research would improve understanding of the potential contributions of melting glaciers and ice sheets to sea level.

Land use and land cover changes cause the boundaries between wet and dry regions to shift, altering regional climate patterns and vulnerability to droughts and floods. As regional resource managers plan future alterations or restorations of the landscape, those plans could be better supported by science that integrates long historical records of land change with modern Landsat satellite-based records of land change, and integrates these records into climate modeling efforts. Scientists and resource managers would benefit from a better representation of historical and modern-day water bodies, wetlands, and other hydrologic features in models. Important steps to provide this information have already started on the Florida peninsula, the proposed funding increase would allow the USGS to expand their efforts to include the Upper Colorado Basin. Likewise, water supply, demand, and drought are important issues in the Colorado River Basin, and the relative controls of climate variability versus human modification of the landscape on water availability are poorly known. Changes in fire frequency, arroyo cutting, and hydrology have been observed since the mid-19th century, and regional climate simulations that compare outcomes using pre-settlement and present-day land cover would clarify how such changes have influenced climate and the hydrologic system. The proposed increase would allow USGS researchers to develop pre-settlement and modern land cover datasets in a consistent format for input to regional climate sensitivity experiments. The datasets will be used in a regional climate model simulation to conduct paired pre-settlement and present-day simulations. Ultimately, researchers would work with resource managers to couple model outputs with hydrologic and ecological models to support proper management and planning needs.

Community Resilience and Partnerships **+\$16,500,000/+2 FTE**

Community Resilience Toolkit	(+\$11,000,000/0 FTE)
Translational Science Grants	(+\$3,000,000/+2 FTE)
Tribal Climate Science Partnerships	(+\$2,500,000/0 FTE)

Overview

Communities across the Nation face growing environmental challenges from natural hazards such as drought, floods, storms, and wildfires. The Community Resilience Toolkit (Toolkit) will improve community resilience by providing tools that help Federal, State, local and tribal governments understand, respond to climate and related environmental changes, and adapt their planning to maximize economic sustainability to these changes. Data include foundational and real-time data such as rainfall and tools include flood inundation and storm surge modeling. The use of these data and tools would improve community resilience, economic sustainability, and reduce long-term economic and human impacts of extreme storm events and natural disasters.

Water resource management across sectors ranging from energy and manufacturing to agriculture and drinking water in the 21st century require access to open and accessible water data. Another tool in the Toolkit will be to integrate water data into the toolkit and help the USGS participate in a new multi-agency Open Water Data Initiative. The 2016 budget request would allow water data that is fragmented among multiple bureaus and not readily accessible, into a connected, national water data framework on a geospatial platform. The Open Water Data Initiative will leverage existing partnerships and infrastructure to allow for greater data accessibility and better tools solution development.

The USGS has requested an increase in 2016 for the Community Resilience Toolkit. The Toolkit creates a clearinghouse where Big Earth Data Initiative (BEDI) data and other information could be made available. In addition the USGS would develop Web services that will apply the Observations and Measurements Data Model, an International Standards Organization standard, on priority climate data which would contribute to the Climate Data Initiative. This effort would provide an application that makes it easier for scientists and others to access, integrate, and apply their information. Leveraging the National Geospatial Platform, this effort would increase the availability of USGS scientific data that is required to support more informed landscape level decisionmaking.

These data and tools are resources that governors, mayors, county executives, tribal leaders and citizens can use to inform decisions and demonstrate how to best protect their communities by investing in more resilient infrastructure, updating building codes, adjusting the way they manage natural resources, and planning for rapid recovery from extreme weather events. The Toolkit would be a national clearinghouse for these data and tools. This clearinghouse is also a place where, scientists and community leaders can share their lessons learned and best practices as they develop innovative solutions in their own back yards.

The Toolkit creates the clearinghouse where other 2016 USGS requests could be available, such as: Big Earth Data and Open Water Data Initiative.

Program Performance

By providing competitive grant and agreement awards through the Federal Geographic Data Committee to other agencies, State, local and tribal governments, and non-government organization partners, the USGS would support the work of all Toolkit partners to develop a number of datasets and tools to ensure the long term sustainability of the Toolkit. This would require the expansion of the current USGS application and data hosting cloud environment to ensure that adequate technical infrastructure is available to support growing Toolkit requirements. Additionally, the National Geospatial Platform team would lead the development, enhancement and maintenance of the Climate Explorer application, the key geospatial viewer application for a wide range of resiliency data which is currently available.

These efforts support the Secretarial priority for Building a Landscape-Level Understanding of Our Resources. Community resilience can affect the economy, jobs, the environment, public health and welfare, security, and quality of life. The Toolkit would provide a portal with decision support tools, shared applications, visualization, and geospatial data to support resource-management decisionmakers and others. Applications developed for a specific event or scenario would provide capabilities that are accessible, shared, and applied to other events or actions through a community best practices clearinghouse where all levels of government would be leveraged collectively to address a wide range of local- to national-level challenges.

Community Resilience Toolkit (+\$11,000,000/0 FTE)

National Geospatial Program (+\$11,000,000/0 FTE)

In 2016, the USGS would capitalize on recent work undertaken by the USGS FGDC and several Federal agencies (the Department of Homeland Security, the National Aeronautics and Space Administration, the National Oceanic and Atmospheric Administration, and the U.S. Global Change Research Program) to establish the Toolkit. The FGDC would use its many stakeholders to leverage and expand existing efforts to create the clearinghouse.

One important function of the Toolkit would be to provide communities with expanded access to data, trends, and projections in environmental change at scales that are relevant to decisionmaking. Currently, several Federal agencies are producing downscaled climate model information and scenarios that can be used for various planning activities. Communities do not have access to internally consistent, geographically scalable scenarios of change (e.g., climate, population, land use) across the United States, along with guidance on what the uncertainties are that should be considered when using these scenarios. One of the obstacles to filling this void in local and regional scenario development is a sustainable location on the Internet, which is accessible and widely known by all of our partners. This vision of providing coherent scenarios for use at local scales is consistent with the goal of the U.S. Global Change Research Program to provide “Actionable Science” to support climate change adaptation. Scenario development will be coordinated closely with the U.S. Global Change Research Program National Coordination Office with the aim of supporting a wide range of national, regional, State and local climate assessments and adaptation planning.

Another important function of the geospatial platform is the sharing of climate adaptation strategies and adaptation results in a setting that fosters the development of “communities of practice.” Currently, there does not exist a U.S. government platform that facilitates the exchange of climate adaptation information among and across the Nation’s local communities, or one that links communities with results from relevant private efforts such as the 100 Resilient Cities (100RC) project, which is working to build urban resilience in 100 member cities around the world. A Community of Practice Exchange will be initiated in the Toolkit in 2016 with the express purpose of helping communities identify best practices for adaptation planning, implementation, and evaluation. A rigorous and comparative analysis of the effectiveness of iterative risk management, adaptation strategies and decision support tools will be conducted and include consideration of stakeholder needs, institutional structures including multi-agency programs, cost/benefit analyses, model validation and traditional knowledge. Partnerships, including grants and other forms of support, will be offered to other governments, NGOs and other institutions that have already made substantial progress in some sectors and regions.

To assist and support community resiliency activities, the National Spatial Data Infrastructure (NSDI) Cooperative Agreements Program will be used to provide resources and support to competitively selected proposals. The program will be open to State, local and tribal governments, academia, and non-profit organizations. The projects will support community collaborations, application and tool development and data management efforts.

The requested increase would enable the USGS to extend the cloud computing technical infrastructure for the Toolkit to support the large data storage, data publication, and application hosting. This includes the data and models needed to support long-term scenarios for environmental management, economic development; and public health, welfare, safety and security. Additionally, the USGS would manage and maintain the Climate Explorer application and other centrally hosted and managed components of the Toolkit.

By the end of 2016, communities across the Nation will have access to a wide ranging and rapidly growing collection of data, tools, best practices and lessons learned that will help them make better decisions and build more resilient infrastructure as they plan for the future. By bringing together a comprehensive, national clearinghouse of key data, tools and expertise, and by enabling partners in other levels of government and the NGO community with grant funds and advanced technology tools, the Toolkit would help communities assess and understand their vulnerabilities and determine how to best take action.

Initial Plan for the Community Resilience Toolkit – The initial plan to develop and implement the Toolkit consists of three components: Community Development, Partnerships, and Infrastructure.

Community Development

In 2016, the USGS would use the requested increase to issue Grant proposals to enable the development of “communities of practice” as a part of the Toolkit in 2016. The requested increase would be applied to these grants/cooperative agreements to establish and support communities. The USGS would begin developing the Toolkit’s core community components built in a way that could be used by all Toolkit partners. The requested increase would be used for outreach efforts, community assistance, and communication efforts to ensure community development and grant proposals are diverse and wide ranging.

Partnerships

The initiative would include a diverse number of partnerships to ensure the ongoing and permanent success of the Toolkit. The initiative would establish Public/Private partnerships to enable development of tools and support for community resiliency, such as, the publication of climate adaptation information and critical data and applications on adaptation scenarios at the local and regional levels. The requested increase would be used to support the development and publication of high-resolution regional climate scenarios and to support the further development of the Climate Explorer tool in collaboration with our partners at NOAA.

Infrastructure

The requested increase would enable the USGS to extend the cloud computing technical infrastructure for the Toolkit to support the large data storage, data publication, and application hosting. This includes the data and models needed to support long-term scenarios for environmental management, economic development; and public health, welfare, safety and security. The requested increase would be used to support a commercial cloud-computing infrastructure and would be used to provide technical support services for Toolkit partners.

Translational Science Grants

(+\$3,000,000/+2 FTE)

National Climate Change and Wildlife Science Center/
DOI Climate Science Centers (CSCs)

(+\$3,000,000/+2 FTE)

Ensuring that scientific understanding translates into practical application-ready solutions is a major challenge for the scientific community. The NCCWSC and the CSCs are implementing multiple approaches to ensure that managers and scientists “co-develop” actionable scientific products. In 2016, all CSCs would significantly expand their activities that support adaptation planning, with a focus on meeting the needs of specific decisions and planning activities, and on delivering application-ready scientific information. Building on existing CSC stakeholder interactions, the CSCs would work with

regional managers to identify high priority policy management decisions that could be informed by research results, then ensure close working relationships between scientists, managers and decisionmakers to assure that science projects provide decision ready outcomes. This ongoing collaboration between research scientists and land managers is essential to the successful production of actionable science. The NCCWSC would work with the USGS biological carbon sequestration project to identify options for building climate mitigation into climate adaptation planning, in particular by developing decision tools to help natural resource managers account for the carbon impacts of routine management practices as well as future climate adaptations. The CSCs would pilot this effort through regional projects focused on migratory birds and on the impacts of extended drought on ecosystems.

Tribal Climate Science Partnerships (+\$2,500,000/0 FTE)

National Climate Change and Wildlife Science Center/
DOI Climate Science Centers (CSCs) (+\$2,500,000/0 FTE)

Native American communities are increasingly engaging with the USGS and other partners to develop climate adaptation programs, and their needs for scientific and planning information are likewise increasing. In 2013, the NCCWSC/CSC Program established a Federal Advisory Committee: the Advisory Committee on Climate Change and Natural Resource Science (ACCCNRS). In early 2014, the ACCCNRS recommended that the USGS convene tribal and indigenous partners from across the CSC network to identify common and high priority tribal needs and are highlighted in an ACCCNRS report expected in April 2015. This recommendation would complement work at each of the CSCs, where scientists work with tribes to identify high priority tribal resource management concerns and build a science portfolio that provides information directly responsive to these needs. In 2016, the NCCWSC and the CSCs would help identify and implement best practices for the integration of traditional ecological knowledge into CSC science products. These efforts would be guided and supported by participation of tribal interests on CSC stakeholder committees and on the ACCCNRS as well as be coordinated with the Bureau of Indian Affairs (BIA) climate programs, tribal governments, consortia, and organizations, and other Federal climate efforts in Indian Country. Each CSC includes Native American representation on their stakeholder committees, and is developing trusted relationships with tribes in their region to identify high priority needs, and fund activities to meet those needs. The implementation of the BIA program to locate tribal climate science liaisons in five CSCs will provide additional capacity to both identify needs and communicate results to tribal users. Finally, in 2016, the CSCs would build on existing training and educational efforts, working with tribes in the development of climate adaptation strategies. The CSCs would expand research on key climate concerns, such as identifying those “First Foods” and similar culturally valued interests (plants, animals) whose existence or access is threatened by climate change.

Energy and Minerals

Energy and Minerals (\$ in Thousands)			
	2016 President's Budget Program Changes	2016 President's Budget Program Changes - FTE	Page #
All-of-the-Above Energy	8,549	30	C-68
Unconventional Oil and Gas Research	5,301	16	C-69
Fisheries Program	1,200	4	C-71
Energy Resources	1,550	4	C-69
Contaminant Biology	1,400	5	C-70
Toxic Substance Hydrology	250	1	C-70
National Water Quality Program	901	2	C-69
Renewable Energy	1,425	5	C-71
Wildlife Program	150	1	C-71
Energy Resources	1,075	3	C-72
Volcano Hazards	200	1	C-72
Environmental Impacts of Uranium Mining	2,023	9	C-73
Contaminant Biology	273	1	C-73
Toxic Substance Hydrology	1,750	8	C-74
Redirection - ERP Publications	-200	0	C-74
Energy Resources	-200	0	C-74
Critical Minerals	999	14	C-75
Critical Minerals for the Nation's Economic Vitality	440	14	C-75
Mineral Resources	440	14	C-75
R&D to Address Environmental Impacts of Minerals Development	559	0	C-76
Mineral Resources	559	0	C-76
Grand Total	9,548	44	

Justification of 2016 Program Changes

(+\$9,548,000/+44 FTE)

All-of-the-Above Energy

(+\$8,549,000/+30 FTE)

Critical Minerals

(+\$999,000/+14 FTE)

Overview

Energy and mineral development affect the economy, national security, and standard of living of the Nation. The USGS provides science to inform decisionmakers as they balance adequate and reliable energy and mineral supplies with the potential impacts of their development and use. In 2016, the USGS is requesting an additional \$9.5 million to continue and expand science efforts on environmental effects of unconventional oil and gas development; renewable energy development such as wind, solar, and geothermal; environmental impacts of uranium mining; a life-cycle analysis of critical minerals; and impacts of minerals development on the environment.

Program Performance

All-of-the-Above Energy **(+\$8,549,000)/+30 FTE)**

Unconventional Oil and Gas Research	(+\$5,301,000/+16 FTE)
Renewable Energy	+\$1,425,000/+5 FTE
Environmental Impacts of Uranium Mining	(+\$2,023,000/+9 FTE)
Redirection – ERP Publications	(-\$200,000/0 FTE)

Overview

To improve understanding and addressing potential environmental, human health, and safety impacts of hydraulic fracturing and associated operational activities, the Department of the Interior (Interior), the Department of Energy (DOE), and the Environmental Protection Agency (EPA) are building on the core capabilities of each agency in synergistic ways that lead to complementary work, and conduct research that supports sound management and policy decisions by Federal, State, tribal, and local entities. In 2014, the three agencies released the *Federal Multiagency Collaboration on UOG Research Strategy* (http://unconventional.energy.gov/pdf/Multiagency_UOG_Research_Strateg.pdf). The Research Strategy addresses the highest priority research questions, incorporates new and innovative technological opportunities, and addresses community concerns associated with safely and prudently developing resources through hydraulic fracturing. The research strategy consists of the following topics: understanding the scale and nature of U.S. Unconventional Oil and Gas (UOG) resources; water quality; water availability; air quality and greenhouse gas emissions; effects on human health; ecological effects; and induced seismicity. In addition, the Research Strategy identifies a set of six multidisciplinary, collaborative “Flagship Projects” to provide examples of potential research and deliverables for the multiagency collaboration outlined in the Memorandum of Agreement. Interior, the DOE, and the EPA are conducting research that supports sound management and policy decisions by Federal, State, tribal, and local entities. The goal is to produce decision-ready information to ensure the prudent development of energy resources and the protection of human health and the environment.

While there are economic benefits associated with oil and gas production and industry has developed best management practices for well site activities, concerns remain about potential environmental, health, and safety impacts of hydraulic fracturing. A comprehensive understanding of these potential impacts will require a significant research effort, including baseline data collection across various geologic settings. Potential effects of hydraulic fracturing may include: (1) impacts to water resources, including the contamination of aquifers and surface waters from drilling and hydraulic fracturing chemicals, the cross-contamination of aquifers through faulty well construction and casing installation, the release of methane and other greenhouse gases into aquifers and the atmosphere, contamination from radioactive elements and other toxic chemicals in waters recovered during gas production, and the reduced availability of water, particularly in water-scarce areas; (2) landscape changes including soil erosion and habitat fragmentation; (3) generation of airborne pollutants; and (4) unintended seismic events from the subsurface injection disposal of recovered hydraulic fracturing and rock formation fluids. Singly or in combination, these potential effects might result in harmful impacts on human health or on terrestrial and aquatic wildlife and ecosystems.

The requested increase supports a continuation of ongoing research and monitoring activities, and continued work on the multidisciplinary, collaborative flagship projects on UOG resources identified in the *Federal Multiagency Collaboration on UOG Research Strategy*.

Program Performance

Unconventional Oil and Gas Research (+\$5,301,000/+16 FTE)

**Understanding the Scale and Nature of the
U.S. Unconventional Oil and Gas Resources** (+\$1,550,000 /+4 FTE)

Energy Resources Program (+1,550,000/+4 FTE)

In 2016, the USGS would work to emphasize products that contain decision-ready information about the national unconventional oil and gas endowment. In 2016, the USGS would start a new effort to compare the characteristics and impacts of gas development and production using hydraulic fracturing in the Marcellus Shale both in Pennsylvania (where hydraulic fracturing is permitted) and in New York (where hydraulic fracturing is currently prohibited). There are areas of the Marcellus Shale natural gas trend in Pennsylvania and New York that are similar geologically and ecologically but are quite distinct regarding Marcellus gas production. For this new study, the USGS would study the geologic causes of variability in the Marcellus Shale in Pennsylvania and New York as related to the recovery of petroleum and water. This research would be tied to an investigation of baseline water quality and produced water disposal practices on the two sides of the border as part of a broader life cycle analysis.

Water Quality (+\$926,000 /+3 FTE)

National Water Quality Program (+\$676,000/+2 FTE)

The USGS would continue its efforts in 2016 to examine UOG impacts on groundwater and surface water quality. Understanding and managing risks from UOG development on water resources is one of the flagship projects identified in the Research Strategy. This project includes the development of analytical methods to detect a range of chemical additives (i.e., surfactants, corrosion inhibitors, biocides) commonly used in hydraulic fracturing fluid mixtures. This research is needed to understand potential impacts over the entire cycle of UOG operations, and develop best practices and mitigation technologies. The National Water Quality Program would also develop geochemical methods and models to evaluate contamination of water supplies. This includes examining possible inorganic elemental or isotopic fingerprints that could be used to identify UOG wastes as a source of contamination to environmental receptors. A focus would also be to identify the sources of the high selenium concentrations that have unexpectedly appeared in groundwater at several locations and conduct research on the use of stable carbon isotopes as a marker for injected fluids, such as fracturing fluid, into groundwater and surface water systems.

Toxic Substance Hydrology Program (+\$250,000/+1 FTE)

In 2014, the Toxic Substance Hydrology Program collected environmental samples of water and sediment associated with a potential environmental release of UOG wastewater from a holding pond at an underground injection site in West Virginia. These samples are currently being analyzed by a battery of tests including naturally occurring inorganic and organic compound analyses, synthetic organic compound analyses, bioassays, and microbial analyses. These tests will determine if the wastewaters and associated contaminants can be detected in the environment. In 2015, the Toxic Substances Hydrology Program would continue this work and with additional funding in 2016, the USGS would continue its efforts to examine UOG impacts on water quality. Understanding and managing risks from UOG development on water resources is one of the flagship projects identified in the National Research Strategy. This project includes the development of analytical methods to detect a range of chemical additives (i.e., surfactants, corrosion inhibitors, biocides) commonly used in hydraulic fracturing fluid mixtures. This research is needed to help understand potential impacts over the entire cycle of UOG operations, and develop best practices and mitigation technologies. The USGS would continue to investigate the role of bacteria in natural attenuation of organic compounds in wastewaters from hydraulic fracturing flowback and produced waters.

Water Availability (+\$225,000/0 FTE)

National Water Quality Program (+\$225,000/0 FTE)

The USGS would continue to assess water quantity impacts of the development of unconventional petroleum resources and study how to identify alternate sources of water to replace the use of scarce fresh water. This work would be focused in the Williston Basin, where water resources are scarce and UOG development is proceeding at a rapid pace. Objectives of the multi-year effort, beginning in 2015 are (1) obtain and analyze water use data for related to unconventional oil and gas development in the Williston Basin from 2005-2015, (2) estimate consumptive use, (3) assist stakeholders in projecting water use requirements and availability associated with future UOG development, and (4) assess environmental risk (e.g., low-order stream vulnerability and prairie pothole risk assessment) attributed to UOG operations and water use.

Effects on Human Health (+\$1,400,000/+5 FTE)

Contaminant Biology (+\$1,400,000/+5 FTE)

The Contaminants Biology Program is requesting new funding in 2016 to assess the health and ecological impacts of unconventional oil and gas. In 2016, the Contaminants Biology Program would expand research on potential environmental exposure to organic and inorganic contaminants associated with UOG activity, to include the biological effects of that exposure to living organisms. The Contaminant Biology Program would focus on sites of highest priority to optimize field activity, sampling, and biological effects studies. This effort would add to the scientific knowledge needed to assess the toxicology and biological contributions of UOG development to potential health risks for living systems, which include humans.

Ecological Effects (+\$1,200,000/+4 FTE)

Fisheries Program (+\$1,200,000/+4 FTE)

The Fisheries program would continue to build upon the 2015 enacted investment into assessing potential ecological impacts associated with UOG development with an additional request for funding in 2016. wastewater toxicity testing will characterize and build upon the available ecological toxicity data for the chemicals in wastewaters that we project pose the greatest potential risk to terrestrial and aquatic ecosystems and species of concern. This includes testing for water contamination from salts, Naturally Occurring Radioactive Materials (NORMs), and toxic chemicals that are specifically used for hydraulic fracturing. Another project that the Fisheries program would continue to build upon is conducting landscape scale vulnerability assessments. Assessments will identify and prioritize key geographic regions, terrestrial and aquatic ecosystems and their services, sensitive aquatic communities, and critical wildlife habitats that have the greatest potential for impact from ongoing and potential UOG activities. This includes assessing impacts to aquatic life from large water withdrawals especially in headwater streams, and significant land disturbance from higher than average density of feeder pipelines from well pads to collector pipelines.

Renewable Energy +\$1,425,000/+5 FTE**Wind and Solar** (+\$150,000/+1 FTE)

Wildlife Program (+\$150,000/+1 FTE)

Geothermal (+\$400,000 /+3 FTE)

Energy Resources Program (+\$200,000/+2 FTE)

Volcano Hazards (+\$200,000/+1 FTE)

Alternative Energy Permitting on Federal Lands (+\$875,000/+1 FTE)

Energy Resources Program (+\$875,000/+1 FTE)

Renewable Energy – Wind and Solar (+\$150,000/+1 FTE)

Wildlife Program (+\$150,000/+1 FTE)

Research on the causes and impacts of wildlife mortality from wind turbines and development of criteria for siting new facilities is well underway. However, little is known about the impacts of solar development on wildlife. Along with the need for increased understanding of potential impacts from solar, is the need for research on how to reduce impacts from commercial wind and solar energy development. Public and private managers are seeking efficient and effective ways to reduce wildlife interactions with solar and wind operations and to mitigate for possible impacts. Using technologies developed to enable the study of interactions of bats and birds with wind turbines, the USGS will expand investigations at solar facilities and explore options for innovative methods to reduce or offset negative interactions between wildlife and wind and solar operations. Preliminary studies showed that ultrasonic sounds and altering turbine operations had the potential to reduce the number of bird and bat fatalities. New research will be focused on developing these technologies and management strategies to reduce the chances that birds and bats will interact with energy facilities, such as a wind turbine, and reduce

associated fatalities that come with these interactions. This research will directly support the goals of State and Federal agencies, tribes, and energy managers to develop curtailment and mitigation strategies at wind and solar facilities.

Renewable Energy – Geothermal **(+\$400,000/+3 FTE)**

Energy Resources Program (+\$200,000/+2 FTE)

The Nation's transition to renewable fuels is challenged to provide "base power" that is steady, uninterrupted power, like coal and natural gas. Geothermal resources are a renewable energy source that can fill that base power role, but are highly underutilized in this country. The Energy Independence and Security Act (EISA) of 2007 directed the USGS to complete a comprehensive nationwide geothermal resource assessment that examines the full range of geothermal resources of the United States. The 2008 USGS geothermal resource assessment estimated the resource potential in identified and undiscovered geothermal systems, and documented that enhanced geothermal systems (EGS), a form of unconventional geothermal energy, could increase substantially the amount of geothermal resources. There is substantial potential for unconventional geothermal resources (EGS) on Federal lands, but these resources have not been thoroughly evaluated. New research and assessment work is critical to understanding these geothermal systems and determining the extent to which unconventional geothermal resources can play in the domestic energy mix. With the requested increase, the USGS would evaluate the geology and subsurface characteristics, and build on a very successful recent field test, to identify likely areas of potential exploration and development of unconventional geothermal resources. The USGS would improve research efficiency and improve decision-relevant products by investigating potential hazard and vulnerability at the same time as resource evaluations. This information is needed to support the periodic updates of a comprehensive national geothermal resource assessment as called for in EISA 2007.

Volcano Hazards (+\$200,000/+1 FTE)

This effort proposes to build on Volcano Hazard Program assessment and monitoring capabilities to focus on high-priority geothermal targets including Akutan Island in Alaska and the Salton Sea Geothermal Field in California. Both targets could potentially generate power from geothermal resources for nearby residents and businesses, reducing reliance on other sources of energy. In Alaska, seismic monitoring equipment would be deployed that would help assess the size and extent of the subsurface geothermal system and estimate the size and stability of the geothermal system's production capability. At the Salton Sea, efforts will focus on modeling to assist in geothermal exploration and forecasting resource longevity.

Alternative Energy Permitting on Federal Lands **(+\$875,000/+1 FTE)**

Energy Resources Program (+\$875,000/+1 FTE)

The requested increase provides science to the agencies responsible for energy resource management on Federal Lands in several ways. Since the majority of geothermal resources are on public lands in the Western United States, the USGS works closely with the Bureau of Land Management (BLM) and others. The increase would allow a focused effort in targeted areas to survey and subsequently track the impacts

of geothermal development over time, which have been poorly characterized to date. This effort would focus on key areas where there are, or may be, issues related to ongoing geothermal production. The increase would also allow for additional support for researching induced seismicity related to geothermal development on Federal lands, and help to determine the risks and potential mitigation plans should development be proposed. The BLM and other bureaus could use information from this proposed increase for land use planning and potentially a targeted environmental impact statement for high potential use areas. In addition, outcomes from this research would support science and information needs identified by BLM, Fish and Wildlife Service, and others in the draft Desert Renewable Energy Conservation Plan (DRECP), which is a “landscape-scale plan that uses science to inform the siting of renewable energy development projects and the conservation of species, creating systematic habitat protection and connectivity improvements across the Mojave and Colorado/Sonoran desert regions” (DRECP Executive Summary, September 2014). Additional users of this information include geothermal power companies, which can use probabilistic hazard and risk data to lower vulnerability of potential power development assets and design better monitoring to protect those assets. With the additional funding, the USGS will be able to accelerate work at an existing research site or begin work at a new site.

Environmental Impacts of Uranium Mining **(+\$2,023,000/+9 FTE)**

Contaminant Biology	(+\$273,000/+1 FTE)
Toxic Substances Hydrology	(+\$1,750,000/+8 FTE)

Overview

In January 2012, the Secretary of the Interior withdrew over one million acres of public lands in the Grand Canyon region from mining for 20 years under the Mining Law of 1872. However, even under the withdrawal, some mining will occur on valid existing claims. For example, the Canyon Mine (on U.S. Forest Service [USFS] lands south of the Grand Canyon) and the EZ Mine (on Bureau of Land Management [BLM] property north of the Grand Canyon) are expected to begin ore extraction in the near future. A key factor in the Secretary’s decision was a lack of scientific information. The USGS developed a 15-year science plan in collaboration with the BLM, National Park Service, U.S. Fish and Wildlife Service, and the USFS. The studies would provide critical information for future decisions on withdrawal of lands and help inform the development, mitigation, reclamation, and ecological restoration of mines on valid existing claims, as applicable.

Northern Arizona Uranium Mining Contamination Research **(+\$2,023,000/+9 FTE)**

Contaminant Biology	(+\$273,000/+1 FTE)
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The proposed increase would support characterization of radiation and chemical concentrations in sentinel species (e.g., birds, mammals, and reptiles) from samples obtained at targeted active mine sites. Biological surveys and samples (water, dust, and biota) were collected at the Pinenut and Arizona 1 Uranium Mines, Arizona Strip in 2015. These results will complement the characterization of radiation and chemical concentrations in biota from a pre-mined ore body that was completed in 2015. These foundational activities are necessary for measuring the environmental effects of mining uranium, and its

associated release of radiation, beyond what is naturally occurring in this area of the country to determine whether those increases pose a risk to biota. In 2016, the USGS would analyze the levels of uranium in dust, water, and biota at active mine sites, and begin modeling the “natural” transport and occurrence of uranium and radiation in native animals and plants. Biological samples will also be collected at springs near reclaimed mine sites to determine if residual contamination is cause for concern for humans and wildlife. Results will be used to develop a modeling tool to assess ecosystem health before, during, and eventually after uranium extraction. The knowledge gained from these studies will be used for developing prevention and mitigation strategies to ensure that the health and sustainability of natural resources are balanced with economic development. This study will provide science needed by the Secretary of the Interior for making sound decisions regarding extraction activities on Federal lands.

Toxic Substances Hydrology (+\$1,750,000/+8 FTE)

The requested increase continues the implementation of the integrated 15-year science plan by collecting new baseline data, expanding smaller scale studies begun in previous years, and laying the foundation for future modeling and monitoring efforts. The increase would also be used to begin new work on the potential for persistent contaminant threats from abandoned and legacy mining activities. Work initiated in 2015 would continue in 2016 to characterize the baseline conditions of soil, groundwater, and surface water at the Canyon and EZ Mine sites before ore extraction begins. This would be done in cooperation with agency partners and private mining companies, and would complement USGS work on Trust resources (animal and plant species) started at Canyon Mine in 2013 and 2014. This baseline work is crucial for comparison after extraction occurs and enables understanding of the extent of naturally occurring versus mine-related uranium and associated contaminants in soil, water, and biota.

In addition, work would begin to determine potential pathways of uranium exposure, such as movement through groundwater-flow paths, surface water, and wind dispersion as well as the potential for biological uptake from legacy as well as new mining activities. This includes continued and expanded monitoring of water quality and uranium levels in the Colorado River in the Grand Canyon, Kanab and Havasu Creeks, and other regional rivers, streams, intermittent washes, and springs. USGS researchers would analyze data continually to describe spatial and temporal patterns of uranium in soil and water samples, and include information to develop regional exposure models that would shape subsequent research and monitoring components.

Redirection – ERP Publications (-\$200,000/0 FTE)

Energy Resources Program (-\$200,000/0 FTE)

This redirection would allow for many of the ERP’s publications to be published in a digital format in outside journals, allowing funds to be redirected towards other priorities in the Energy Resources Program.

Critical Minerals **+\$999,000/+14 FTE**

Critical Minerals for the Nation’s Economic Vitality	(+\$440,000/+14 FTE)
R&D to Address Environmental Impacts of Minerals Development	(+\$559,000/0 FTE)

Program Performance**Critical Minerals for the Nation’s Economic Vitality** **(+\$440,000/+14 FTE)**

Mineral Resources Program – Critical Minerals	(+\$2,440,000/+14 FTE)
Mineral Resources Program - Sun Setting Activities	(-\$2,000,000/0 FTE)

The 2016 request for the Mineral Resources Program will be used to continue life-cycle analysis for critical minerals such as rare earth elements. A life-cycle analysis will trace the flow of these critical minerals from generation and occurrence through interaction with society and the environment to ultimate disposition and disposal. The Nation faces key economic decisions within each stage of the resource life cycle. Scientific understanding is an essential input to these decisions. The program change will support new workforce capability to address the main thrusts of the President’s four Office of Science and Technology Policy (OSTP) Working Groups currently focused on critical and strategic materials essential to national security, economic vitality, and environmental protection. By expanding work on Materials Flow analysis, the initiative will also accomplish needed modernization of the National Minerals Information Center part of the Mineral Resources Program. Redirection of sun-setting activities in the Mineral Resources Program will support Administration priorities in the areas of Critical Minerals and Research and Development to Address the Environmental Impacts of Minerals Resource Development.

In addition to national security and economic vitality, critical minerals research is important to the President’s focus on protecting the environment. Critical minerals research fosters better understanding of the environmental consequences of mining, such as the impacts of metal mixtures in mineralized drainage, mineral levels in the built and waste stream environments, geochemical composition of soil, and the impacts of mining on human health. For instance, the Mineral Resources Program’s development of an interactive Web tool called the U.S. Soil Map has helped further the understanding of the geochemical makeup of soil at thousands of sites all over the Nation. This and additional data that will become available from the extension of critical minerals research will be used to better understand whether elements in soil are naturally occurring or externally introduced. These data can be used to extrapolate potential health effects arising from areas that contain a higher-than-normal concentration of a particular element. Furthermore, critical minerals research provides information essential to the development of renewable energy resources. Knowledge of the elements needed for the production of wind turbines and solar panels, as well as the quantities and locations of those elements, can support the proliferation of clean energy solutions for the Nation.

R&D to Address Environmental Impacts of Minerals Development (+\$559,000/0 FTE)

Mineral Resources Program (+\$559,000/0 FTE)

The 2016 request will allow for the focus of efforts on development of new science and tools to reduce the impacts of minerals extraction, production, and recycling on the global environment and human health, including research on supply chain, life cycle, resource sustainability, and minimizing environmental impacts of mineral extraction. This additional funding will allow for enhanced work on: toxicity of multiple metals associated with platinum group deposits; trace metal mobility in the Yellow Pine mining district, Idaho; groundwater quality in uranium mining; geoenvironmental health models of mineral deposits; geoenvironmental signatures of rare earth element deposits in Alaska; and refinement of national geoenvironmental models. Other environmental activities include efforts to better understand emerging environmental geochemical challenges for future mining, and the uses, characteristics, and environmental health implications of metal and mineral commodities in the built environment.

Science Infrastructure

Science Infrastructure (\$ in Thousands)			
	2016 President's Budget Program Changes	2016 President's Budget Program Changes - FTE	Page #
Infrastructure Capacity to Support the Science Mission	18,931	16	C-78
Enhancing Science Support Capability to Support Science Mission Goals	2,617	16	C-78
Administration and Management	1,997	14	C-78
Information Services	620	2	C-78
Operations and Maintenance Stewardship	2,712	0	C-80
Rental Payments and Operations & Maintenance	2,712	0	C-80
Reducing the Facilities Footprint - Cost Savings and Innovation Plan (CSIP)	11,602	0	C-80
Rental Payments and Operations & Maintenance	11,602	0	C-80
Sustainability Investments	2,000	0	C-81
Rental Payments and Operations & Maintenance	2,000	0	C-81
Science Coordination	500	1	C-82
Tribal Science Coordination	300	0	C-82
Administration and Management	300	0	C-82
DOI Science Coordination	200	1	C-82
Administration and Management	200	1	C-82
Engaging the Next Generation: Building a 21st Century Workforce	1,700	2	C-83
Mendenhall Program Postdocs	500	1	C-83
Administration and Management	500	1	C-83
Youth in Underserved Communities	200	0	C-84
Administration and Management	200	0	C-84
Youth & Education in Science	1,000	1	C-84
Administration and Management	1,000	1	C-84
Grand Total	21,131	19	

Justification of 2016 Program Changes

(+\$21,131,000/+19 FTE)

Infrastructure Capacity to Support the Science Mission	(+\$18,931,000/+16 FTE)
Science Coordination	(+\$500,000/+1 FTE)
Engaging the Next Generation: Building a 21 st Century Workforce	(+\$1,700,000/+2 FTE)

Overview

Science Infrastructure includes the essential support functions and services and facilities which form the foundation for the USGS science mission. Achieving high-quality science research depends on having the required resources, including scientific equipment and supplies, facilities and laboratories; scientists, technicians and researchers; partnership agreements and contracts in place when needed, and the management processes to control and best utilize these resources. In 2016, the USGS is requesting an increase of \$21,131,000 million for these critical activities. Included in the increase is funding to enhance science coordination, expand youth and education opportunities, implement cost savings and sustainability efforts, and support essential management, finance, acquisition, safety, and information technology services. The request for science infrastructure is commensurate with the increase request for science funding, and will strengthen core capabilities and science support activities.

It is comprised of:

- Administration and Management (A&M)
- Information Services
- Facilities

Infrastructure Capacity to Support the Science Mission

(+\$18,931,000/+16 FTE)

Enhancing Science Support Capability to Support Science Mission Goals	(+\$2,617,000/+16 FTE)
Operations and Maintenance Stewardship	(+\$2,712,000/0 FTE)
Reduce Facilities Footprint-Cost Savings and Innovation Plan (CSIP)	(+\$11,602,000/0 FTE)
Sustainability Investments	(+\$2,000,000/0 FTE)

Program Performance

Enhancing Science Support Capability to Support Science Mission Goals **(+\$2,617,000/+16 FTE)**

Administration and Management	(+\$1,997,000/+14 FTE)
Information Services	(+\$620,000/+ 2 FTE)

The essential support functions and services provided by the Administration and Management (A&M) subactivity form the foundation for the USGS science mission. Achieving high-quality science research depends on having the required resources, including scientific equipment and supplies, facilities and laboratories; scientists, technicians and researchers; partnership agreements and contracts in place when needed, and the management processes to control and best utilize these resources. The breadth of responsibilities required include scientific integrity processes, purchasing scientific equipment and field supplies, developing science agreements with partners, contracting for support scientists and researchers, safety training, hazardous waste management, funds management, succession planning, hiring, staffing and employee development and training and property and facilities management. Each of these fulfills unique responsibilities with unique training and skillsets and the functions are not interchangeable. Growth of the science mission and changes to science projects generate additional requirements for these support functions. The ability to execute the science mission is jeopardized if A&M funding is not maintained commensurate with science funding. This program change would allow A&M to strengthen these core capabilities and science support activities. New science projects require appropriately trained and qualified people, equipment and supplies to conduct research and field work. This increase will ensure that science support has the capacity to support programmatic increases for science provided in 2016.

Strategic reviews and workforce analysis have guided the A&M subactivity in preserving core capabilities while adapting to changing requirements and technologies. A&M supported functions will continue to use workload and workforce analysis to adapt to meet evolving requirements, and ensure that science support funding is “right sized” to appropriately support the science mission of the USGS.

This increase would enhance the ability to continue these strides, and improve service delivery by supporting closer collaboration between service providers and scientists. Examples of the critical support provided may include:

- Additional acquisition support that would assist with developing new statements of work and accomplish procurement actions for the \$137.2 million in proposed 2016 programmatic changes requiring procurements for new research capability for initiatives such as earthquake early warning, volcano ash-fall modeling and seismic monitoring of geothermal energy producing fields and modification of existing agreements affected by research projects which are reduced or eliminated.
- Additional human capital support to hire the 207 FTE increase for new initiatives such as pollinator studies, wildlife and fish population response to climate change in the Arctic and Sage-land assessments, and new researchers for drought, and scientists redirected from lower priority science.
- Management analysts and funding to develop automated tracking systems, to establish customer service metrics and quality standards for administrative processes for executive leadership and senior management use in continuous evaluation of service and quality levels and balancing resources. For instance, ensuring that acquisition and human resources have the tools to better communicate with their customers about the status of their procurement and hiring actions, and streamline processes to ensure that the work is being done in a timely and reasonable manner.
- Bureau approving official would apply scientific integrity principals in support of the \$137.2 million in additional science priorities for the USGS. New science projects focusing on areas such as pollinators, drought, and the Arctic produce new research results that would require the application of scientific integrity principals to evaluate methods and assure delivery of peer-reviewed science to publications. In addition, the implementation of Web-based journals, similar to the 24-hour news cycle, increases the pressure to compress the time it takes to deliver scientific study results. An increase to FTE in this area would decrease the amount of backlog and time it takes to move through the review process, delivering science products to land-use managers and the public quicker, without risking scientific quality.
- Technology transfer and agreements specialist would review new and modified non-standard agreements for statutory and regulatory compliance and assist scientists with the development of cooperative research and development agreements and technology transfer. Technology transfer enables the rapid commercial exploitation of federally funded research. For instance, USGS science recently led to an invention that has been submitted for a U.S. patent for antibacterial clay that can be used to treat skin infections resistant to antibiotics. Antibiotic resistant infections affect two million people each year and at least 23,000 die as a direct result of these infections. Rapid commercialization, for instance, will also make earthquake early warning technology more widely available.
- Internal controls specialists to evaluate increased risk associated with program changes and assist science management in developing risk reduction processes. This FTE would assist in developing adequate internal controls to ensure resources are efficiently managed and fulfill mission requirements for new cooperative agreements, which consist of field activities, data-

collection and equipment that produce models and recommendations for improving disaster response to coastal hazards and contracts for high-resolution data. Historically, programs undergoing significant change are susceptible to increased risk and audit visibility.

Investments in A&M support functions and processes allow scientists to focus on science by providing the tools, people and support needed to accomplish the mission.

The proposed increase to Information Services would provide more robust support for the bureau in the areas of information hosting and processing and information technology services. The Office of Enterprise Information (EI) will make high-value assets and technical tools available to the public in support of the administration's Open Government Initiatives. EI would use the funding to increase efficiency in USGS processes, such as programming and developing tools, to assist with IT spending and use of Universal Product Codes and reporting to DOI, and improving existing Web forms and tools that will benefit and impact a large body of employees within the USGS.

Operations and Maintenance Stewardship (+\$2,712,000/0 FTE)

Rental Payments and Operations and Maintenance (+\$2,712,000/0 FTE)

The requested increase will improve the performance of the USGS real property portfolio by providing the bureau the ability to complete annual operations and maintenance responsibilities and would ultimately have a positive impact on the science programs, decreasing the amount of science dollars needed to cover the existing facilities shortfall.

The increase will allow the USGS to approach proper funding levels in the Operations and Maintenance component of the Rental Payments and Operations and Maintenance subactivity for USGS owned facilities slowing the increasing deferred maintenance backlog. The increase will help the bureau realize the full life cycle of its real property assets and help prevent emergency repairs that result in unplanned additional repair costs and unexpected outages compromising the science missions of the USGS. In addition, the increase will enhance the ability to meet the requirements of statutory energy goals; increase efforts of energy reduction, water conservation, and waste reduction; and enhance the USGS's ability to meet specified environmental requirements, as well as enable more efficient and economical maintenance of its real property assets and enhance the bureau's ability to fund Cost Savings and Innovation Plan (CSIP) projects.

Reducing the Facilities Footprint-Cost Savings and Innovation Plan (CSIP) (+\$11,602,000/0 FTE)

Rental Payments and Operations and Maintenance (+\$11,602,000/0 FTE)

Because the USGS relies on the General Services Administration (GSA) owned and leased buildings for about 67 percent of the space it occupies, the USGS has no ability to reduce fixed rental rates at these sites and can only offset the higher facility costs by vacating space. Therefore, primary emphasis is placed on improving space utilization, consolidating operations within, and relinquishing space to GSA provided offices, laboratories, data centers, and warehouses.

The proposed increase would accomplish a mixture of Cost Savings and Innovation Plan (CSIP) projects and Deferred Maintenance (DM) projects. Since 2012, the USGS has been funding its CSIP projects from the Deferred Maintenance and Capital Improvements (DMCI) subactivity. The proposed increase in funding would allow the USGS to restore the \$2.22 million in DMCI funding currently being used to fund CSIP projects, and give the USGS the ability to invest in additional CSIP projects that allow the USGS to consolidate space, reduce the occupancy footprint, improve utilization and create real property cost savings and other efficiencies. The requested increase for CSIP projects would allow the USGS to implement numerous projects that would further reduce the USGS footprint by approximately 138,000 Rentable Square Feet (RSF).

The CSIP has provided the USGS with the ability to reduce its footprint by more than 540,000 RSF from 2012 through 2014. By 2016, the USGS anticipates an additional reduction of 175,000 RSF, bringing the overall footprint reduction to 715,000 RSF. This would be a 12 percent decrease of the USGS space portfolio since 2012. These efforts focused on the USGS three major centers in Reston, VA, Denver, CO, and Menlo Park, CA. Each of these centers were successful in taking on major consolidation projects, reducing space requirements, actively seeking co-location opportunities and vacating more expensive space. The achieved results were the direct impact of the bureau's CSIP activity.

In 2016, the bureau will continue its progress toward accomplishing the savings targets set by Interior. The USGS will continue to fund the library consolidation projects at the Denver Federal Center and Menlo Park Campus, which will immediately reduce the space occupied by the library by 29,400 SF; a 48 percent reduction. Completing the Menlo Park library project will also speed up the overall consolidation plan at the Menlo Park Campus, which will ultimately release the remainder of Building 3; an additional reduction of 50,100 SF. The USGS will also continue to fund a co-location project with the Bureau of Reclamation, in Boulder City, NV. This project will significantly reduce the rent costs as well as lessen the Interior's overall footprint.

Sustainability Investments (+\$2,000,000/0 FTE)

Rental Payments and Operations and Maintenance (+\$2,000,000/0 FTE)

The USGS awarded an Energy Savings Performance Contract (ESPC) in July 2014 for \$12 million. The ESPC will reduce the USGS's energy consumption by 15 percent, potable water use by five percent and Scope 1&2 Greenhouse Gas emissions by nine percent. The ESPC will annually generate over \$650,000 of savings, which will pay for the energy and water improvements. On average these projects would pay for themselves in 16 years. During the ESPC award process, a series of preliminary audits were performed that identified an additional \$13.0 million in Energy Conservation Measures (ECMs) not included in the ESPC award. The ECMs include a wide range of improvements in boiler systems, chiller plants, building automation, HVAC, building envelope, and electric motors and drives. The ECMs would take place at the Earth Resources Observation and Science Center, Leetown Science Center, Patuxent Wildlife Research Center, Northern Appalachian Research Laboratory, Conte Anadromous Fish Laboratory, Northern Prairie Wildlife Research Center, Upper Midwest Environmental Sciences Center, and National Wetlands Research Center. Due to various reasons, these ECMs were evaluated for inclusion in the ESPC but ultimately were not included in the award. These additional ECMs are still

viable measures and the \$2 million program change will allow the USGS to pursue these ECMs to further reduce the bureau's energy consumption and generate savings of approximately \$100,000 to \$150,000 annually.

Science Coordination **(+\$500,000 /+1 FTE)**

Tribal Science Coordination	(+\$300,000/0 FTE)
DOI Science Coordination	(+\$200,000/+1 FTE)

Overview

Scientific research provides the basis for technological advancements such as earthquake early warning; limiting ecosystem destruction from invasive species such as Asian carp and developing complementary land-use management techniques for Federal lands such as energy exploitation and endangered species refuges. Collaborating with partners on science projects and goals expands science knowledge exponentially by sharing knowledge and data across organizations, developing complementary rather than duplicative projects, and integrating results to derive decision-quality data sooner than would be possible from isolated science projects.

Program Performance

Tribal Science Coordination	(+\$300,000/0 FTE)
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Administration and Management	(+\$300,000/0 FTE)
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Efforts to strengthen tribal partnerships in science are proposed for the USGS Office of Tribal Relations (OTR). The USGS would make existing partnerships more robust by enhancing and expanding outreach coordination efforts among Tribes and USGS regions. Working with the USGS Regional and Mission Area tribal liaisons, the increased support to the USGS OTR will increase the USGS ability to forge partnerships with intertribal organizations and to connect Tribes to USGS scientists and staff in other Interior bureaus and Federal agencies. The funding would also support expanding tribal training via the Technical training in Support of Native American Relations (TESNAR) program, which provides for the transfer of information from USGS to tribal members in the use of research techniques and technology for use in climate resilience and mitigation. This training provides capacity building to Tribes and supports self-determination in their climate resilience and mitigation activities.

DOI Science Coordination	(+\$200,000/+1 FTE)
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Administration and Management	(+\$200,000/+1 FTE)
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As the science bureau of the Department of the Interior, the USGS provides science to inform the land and resource management decisions of Interior. The increase supports strengthening the coordination of the science priorities of Interior bureaus to ensure the USGS is delivering decision ready science to meet Interior's highest priority needs. The science delivered must be of the highest quality and conducted with

the highest integrity. The increase also supports Interior's scientific integrity process. The USGS leads the scientific integrity process for all Interior bureaus. This unified approach strengthens scientific research and application across Interior and aids land management and land use policy development and implementation. The scientific integrity process ensures all research is conducted with integrity and is subject to rigorous review. The funding would support a dedicated scientist to coordinate USGS science efforts with other Interior bureaus and to support Interior's science integrity process.

Engaging the Next Generation:

Building a 21st Century Workforce **(+\$1,700,000/+2 FTE)**

Mendenhall Program Postdocs	(+\$500,000/+1 FTE)
Youth in Underserved Communities	(+\$200,000/0 FTE)
Youth and Education in Science	(+\$1,000,000/+1 FTE)

Overview

Engaging the next generation in the USGS science and science support workforce is an investment in the future economic vitality of the Nation, which will contribute to maintaining the Nation's preeminence in science and technology. This benefits all United States citizens through economic advancement, mitigation of natural hazards, and stewardship of natural resources and public lands. As part of the Nation's effort to lead the world in science and technology, the USGS provides robust mentoring, training, and educational opportunities to young people to grow the science workforce in the 21st century. Engaging youth is a part of the USGS legacy. USGS internships provide initial work experiences and science literacy to young people on relevant, cutting-edge science issues and creates a ready source of future employees, contributing to a robust national scientific community.

Program Performance

Mendenhall Program Postdocs	(+\$500,000/+1 FTE)
Administration and Management	(+\$500,000/+1 FTE)

The Mendenhall Research Fellowship Program is the flagship postdoctoral research program for the USGS. Established in 2001, this program has grown into one of the most prestigious and coveted postdoc programs in science. Through the Mendenhall Program, the USGS obtains the some of the best available new PhD talent to address the needs of its science mission. This funding will be used to recruit a specific number of Mendenhall Fellows to carry out research that covers the entire spectrum of USGS science. This increased funding will provide stability to the program and the opportunity for the establishment of a consistent high standard for projects and researchers.

Youth in Underserved Communities (+\$200,000/0 FTE)

Administration and Management (+\$200,000/0 FTE)

This increase would provide opportunities to grow outreach programs to youth in underserved communities, such as the Denver Mayor's Office/USGS partnership and the Native Youth in Science – Preserving our Homelands programs. Additional funding would help the USGS to provide an understanding of the opportunities available through science, technology, engineering and mathematics (STEM) studies and demonstrate a path toward development as future scientists, as illustrated in our work with GeoFORCE students. Increased funding would build upon and expand current hydrologic, biologic, and physical science technician programs with Gateway, Vermillion, SD, and Northern Virginia Community Colleges, and allow for program startup at new minority serving institutions and tribal colleges. Hydrologic Technicians constitute one of the top two career series within the USGS, with 25 percent vacancies estimated from retirements or other departures from the USGS in the next three to five years. The Hydrologic Technician Interest Committee, comprised of USGS leaders in Hydrology across the Nation, is dedicated to mentoring and succession planning efforts, with a focus on veterans, youth, and diversity.

Youth and Education in Science (+\$1,000,000/+1 FTE)

Administration and Management (+\$1,000,000/+1 FTE)

The requested increase would enable the USGS to sustain and build on existing youth hiring and youth outreach activities which contribute directly to STEM capabilities for the Nation and introduce future scientists to the value of public service in the Earth and biological sciences. The Office of Science Quality and Integrity combined the Youth and Education Offices to form the Youth and Education in Science Office in 2015. This office (1) facilitates a strong coordinated effort across the USGS to leverage resources and support the engagement, mentoring, and employment of youth; (2) develops youth and education strategic directions as they relate to the USGS science and workforce planning goals; (3) expands USGS education and internship programs for students underrepresented in STEM, tribal colleges, and to veterans; (4) develops and enhances current STEM programs that are pipelines to STEM careers (i.e., EdMAP); and (5) provides opportunities to expand partnerships in support of the 21st Century Conservation Service Corps. As part of this strategy, the Youth and Education in Science Council has been developed, which will help leverage youth engagement opportunities by partnering with USGS science centers, offices and stakeholders to achieve mission goals.