

Water Power Technologies Office Peer Review Hydropower Program

U.S. DEPARTMENT OF
ENERGY

Energy Efficiency &
Renewable Energy

National Hydropower Asset Assessment Program



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The Oak Ridge National Laboratory's (ORNL) National Hydropower Asset Assessment Program (NHAAP) is an integrated energy, water, and ecosystem research and geospatial data integration effort for efficient, sustainable, and environmentally friendly hydroelectricity generation and water management. The NHAAP is sponsored by the U.S. Department of Energy Office of Energy Efficiency and Renewable Energy (EERE) and our partners include state and federal agencies, non-governmental organizations, technology and resource developers, utilities, and researchers.



Project Overview

The overarching goal of the ORNL's NHAAP effort is to provide the Federal geospatial data standard for existing and potential hydropower resource evaluation in the United States. By offering comprehensive, detailed, reliable, and up-to-date geospatial coverage of U.S. hydropower resources, water, and environmental information, the NHAAP effort delivers information that is critical for stimulating U.S. hydropower market acceleration, deployment, technology-to-market activities, and environmental impact reduction. Through ongoing development efforts, we aim to improve and extend our geospatial data and analysis capabilities to enable more effective and efficient support for initiatives of the DOE's Water Power Program

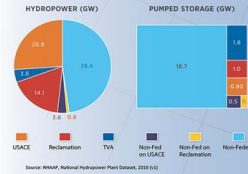
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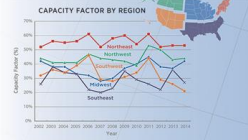
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STATISTICS ON U.S. EXISTING HYDROPOWER ASSETS

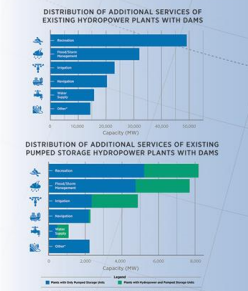
CAPACITY



PERFORMANCE



BENEFITS BEYOND POWER



THE 2016 NATIONAL HYDROPOWER MAP

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National Hydropower Asset Assessment Program (NHAAP)

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February XX, 2017



National Hydropower Asset Assessment Program (NHAAP)

The Challenge

Fulfill the hydropower community's need for a comprehensive U.S. hydropower data set

- Existing asset
- Growth potential
- Environmental concerns

Partners

Bureau of Reclamation (Reclamation), U.S. Army Corps of Engineers (USACE), Federal Regulatory Energy Commission (FERC), and the Energy Information Administration (EIA).

Next Generation Hydropower (HydroNEXT)

Optimization

- Optimize technical, environmental, and water-use efficiency of existing fleet
- **Collect and disseminate data on new and existing assets**
- Facilitate interagency collaboration to increase regulatory process efficiency
- Identify revenue streams for ancillary services

Growth

- Lower costs of hydropower components and civil works
- Increase power train efficiency for low-head, variable flow applications
- Facilitate mechanisms for testing and advancing new hydropower systems and components
- Reduce costs and deployment timelines of new PSH plants
- Prepare the incoming hydropower workforce

Sustainability

- Design new hydropower systems that minimize or avoid environmental impacts
- Support development of new fish passage technologies and approaches
- **Develop technologies, tools, and strategies to evaluate and address environmental impacts**
- Increase resilience to climate change

Next Generation Hydropower (HydroNEXT)

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- **Collect and disseminate data on new and existing assets.**
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- Increase revenue streams for ancillary services.

The Impacts

- Provide best-available baseline U.S. hydropower information to support national R&D:
 - Existing hydropower asset
 - Future potential
 - Environmental characterization
- Help identify potential market opportunities and barriers to stimulate hydropower market acceleration
- Identify data gaps and recommend further collaborative actions to collect and expand U.S. hydropower knowledge base.

Next Generation Hydropower (HydroNEXT)

Sustainability

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The Impacts

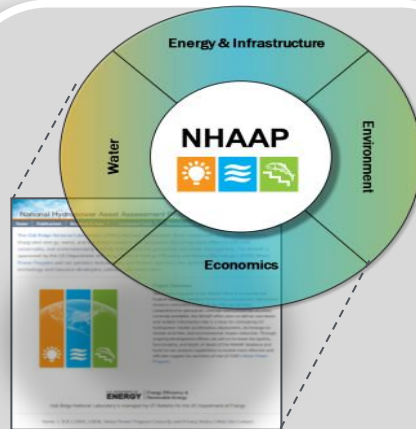
- Understanding of environmental impacts (e.g. Environmental Considerations in the *Hydropower Vision*)
- Develop tools to increase the objectiveness, efficiency, and effectiveness of environmental improvement strategies (e.g. environmental metrics and the sustainability of hydropower development)
- Inform the design parameters (e.g. head and flow), co-objectives (e.g. species passage, WQ enhancement, recreation), and market potential that multiple DOE-funded tech developments are targeting.
- Identify environmental and science and knowledge gaps through data exploration and creation, respectively (e.g. Stream Classification and Mitigation Prediction).

NHAAP Operations

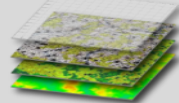
Collection

Public &
Proprietary
Information

Synthesis



Data Stewardship



Maintenance



Collaboration

- FERC
- USACE
- Reclamation

Public Outreach

Publications

PUBLICATIONS

Search

Author Title Type Year Found 25 results

DOE EERE Report

Loza-Martinez, R., M.M. Johnson, and P.W. O'Connor. 2015. "2014 Hydropower Market Report". Washington, DC: Wind and Water Power Technologies Office, U.S. Department of Energy. http://nhaap.ornl.gov/sites/default/files/ORNL_2014_Hydropower_Market_Report.pdf.

Hadjerlou, B., Y. Wei, and S.-C. Kao. 2012. "An Assessment Of Energy Potential At Non-Powered Dams In The United States". Washington, DC: Wind and Water Power Program, Department of Energy. http://nhaap.ornl.gov/sites/default/files/NHAAP_NPD_FY11_Final_Report.pdf.

Kao, S.-C., R. A. McManamy, K. M. Stewart, N. M. Sams, B. Hadjerlou, S. T. DeNeale, D. Yasmin, M. FK Pasha, A. A. Oubaidillah, and B. T. Smith. 2014. "New Stream-Reach Development: A Comprehensive Assessment Of Hydropower Energy Potential In The United States". http://nhaap.ornl.gov/sites/default/files/ORNL_HSD_FY14_Final_Report.pdf.

Research & Data

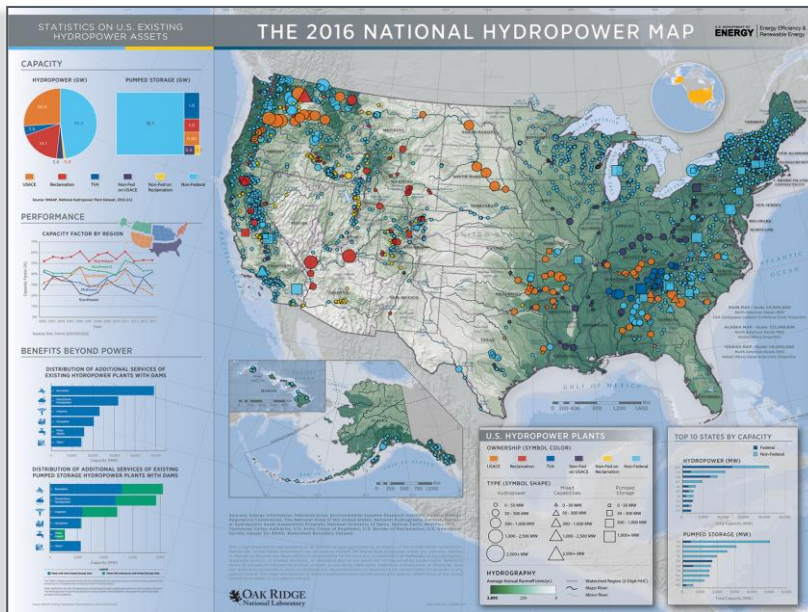
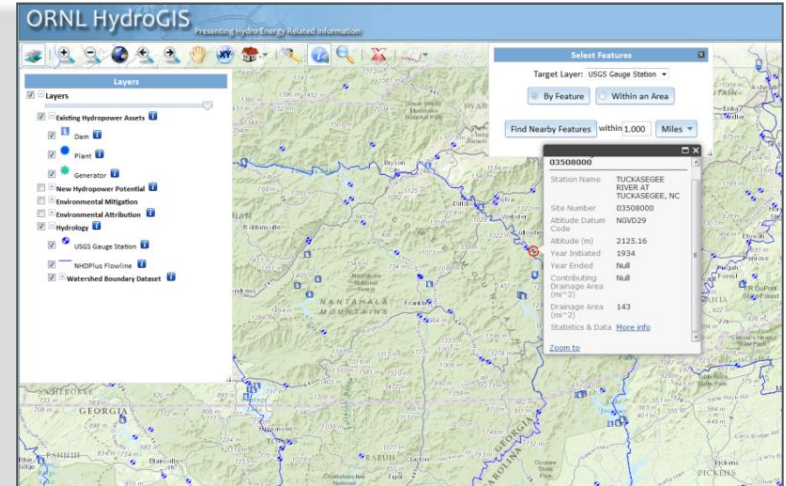
Geospatial Tools

Overview of NHAAP Data Holdings

Data Efforts	Description
Baseline – Baseline Data	A collection of most recent water, energy, infrastructure, and environment data from EIA, FERC, and other sources (http://nhaap.ornl.gov/content/nhaap-data-sources)
EHA – Existing Hydropower Asset	Location, power plant capacity, historic generation, and other facility information of U.S. existing hydropower fleet and newly licensed projects (updated every quarter)
NPD – Non-Powered Dams	Undeveloped U.S. hydropower resource potential from over 45000 national non-power dams (DOE 2012 NPD study)
NSD – New Stream-Reach	Undeveloped U.S. hydropower resource potential from over 2.7 million national new stream-reaches (DOE 2014 NSD study)
EA – Environmental Attribution	Comprehensive national geospatial polygons summarizing environmental concerns for hydropower development and operation.
SCT – Stream Classification Tool	A national stream-reach classification system that geospatially characterizes the biophysical settings of stream environments
MPT – Mitigation Data Set and Prediction Tool	A mitigation prediction model based on mitigation records summarized from over 380 FERC licenses issued within the last 15 years

NHAAP Baseline Services

- Provided fundamental asset, resource, and environmental data to support the DOE Hydropower Vision Study.
- Provided maps, summary tables, and visualizations to support the broader hydropower community.



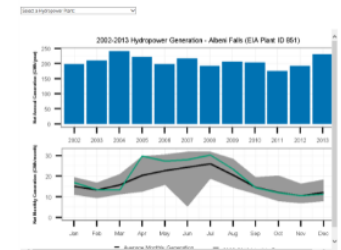
Historic hydropower Generation

U.S. HYDROPOWER GENERATION OVER TIME

EIA developed interactive charts of annual and monthly plant-level hydropower generation over time using historical data from the Energy Information Administration EIA. Select a state from the drop-down menu or map to view power plant-level summaries. Please note EIA data used for calculating historical trends includes records of hydropower and pumped storage generation and excludes any plants not currently active. Charts were excluded for power plants lacking sufficient historical data for calculating statistics (i.e., comprising more than 5% of EIA records between 2002-2015).

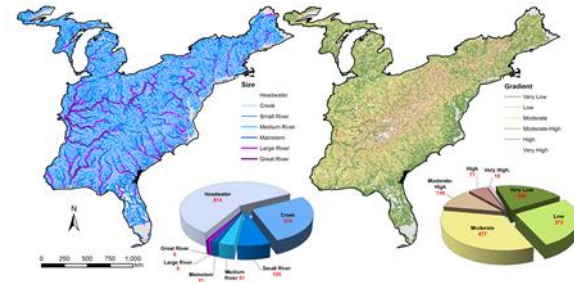


HISTORIC HYDROPOWER GENERATION - GW/HR



Stream Classification Tool

- Completed classification of ~ 1 million stream reaches in Eastern US
- 6 Layers: Hydrology, temperature, size, gradient, confinement, substrate
- Provided 11 different Google Earth layers (.kmz) for each region to be used in licensing/relicensing agreements



National Hydropower Asset Assessment Program
OAK RIDGE National Laboratory

STREAM CLASSIFICATION TOOL
A classification system to characterize and assess the hydrologic, thermal, geomorphological, and biological settings of stream environments including hydrologic, thermal, geomorphological, and biological sources.

Objectives:

- Improving the efficiency of Environmental Impact Assessment (EIA) and scoping for licensing/relicensing.
- Providing high resolution datasets to foster future water power research.
- Prioritizing conservation measures for different stream types and areas for future development.
- Providing a generalized framework to understand the extent of hydropower and associated mitigation measures.

To date this project has classified almost 1 million stream reaches in the US into groups of similar hydrology, temperature, and morphology. These datasets provide a tool that can be used to identify case studies or reference streams for comparison, and filter (4-digit HUK) and view within Google Earth to provide a user-friendly interface.

What is a Stream Classification?
At a basic level, stream classifications are an inventory of differences among different types of streams, make inferences regarding ecosystem health. While classifications aid in understanding fundamental differences among different types of streams, such as grouping sites with similar character, stratifying analyses of aquatic conservation, and generalizing ecological responses to different stream types.

How is it useful to Hydropower?
The SCT is useful to environmental mitigation for hydropower during the regulatory process by creating an objective and data-rich means to address meaningful mitigation actions. First, the SCT addresses

Tennessee

Information & Publications:

- Stream Classification User Manual and Tutorial
- Stream Classification Layer Definitions
- Stream Classification App Download

Stream Classification Tool

To use the data sets, first visit the Google Earth or Google Earth Pro website on your computer (click here for installation options). Choose a sub-region from the table below and then click to launch any KMZ layers of your choice in Google Earth. For full instructions and general information, please refer to the resources listed above.

Keep For Best Results, please view and download data using Google Chrome or Internet Explorer with Windows. Alternative browsers may cause with Firefox.

Subregion	HUK	Date	Metadata
Upper Tennessee	0601	Updated: 10/11/2011	
Middle Tennessee (Western)	0602	Updated: 10/11/2011	
Middle Tennessee (East)	0603	Updated: 10/11/2011	
Lower Tennessee	0604	Updated: 10/11/2011	

Google Earth

Stream Classification Tool

Empty River

Layer	Color	Update Date
0601	Light Blue	10/11/2011
0602	Light Green	10/11/2011
0603	Light Yellow	10/11/2011
0604	Light Purple	10/11/2011
0605	Light Orange	10/11/2011
0606	Light Red	10/11/2011
0607	Light Pink	10/11/2011
0608	Light Cyan	10/11/2011
0609	Light Blue	10/11/2011
0610	Light Green	10/11/2011
0611	Light Yellow	10/11/2011
0612	Light Purple	10/11/2011
0613	Light Orange	10/11/2011
0614	Light Red	10/11/2011
0615	Light Pink	10/11/2011
0616	Light Cyan	10/11/2011
0617	Light Blue	10/11/2011
0618	Light Green	10/11/2011
0619	Light Yellow	10/11/2011
0620	Light Purple	10/11/2011
0621	Light Orange	10/11/2011
0622	Light Red	10/11/2011
0623	Light Pink	10/11/2011
0624	Light Cyan	10/11/2011
0625	Light Blue	10/11/2011
0626	Light Green	10/11/2011
0627	Light Yellow	10/11/2011
0628	Light Purple	10/11/2011
0629	Light Orange	10/11/2011
0630	Light Red	10/11/2011
0631	Light Pink	10/11/2011
0632	Light Cyan	10/11/2011
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0636	Light Purple	10/11/2011
0637	Light Orange	10/11/2011
0638	Light Red	10/11/2011
0639	Light Pink	10/11/2011
0640	Light Cyan	10/11/2011
0641	Light Blue	10/11/2011
0642	Light Green	10/11/2011
0643	Light Yellow	10/11/2011
0644	Light Purple	10/11/2011
0645	Light Orange	10/11/2011
0646	Light Red	10/11/2011
0647	Light Pink	10/11/2011
0648	Light Cyan	10/11/2011
0649	Light Blue	10/11/2011
0650	Light Green	10/11/2011
0651	Light Yellow	10/11/2011
0652	Light Purple	10/11/2011
0653	Light Orange	10/11/2011
0654	Light Red	10/11/2011
0655	Light Pink	10/11/2011
0656	Light Cyan	10/11/2011
0657	Light Blue	10/11/2011
0658	Light Green	10/11/2011
0659	Light Yellow	10/11/2011
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0663	Light Pink	10/11/2011
0664	Light Cyan	10/11/2011
0665	Light Blue	10/11/2011
0666	Light Green	10/11/2011
0667	Light Yellow	10/11/2011
0668	Light Purple	10/11/2011
0669	Light Orange	10/11/2011
0670	Light Red	10/11/2011
0671	Light Pink	10/11/2011
0672	Light Cyan	10/11/2011
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0675	Light Yellow	10/11/2011
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0697	Light Blue	10/11/2011
0698	Light Green	10/11/2011
0699	Light Yellow	10/11/2011
0700	Light Purple	10/11/2011

Environmental Mitigation Tool

- Developed database of mitigation records for hydropower facilities
- Searched over 380 FERC licenses issued within the last 15 years
- Developed mitigation classification framework
- Developed prediction of mitigation requirements at non-powered dams

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Environmental Mitigation

2014 Hydropower Market Report

In consideration of goals to deployment of sustainable Environmental Mitigation environmental requirements The goal of the Environment NHAAP effort to provide h (1) develop a database of licenses of non-federal hy predictive models that can scenarios based on project

Mitigation Database

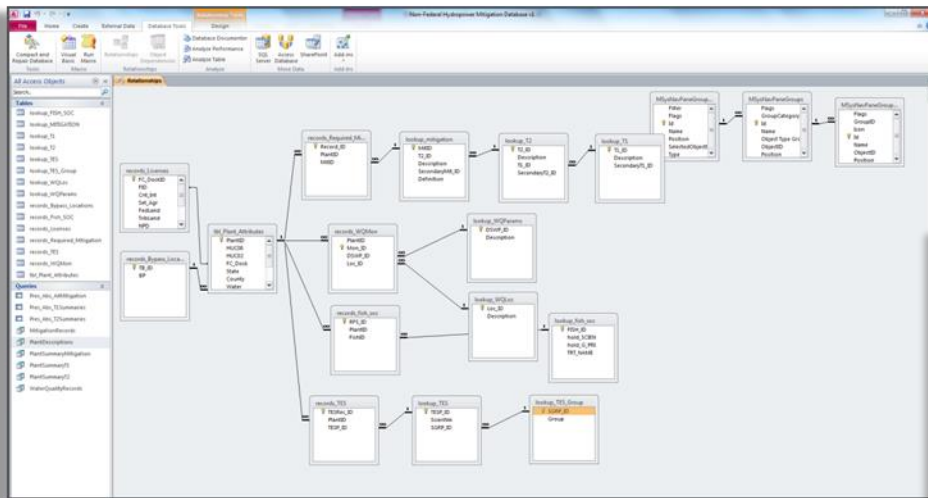
Mitigation requirements were compiled from FERC hydropower licenses issued from 1998 through 2013. Each mitigation record is associated with a unique plant identifier, state, hydrologic unit code, and a mitigation classification. Database development methodology and mitigation assessment reports are forthcoming. Summarized mitigation data at the 2-digit hydrologic unit code (HUC-02) level are available on NHAAP's HydroGIS. Mitigation data are available as a Microsoft Access database and in Excel format below (note that critical infrastructure information such as location coordinates have been removed from publicly accessible data).

Mitigation Prediction

Mitigation requirements from the mitigation database were linked to predictor variables using GIS. General categories of candidate predictors included facility characteristics, presence of sensitive fish species, human dimensions, hydrology, landscape characteristics, location, and stream network attributes. Predictive models were built using boosted regression trees for mitigation types that were required at greater than 5% of the plants in the mitigation database. Predictions of mitigation requirements can be applied to relicensing sites, non-powered dams, or potential new sites.

Data:

- Mitigation Database [Data: Access, Excel] [Metadata: Excel] [Classification Structure: PDF] [Citation] Bevelhimer, M.S., M.P. Schramm, C.R. DeRolph (2015), Non-Federal Hydropower Mitigation Database, Oak Ridge National Laboratory, available at: <http://nhaap.oakridge.gov/environmental-mitigation>, accessed online: [Month, date, year].



Record_ID	Mitigation	Mitigation_Predictors	Mitigation_Requirements	Mitigation_Status	Mitigation_Type	Mitigation_Year	Mitigation_Location	Mitigation_Environment	Mitigation_Economics	Mitigation_Social	Mitigation_Policy	Mitigation_Regulation	Mitigation_Infrastructure	Mitigation_Health	Mitigation_Education	Mitigation_Research	Mitigation_Distribution	Mitigation_Storage	Mitigation_Transportation	Mitigation_Information	Mitigation_Communication	Mitigation_Management	Mitigation_Maintenance	Mitigation_Improvement	Mitigation_Expansion	Mitigation_Construction	Mitigation_Operational	Mitigation_Closure	Mitigation_Removal	Mitigation_Rehabilitation	Mitigation_Recovery	Mitigation_Renewal	Mitigation_Replacement	Mitigation_Reconstruction	Mitigation_Renovation	Mitigation_Reinforcement	Mitigation_Repair		
3000	Surface Collector	3000	Surface Collector	3000	Surface Collector	3000	Surface Collector	3000	Surface Collector	3000	Surface Collector	3000	Surface Collector	3000	Surface Collector	3000	Surface Collector	3000	Surface Collector	3000	Surface Collector	3000	Surface Collector	3000	Surface Collector	3000	Surface Collector	3000	Surface Collector	3000	Surface Collector	3000	Surface Collector	3000	Surface Collector	3000	Surface Collector	3000	Surface Collector

	FY2014	FY2015	FY2016
Q1	Released national NPD and NSD maps		
Q2	Released final NSD assessment report		Released list of non-federal hydropower on USACE facilities
Q3		Released 2015 HMR data	Released 2016 updated HMR data
Q4	Released National Hydropower Map (v2014)	Evaluated NHAAP public outreach efforts Released environmental mitigation data	Released National Hydropower Map (v2016) Released Hydropower Plant Data Set

- Main project components
 - NHAAP Baseline Services (FY2014 – present)
 - Stream Classification Tool (eastern US, FY2014 – FY2015)
 - New effort in FY2017 on CONUS
 - Mitigation Data Set and Prediction Tool (FY2014 – FY2015)
- Go/No-Go decision point
 - FY2015 Q4 evaluation of NHAAP public outreach efforts
 - Accept and proceed

Budget History

FY2014		FY2015		FY2016	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
\$958K	\$0K	\$858K	\$0K	\$438K	\$0K

- Cost by main project components:
 - NHAAP Baseline Services: ~\$500K/FY (FY2014 – FY2016)
 - Outreach and external data support
 - Visualization and program support
 - Data update and expansion
 - IT operation and maintenance
 - Stream Classification Tool: 200K / FY (FY2014 – FY2015)
 - Mitigation Data Set and Prediction Tool: 200K / FY (FY2014 – FY2015)

Collaborating agencies

- U.S. Bureau of Reclamation (Reclamation), U.S. Army Corps of Engineers (USACE), Federal Energy Regulatory Commission (FERC), and Energy Information Administration (EIA)

Summary of major data support during FY14–16

- Hydropower Vision
 - Provided asset, resource, and environmental data support Hydropower Vision modeling and analysis
- Argonne National Laboratory (ANL)
 - Provided mode-of-operation data to support hydropower-storage study
- Congressional Research Service (CRS)
 - Provided NHAAP existing hydropower asset data
- Massachusetts Department of Protection
 - Provided detailed NSD data to support waste-site remediation study

Next Steps

- Continue to maintain NHAAP as ‘a comprehensive data service effort to support the DOE Water Power Program for various U.S. hydropower R&D data needs’

FY17/Current research

- NHAAP Baseline Services
 - Interagency and Hydropower Industry Engagement
 - Coordination with National Park Service, U.S. Forest Service, National Oceanic and Atmospheric Administration, and other broader hydropower industry / stakeholder groups to increase the usefulness of NHAAP data
 - Information Resource Management and User Services
 - Data Update and Expansion
- U.S. Stream Classification System
 - Development of a U.S. Stream Classification System (SCS) for the entire United States at the NHDPlus stream reach level based on hydrology, temperature, gradient, size, and valley confinement.