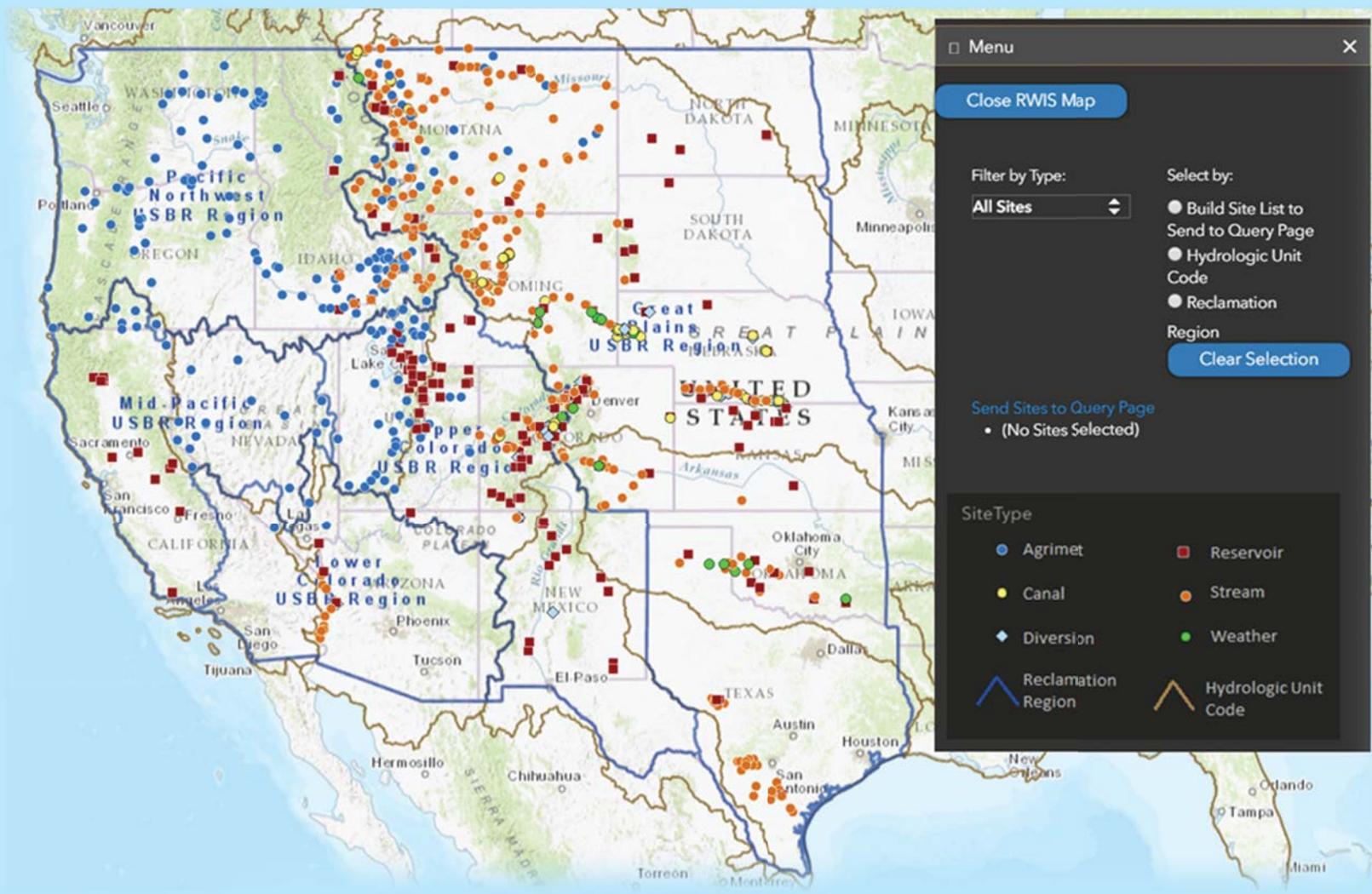


Knowledge Stream

Research and Development Office Magazine

Open Water Data



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Message from the Chief

Hello and welcome to the Spring 2017 edition of the *Knowledge Stream* magazine! Our theme this month is “Open Water Data,” which adhere to goals of making Federal datasets related to water resources more accessible to citizens and the private sector in order to benefit the economy and provide better decision support.

The Science and Technology (S&T) Program in the Research and Development Office (R&D) is supporting a variety of Open Water Data activities. In this issue, you will learn about:

- The Federal Open Water Data Initiative and other drivers motivating our efforts.
- Bureau-wide teams, including the Reclamation Data Council and the Open Data Team, working together to identify needs, opportunities, and project recommendations that will advance Reclamation's open data capabilities.
- Foundational information systems consolidating and centrally publishing water and related datasets, including the recently launched Reclamation Water Information System (RWIS) available at water.usbr.gov, and the in-development Reclamation Information Sharing Environment (RISE) that will address other data areas, including hydropower, infrastructure, and environment.
- Projects exploring new ways to share and visualize data for a variety of subject areas (reservoir water conditions, infrastructure assets, mussels, field data collection, WaterSMART assessments, etc.).
- . . .and much more!

Lastly, you will read about research bulletins announcing new product releases as well as technology prize competition developments, including two new competitions—one focused on helping us better estimate sediment accumulation within our reservoirs and how it may be affecting water supplies, and another inviting new ways to forecast “sub-seasonal climate” describing weather conditions 3 to 6 weeks out.

Activity area coordinators and contacts are provided if you would like to follow up and learn more about these activities. We hope you enjoy!

Levi Brekke
Chief of R&D

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ANGELA ADAMS

**in Reclamation's
Lower Colorado Region
served as topic editor
for this issue**

**NEXT IN
FISCAL YEAR 2017**

**From the Regions
(summer)**

**Renewable Energy
and Hydropower
(fall)**

Community Needs

A Vision for Open Data Within Reclamation

“While consolidating data from various sources can help innovation beyond the public sector, access to data alone cannot spur innovation; it requires commitment, investment of resources, and sustained efforts on the part of the agency to achieve economic and social value” (Krishnamurthy and Awazu 2016; see “more information”).

Data are one of Reclamation’s most important assets. Reclamation program managers use a wide range of data to inform decisions on effectively delivering water and power—historical and real-time information about activity areas, including reservoir operations, hydropower, species recovery and river restoration, lands, structures, and much more. Moreover, Reclamation’s data support a wide range of internal and user communities, from real-time flood and disaster assistance to long-term views of ecosystems and infrastructure.

In 2013, the Office of Management and Budget issued Federal policy, *Open Data Policy—Managing Information as an Asset*, stating that “making information resources accessible, discoverable, and usable by the public can help fuel entrepreneurship, innovation, and scientific discovery—all of which improve Americans’ lives and contribute significantly to job creation” (see “more information”). Currently, the Congress is considering the OPEN Government Data Act, which would require that government data assets be made available by Federal agencies (subject to confidentiality, security, and privacy restrictions) free to the public in standardized, open formats. Within the U.S. Department of the Interior, Reclamation is participating in the Open Water Data Initiative intended to “integrate currently fragmented water information into a connected, national water data framework and leverage existing systems, infrastructure and tools to underpin innovation, modeling, data sharing, and solution development” (Advisory Committee on Water Information; see “more information”).

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This *Knowledge Stream* issue highlights Reclamation projects and activities advancing open data. As addressed in the article on page 10, the Research and Development Office is supporting work on a Reclamation-wide water-related data portal to integrate datasets through use of common standards and addressing tough challenges of data stewardship, privacy, and security—this helps data to be better understood, used, and analyzed in tandem with other datasets.

Publishing and visualizing data are also key factors to ensuring data utility is maximized. Making datasets easier for machines to use in models, apps, and other tools requires working with data producers to overcome behind-the-scenes technical hurdles to connect datasets with program needs as described in the article on page 18. The articles on pages 8 and 16 highlight work that develop tools and visualizations.

Open data activities increase Federal transparency and support accountability, engender civic engagement, spur innovation, and drive economic growth. Reclamation’s open water data initiatives depend heavily upon collaboration across agencies, support of top management, and continued efforts of all staff producing data and users analyzing and making use of the data. Open data is for all.

More Information

Krishnamurthy, R. and Y. Awazu. 2016. “Liberating data for public value: The case of Data.gov.” *International Journal of Information Management*. Elsevier Ltd. Available online at:
<https://static1.squarespace.com/static/547955f9e4b010fe66b4a701/t/584b11846a49633529394231/1481314692674/Liberating+Data+for+Public+Value.pdf>

Office of Management and Budget. 2013. *Open Data Policy—Managing Information as an Asset*. M-13-13, Memorandum for the Heads of Executive Departments and Agencies. Available online at:
https://obamawhitehouse.archives.gov/omb/memoranda_2013

Advisory Committee on Water Information’s “Open Water Data Initiative Overview:” <https://acwi.gov/spatial/owdi/>

For further information, or if you have datasets you would like to tell us about, please contact Angela Adams.

Open Water Web

Water Data Catalog	Water Data as a Service	Enriching Water Data	Community for Water Data Tools
Find Source Data	Consensus Standards	Network Routing	Marketplace for Knowledge
Create Themes	Visualization and Delivery	Coupling Models	Usage Tracking
Recruit/Engage Partners	Catalog and Serve	Geospatial Framework	Best Practices

Open data activities increase Federal transparency and help Reclamation work to deliver on the government’s commitment to open data.

Key Perspectives

Connecting to Reclamation's Data Communities

A community of data stewards lies at the heart of every open data initiative. Data stewards gather, analyze, and share datasets, and need to come together to understand and use core Reclamation mission data. The U.S. Department of the Interior's (DOI) Open Water Data Initiative requests bureaus to inventory and describe datasets, publish those that can be made public, engage with end users to prioritize data releases, and clarify agency roles and processes to manage and release data effectively.

In 2015, Reclamation's Science Advisor, David Raff, established a bureau-wide Open Data Team to help develop foundations for open water data within Reclamation, including advising on how Reclamation could best use open water data funding. Team findings included:

- Reclamation does not track data within, and between, parts of the organization
- Water and power operations data are not typically shared in a machine-readable format
- Systems and data holdings are managed in isolation
- There are no complete, current, and authoritative lists of Reclamation-owned or -managed buildings, structures, or lands holdings at the agency level.

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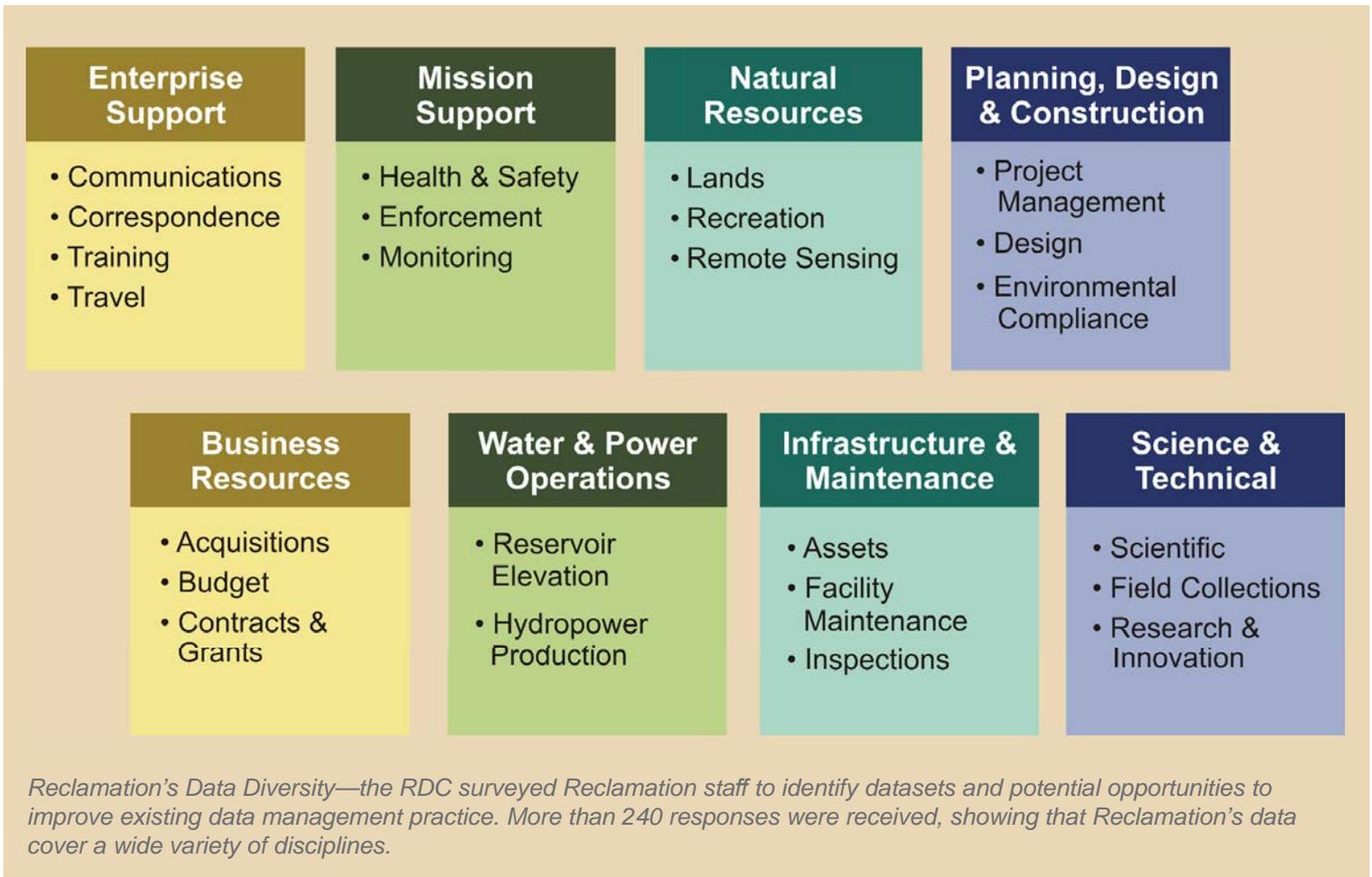
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To address the findings, the team recommended creating an agency-wide coordination and governance group for data planning, acquisition, management, and analysis to improve the quality, currency, completeness, and awareness of Reclamation data holdings. To meet this need, the Reclamation Data Council (RDC) was formed to serve as the coordinating team for Reclamation's open water data and related data management activities.

The RDC operates through Reclamation's Policy and Administration Office, coordinates Reclamation enterprise data management activities, develops policy and guidance, and promotes data stewardship and best practices to efficiently and effectively support the Reclamation mission through its programs, systems, and projects.

As one of its first actions, the RDC conducted a Reclamation-wide survey to identify Reclamation's datasets and potential opportunities to evaluate and improve existing data management practice. More than 240 responses were received, showing that Reclamation's data cover a wide variety of disciplines (see figure). Most respondents manage data in spreadsheets or electronic documents, but 30 percent (%) of respondents indicated that a portion of the data managed within their program only exists in paper format (i.e., no scanned or electronic files). Over 35% of respondents identified interest in working with the RDC and most identified a specific data management pilot activity that would be of interest; pilot topics ranged from digitizing historic records to geospatial databases of Reclamation facilities, environmental compliance records, and water and power operations data.

Financial and business data users compose one of Reclamation’s key user communities. The data these users utilize are important within Reclamation; budget and spending data will also be shared with the public in open formats. To support this transparency and standardize Reclamation’s financial, business, and administrative workflows into a single department-wide system, Reclamation uses DOI’s Financial Business Management System (FBMS). This is an Enterprise Resource Planning System integrating financial, property, and procurement operations and data. FBMS allows Reclamation to incorporate its financial and business process management into a single solution to enter, modify, research, and report on data for their respective functional and reporting areas.



Current Research and Partnerships

Open for Business: Existing Tools and Visualizations That Drive Better Analysis and Decisionmaking

Data have a relationship with reality; as more data are gathered about something and put into context with each other, they become information and can support knowledge growth and decisionmaking. In 1854, Dr. John Snow, a founding father of modern epidemiology, detailed data maps of wells and cholera outbreaks that led to effective ways to prevent the deadly outbreaks. Today, data are far more complicated, with many more potential implications. Presenting data so that users can quickly understand these implications is a daunting task. But Reclamation is pursuing many avenues to effectively visualize data to support analyses and decisionmaking.

Reclamation's WaterSMART Program (Sustain and Manage America's Resources for Tomorrow) has developed two new data visualization tools, using Geographic Information System (GIS) Story Maps. WaterSMART uses a basin-wide approach to water resource management and works with states, Tribes, local partners, and other stakeholders to evaluate 25 river basins and their ability to meet future water demands, and to identify strategy to address imbalances between water supplies and demands. One data visualization tool provides interactive maps to show all of the WaterSMART projects in the Western United States, animated timelines to show the growth of projects, and featured project tours with information and photographs for various projects (see "more information"). The other data visualization tool, presents information from the 2016 SECURE Water Act Report to Congress, which summarizes Reclamation's analysis of climate variability and potential risks from extreme events, droughts, and floods. This report covers eight different water basins with a diverse array of scenarios and analyses, and separate reports (see "more information"). The tools go from a broad overview to specific studies in each basin and allows users to zoom into and pan around maps to explore their area of interest and download all data files. The combination of narrative with data and other graphics promotes a descriptive approach that can be modeled towards a variety of audience segments.

Within the financial arena, the Digital Accountability and Transparency Act of 2014 (DATA Act) establishes governmentwide financial data standards and helps make Federal spending data more accessible, searchable, and reliable (see "more information").

Open financial data not only makes it easier to understand how the Federal Government spends taxpayer dollars, but also serves as a tool for better oversight, data-centric decisionmaking, and innovation both inside and outside of government. The U.S. Department of the Treasury and the Office of Management and Budget (OMB) are leading the governmentwide implementation of the DATA Act. Reclamation will send its DATA Act certification and submission to OMB by April 30, 2017. Reclamation's Program and Budget Office (Washington, D.C.) and Management Services Office (Denver, Colorado) are working collaboratively to provide bureau support to the U.S. Department of the Interior to provide open data for:

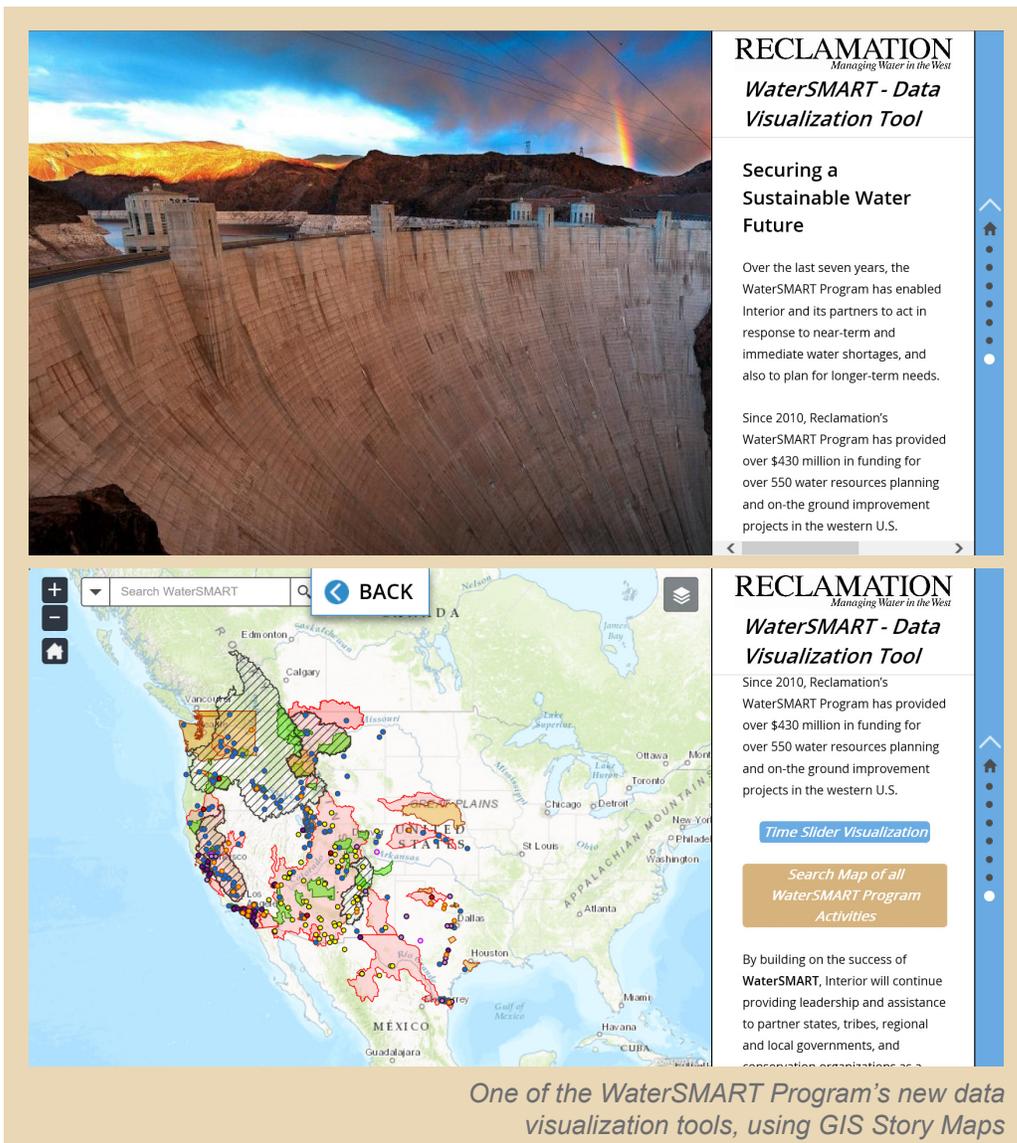
- Award/Financial Information
- Appropriations
- Procurement
- Object Class and Program Activity
- Financial Assistance

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More Information

WaterSMART - Data Visualization Tool website portal:

<http://tinyurl.com/watersmart-programs>

SECURE Report - Data Visualization Tool website portal:

<http://tinyurl.com/secure-climate>

Information available under the DATA Act can be found at:

USASpending.Gov

S&T Program research scoping study/report:

www.usbr.gov/research/projects/download_product.cfm?id=1537

GitHub USBR - DSS, NetCDF, SQLite (and Pisces) tools and documentation:

<https://github.com/usbr/convertdss>

Reclamation's Pacific Northwest (PN) Region's Pisces webpage:

www.usbr.gov/pn/hydromet/pisces/

PN Region's Reservoir Storage "Teacup" Diagrams webpage:

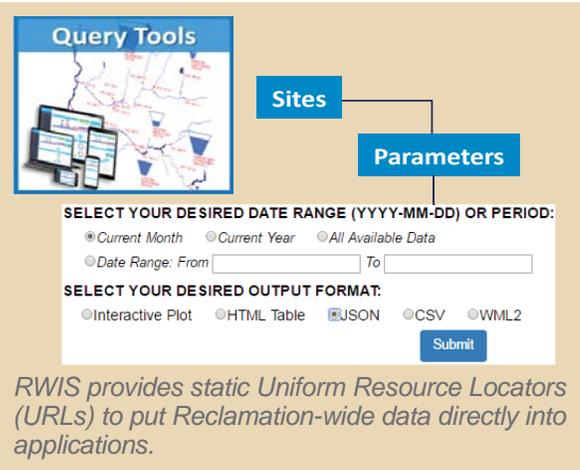
www.usbr.gov/pn/hydromet/select.html

Reclamation's Science and Technology (S&T) Program also funds work on data analysis and visualization tools. Outputs from water resources planning models vary depending on model type (e.g., operational, groundwater, hydrodynamic). To analyze results from a variety of models, Reclamation needs generic database and visualization packages that are open source, user-friendly, and can be customized. These packages can provide a common visualization framework to visualize results from individual models and to allow analysts to integrate results from different models.

For example, an S&T Program research scoping study/report, *Investigation of Software Tools for Visualization of Results from Water Resources Planning Models* (see "more information"), examined what tools would work best for developing a generic data visualization interface for time series outputs from water resources planning models. This study developed tools to convert HEC-DSS format data to NetCDF and SQLite formats (see "more information" for tools and documentation). In addition, this study updated the Pisces software data visualization desktop application to read data in SQLite format (see "more information") and was incorporated into the Reclamation Water Information System (see the article on page 10).

Laying a Durable Foundation for Open Data With Reclamation

Data plays a vital role in Reclamation’s work to deliver water and power. However, until recently, it has been challenging for Reclamation’s internal and external customers and stakeholders to locate and access that data. Reclamation’s operational staff collect, maintain, and use data every day, but these data are typically stored in isolated regional databases or spreadsheets that are not accessible to other Reclamation staff or to those outside Reclamation who may want to use it.



RWIS provides static Uniform Resource Locators (URLs) to put Reclamation-wide data directly into applications.

To address this problem, Reclamation is establishing a foundation for sharing open data through the Reclamation Water Information System (RWIS). This web portal provides query tools, map browsing capabilities, and an Internet interface for viewing, accessing, and using machine-readable data in apps and models. RWIS originated as a prototype in 2015 that demonstrated the possibility of data centralization and dissemination via a basic web service. In 2016, the system was developed into a pilot for sharing daily time series water data from across Reclamation in a centralized data portal. The pilot demonstrated ways to create crosswalking data standards, tools to centralize data while maintaining operational databases, and a web portal for sharing data publicly. The pilot is currently being expanded to encompass a wider range of water data and additional functionality to the web portal. See “more information.”

RWIS paves the way for the Reclamation Information Sharing Environment (RISE), which is envisioned to share data from other topic areas beyond water and other types of data beyond time series in open formats via a centralized, sustainable public data portal. RISE project work began in early 2017, and is currently ongoing. The team working on both the RWIS and RISE projects has grown to include a broad spectrum of Reclamation staff who are adding more water data and expanding the data portal to include data related to infrastructure, hydropower, and environmental areas. RWIS and RISE directly address Reclamation’s need for open data (as discussed in the article on page 11). Together, the RWIS/RISE effort:

More Information

RWIS web portal:

<https://water.usbr.gov/>

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- Builds data communities
- Establishes data standards for crosswalking between databases
- Creates data acquisition systems and builds tools to make data accessible to internal and public stakeholders
- Formulates a common metadata schema and compiles metadata
- Screens and protects data from improper release
- Complies with appropriate security requirements
- Builds visualization and analysis tools

RWIS and its evolution into RISE are currently being implemented as Reclamation Science and Technology Program research projects, but preparations for sustaining the systems beyond the life of these projects are also underway. Strong data communities within Reclamation, like those that have been cultivated through the RWIS/RISE effort, are vital to the ongoing success of data sharing. Maintaining the hardware and software infrastructure for a central database and web portal will require long-term funding arrangements that are currently being discussed. Identifying responsibilities for RWIS/RISE within Reclamation’s organizational structure will ensure that the evolved system is properly governed and managed. These sustainability efforts are needed to ensure that Reclamation’s centralized system for sharing open data can be available to its internal and external stakeholders in the years to come.

What is Open Data?

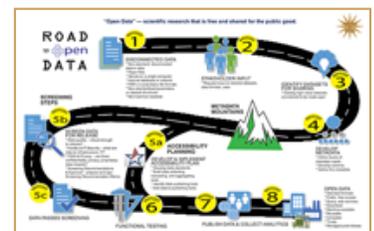
“Open data is data that can be freely used, shared and built-on by anyone, anywhere, for any purpose” (Open Knowledge Foundation).

The concept of “open data”—that scientific research results should be free and shared for the public good—has only been around since 1940, and the term itself is even younger; only in use for the last 20 years. Making data and information resources accessible, discoverable, and usable by the public is required by Federal laws, such as the Digital Accountability and Transparency Act of 2014 (DATA Act), which requires Federal agencies to publish their spending data in a standardized, machine-readable format that the public can access through USAspending.gov (see “more information”). Other laws, policies, and Executive Orders also require Federal agencies to collect or create information in a way that supports downstream information processing and dissemination, and to use machine-readable and open formats for all new information collected or created.

How to Know if Data Is Open

Open data encompasses several concepts, including:

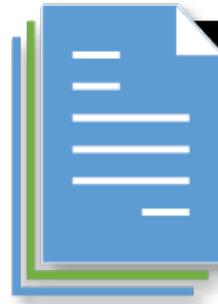
- **Releasable to the Public.** According to the Federal Open Data Policy—Managing Information as an Asset, agencies must presume data will be made open to the extent permitted by law and subject to privacy, confidentiality, security, or other valid restrictions. Agencies are required to analyze privacy, confidentiality, and security risks to identify information that should not be released. Therefore, agencies may, as a result of these processes, determine that some data will not be released to the public. It is important to note that these datasets are still a byproduct of the Open Data Policy, and agencies will internally benefit from cataloging the data and developing greater dataset interoperability within the government.
- **Accessible.** Datasets are made available in convenient, modifiable, and open formats that can be retrieved, downloaded, indexed, and searched. Accessible includes three subconcepts:
 - ❖ **Machine-Processable.** Datasets are reasonably structured to allow automated processing. “Machine-readable” means data (or metadata) are in a format that can be understood by a computer. Having data available in machine-readable formats makes it easier for the computer to extract, transform, and process that data. Examples of data file formats intended principally for processing by machines includes: RDF, XML, JSON (Wikipedia, “Machine-Readable Data”).
 - ❖ **Non-Discriminatory.** Open data structures do not discriminate against any person or group of persons and should be made available to the widest range of users for the widest range of purposes, often by providing the data in multiple formats for consumption.



In this electronic version of the *Knowledge Stream* issue, the “Road to Open Data” pullout has been added as the final page to make printing an 11x17 page easy.

—continued on page 14 with pullout in between

ROAD to pen DATA



WAYPOINT
1

DISCONNECTED DATA

- * Non-standard, disconnected data in silos
- * Paper files
- * Stored on a single computer
- * Internal database or network
- * PDFs or proprietary file formats
- * Non-standardized parameters or dataset structures
- * Not machine-readable

SCREENING STEPS

WAYPOINT
5b

SCREEN DATA FOR RELEASE

- * Data quality – robust enough to release?
- * Facility & IT Security – what are risks to infrastructure, IT?
- * FOIA & Privacy – are there confidentiality, privacy, proprietary data impacts?
- * Screening Recommendations & Approval – prepare and sign Screening Recommendation Memo.

WAYPOINT
5a

ACCESSIBILITY PLANNING

DEVELOP & IMPLEMENT ACCESSIBILITY PLAN

- * Develop data standards
- * Build data collecting, harvesting, and aggregating tools
- * Identify Web publishing tools
- * Add data to publishing tools

WAYPOINT
5c

DATA PASSES SCREENING

WAYPOINT
6

FUNCTIONAL TESTING

What is free and shared for the public good.



WAYPOINT
2

STAKEHOLDER INPUT

- * Request input on desired datasets, data formats, uses



WAYPOINT
3

IDENTIFY DATASETS FOR SHARING

- * Catalog high-value datasets considered to be made open

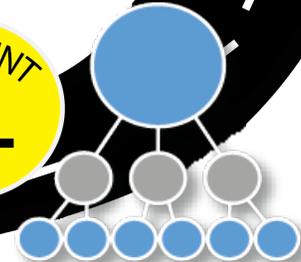
METADATA MOUNTAINS



WAYPOINT
4

DEVELOP METADATA

- * Define levels of metadata needs
- * Develop schema
- * Gather the metadata



ABILITY
G
MENT
AN

g
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WAYPOINT
7



WAYPOINT
8



PUBLISH DATA & COLLECT ANALYTICS

OPEN DATA

- * Standard formats
- * Public, free access
- * Query, web services
- * Described
- * Machine-readable
- * Reusable
- * Complete
- * Timely
- * Managed post-release

What is Open Data?

How to Know if Data Is Open

Open data encompasses several concepts, including:

More Information

DATA Act:

www.congress.gov/bill/113th-congress/senate-bill/994

USAspending.gov:

www.usaspending.gov/Pages/default.aspx

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❖ **Optimally Usable.** Depending on the data subject, it is made available in formats that are specific to the subject's data community. These formats are typically the most widely accepted and used by experts versed in the subject matter. An example of this would be to produce some types of water data in formats that are used by other water resource agencies, state water offices, emergency management organizations, and researchers in water science and usage.

- **Fully Described.** Data are described fully so that consumers of the data have sufficient information to understand their strengths, weaknesses, analytical limitations, and security requirements, as well as how to process them. This involves the use of robust, granular metadata (i.e., fields or elements that describe data), thorough documentation of data elements, data dictionaries, and, if applicable, additional descriptions of the purpose of the collection, the population of interest, the characteristics of the samples, data quality measures, and the method of data collection.
- **Reusable.** Datasets are made available under an open license that places no restrictions on their use.
- **Complete.** Datasets are published in primary forms (i.e., as collected at the source), with the finest possible level of granularity that is practicable and permitted by law and other requirements. Derived or aggregate open data should also be published, but must reference the primary data.
- **Timely.** Datasets are made available as quickly as necessary to preserve the value of the data. Frequency of release should account for key audiences and downstream needs.
- **Managed Post-Release.** A point of contact must be designated to assist with data use and to respond to complaints about adherence to the open data requirements. This may be provided in the metadata.

Safer, Cheaper Data by Using Unmanned Aircraft Systems

For data to be analyzed, they must first be collected, organized, and made available. Within Reclamation, several activities seek to create new paths for collecting and serving data, building tools for using the data, and sharing the data to help advance Reclamation’s mission.

New inroads are being made in the area of collecting data and making them available for analysis. One inroad involves collecting facility data using unmanned aircraft systems (UAS). UAS data retrieval is still new to Reclamation and there are sensitivities to collection, management, and use of data using these tools—so the data they collect may not be able to be publically shared without screening. The data itself constitutes an important source of standardized, high-quality data that can be combined with other data to support enhanced analysis.

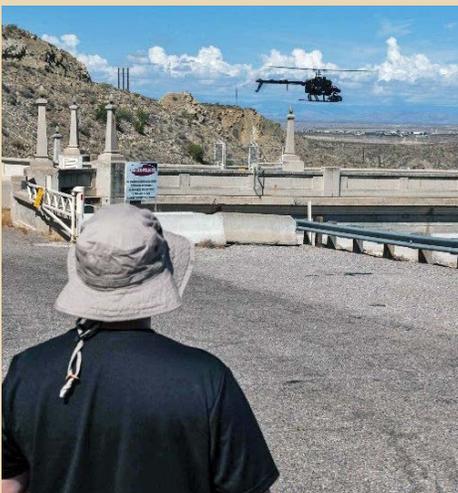
One research project supported by Reclamation’s Science and Technology Program, “Unmanned Aerial Systems Data Collection at Reclamation Sites,” is exploring whether UAS can be used to collect data about Reclamation facilities less expensively and more safely than current methods. The project focuses on inspections of Reclamation’s facility features such as dam structures, foundation elements, and sedimentation, and considers formats such as infrared, high-resolution imagery for photogrammetry, and multispectral data. Data collected can be post-processed into 2D and 3D models, with the models anticipated to allow for virtual inspections and analysis of the different features. The models can help engineers develop condition assessments, identify areas needing repairs, observe changes that occur between inspections, and acquire views of facilities that would otherwise be difficult or impossible to obtain.

Collecting data on Reclamation’s facilities can expose staff to risks. For example, the research project’s principal investigator, Matthew Klein, and team member, Bryan Simpson, from Reclamation’s Technical Service Center cite potential risks in using rope access teams and man lifts to collect data for photogrammetric models of foundation excavations for modifications to Glendo and Guernsey Dams, Wyoming. Due to the remote site locations and the rugged, steep, and often inaccessible areas of modifications, data collection is difficult to coordinate. Further, equipment limitations mean that optimal data collection is sometimes not possible. Using UAS could ensure easier, safer collection of data under such conditions.

UAS-collected data can be put through the open data screening process to determine which elements, if any, can be made open. While data on some critical Reclamation facilities may not be suitable for release, UAS-collected data on nonsensitive Reclamation areas could make it through the open data process for eventual public access.

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UAS data collection at Elephant Butte Dam, New Mexico. Photograph by Alex Stephens, Reclamation’s Public Affairs Office.

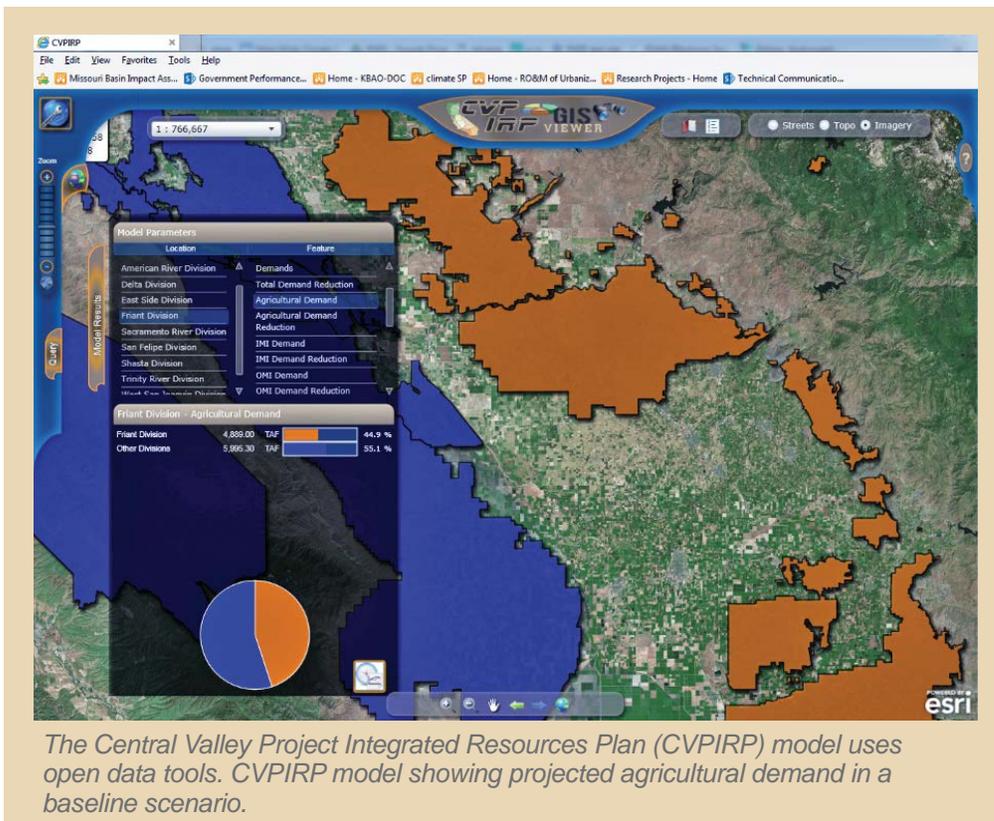


Screenshot of a 3D model of Elephant Butte Dam, New Mexico, comprised of UAS-collected data.

In the Pipeline: Tools and Visualizations Under Development That Drive Better Analysis and Decisionmaking

Reclamation has made great strides in making data open, accessible, and usable. Reclamation is working to use open data to accomplish its mission more effectively in many areas, including managing assets for infrastructure, analyzing water quality to address drought impacts in California, and working with partners to analyze various climate scenarios in California.

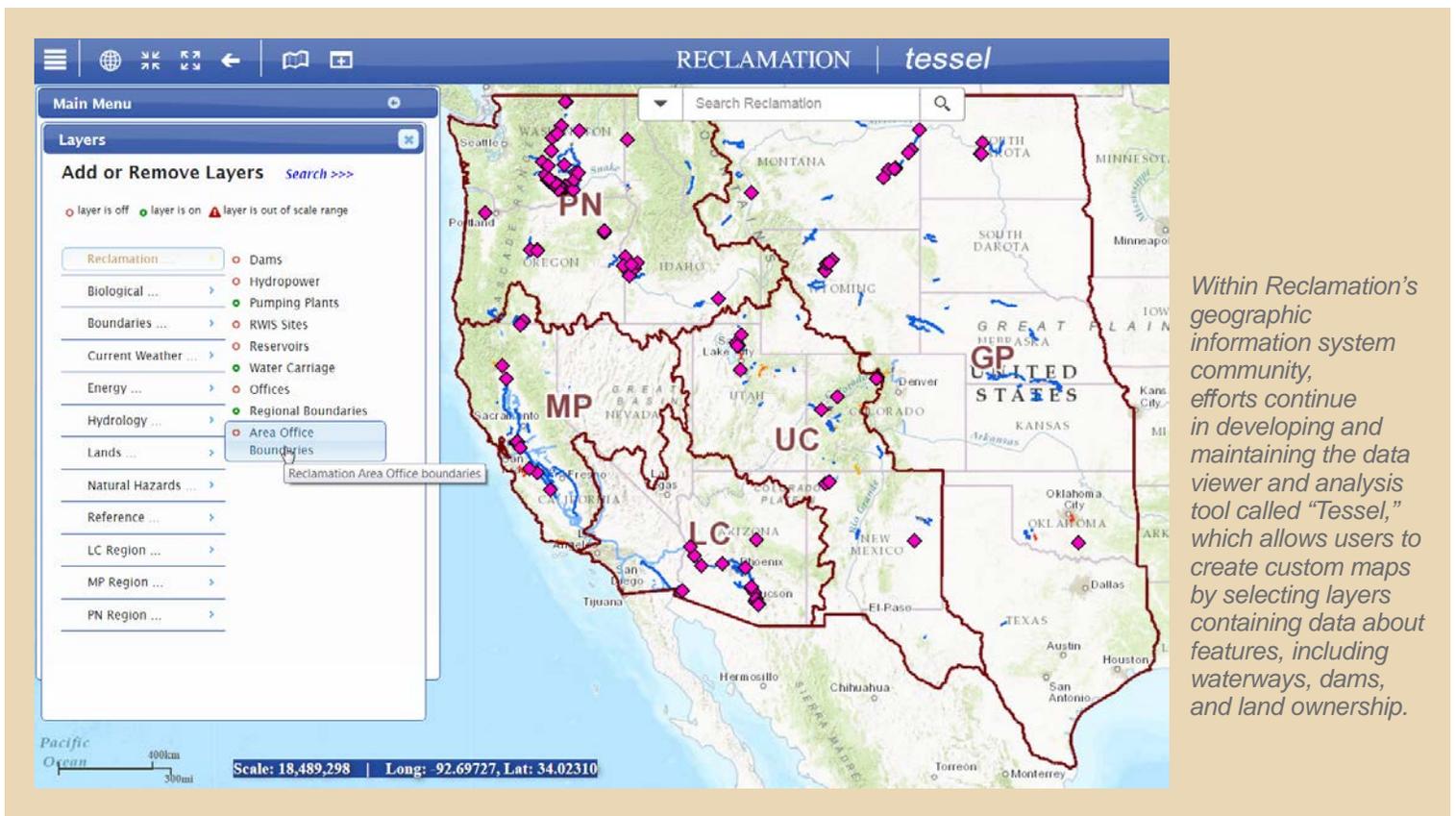
To help manage Reclamation's infrastructure, the Reclamation Data Council (RDC) is funding a pilot project to develop a comprehensive, geospatially enabled, Reclamation-wide asset management tool. The RDC is coordinating this joint effort with assistance from infrastructure subject matter experts in all of the regions. Work commenced in December 2016 to build a standard data management framework for Reclamation's infrastructure assets in two phases: 1) developing core data schema for Reclamation asset types; and 2) collecting data for, and applying the schema to, a selected Reclamation project. The pilot will develop recommendations to improve data schema, collection, and assembly methodologies, and to provide guidance specific to roles, responsibilities, and workflows needed to populate and maintain geospatial and business data required for a full enterprise asset inventory.



The Central Valley Project Integrated Resources Plan (CVPIRP) model uses open data tools. CVPIRP model showing projected agricultural demand in a baseline scenario.

In the area of water management, Reclamation is using open data tools to help manage water in the California drought. Reclamation and partners are developing a potential Drought Sampling Analysis Plan to collect baseline water quality data profiles (temperatures and concentrations) from Mid-Pacific Region reservoirs with low water surface elevations. These data will be organized into a dry year water quality profile for water resource planning and decisionmaking. The water quality data being gathered are complex, so the project is focusing on automated add-on packages to database software to support future Open Water Data Initiative projects (see article on page 11). Automation helps support faster, more accurate data analysis. By harnessing existing graphical capabilities of commonly used software, Reclamation can provide a familiar look and feel to users and water quality modelers as they use these new data.

Open data tools can also be harnessed to support long-term planning, such as helping Reclamation understand complex future climate scenarios. One Reclamation Science and Technology Program research project seeks to develop a West-Wide Climate Planning Data Viewer (WWCPDV) to show various climate scenarios, economic development scenarios, and possible actions. This data viewer, developed in collaboration with the California Department of Water Resources, helps partners to effectively communicate climate change risks and uncertainties as well as the effectiveness of possible adaptation strategies. This easy-to-use web-based platform will encourage stakeholders and others to explore planning study results and data. When deployed, it will be able to facilitate widely distributed group interactions in support of planning and decisionmaking activities. The WWCPDV is currently in an initial design phase and will expand the capabilities of an earlier web-based tool developed for the Central Valley Project Integrated Resources Plan (CVPIRP) by adding user access to the hydroclimate data as well as adaptation strategy results. These capabilities will also allow existing and future planning studies to add their results to the template.



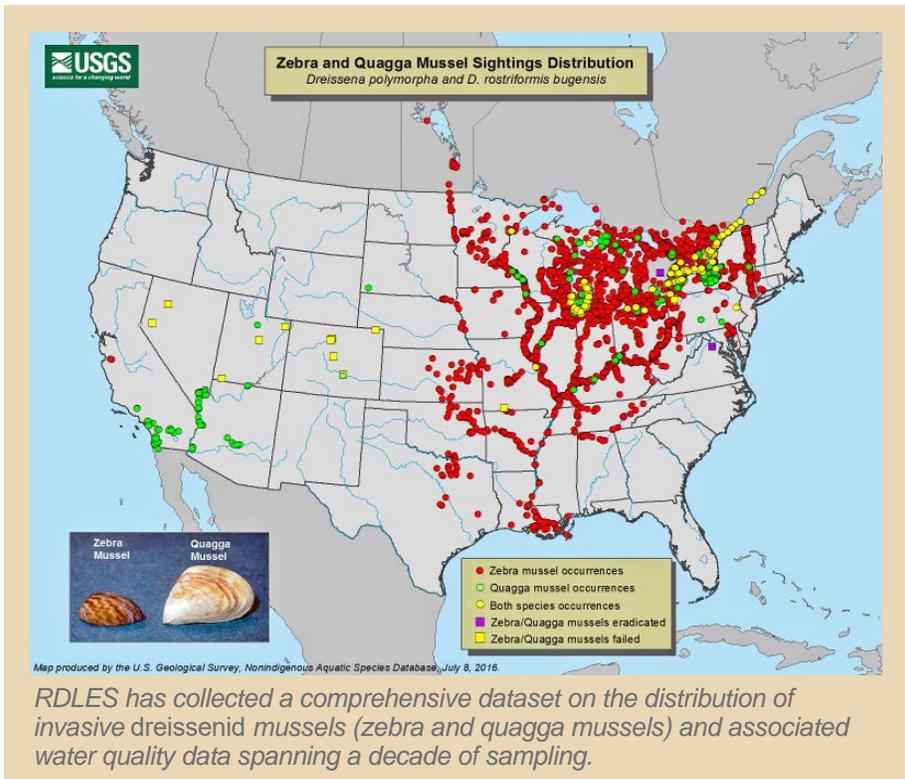
Within Reclamation's geographic information system community, efforts continue in developing and maintaining the data viewer and analysis tool called "Tessel," which allows users to create custom maps by selecting layers containing data about features, including waterways, dams, and land ownership.

Contact

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Open Data Infrastructure: Building a Database to Support Public Access to Mussel and Water Quality Data

Which open data functions are most critical: making data open and accessible or creating analytical and visualization tools that support analysis and decisionmaking? No matter what the answer is, both of these two functions depend on a third element of open data—the behind-the-scenes hardware and software infrastructure that make both data accessibility and visualization possible.



One such software infrastructure component is a computerized database, which allows data to be structured, stored, and accessed in a variety of ways. For example, the Reclamation Detection Laboratory for Exotic Species (RDLES) in Denver, Colorado, has collected a comprehensive dataset on the distribution of invasive dreissenid mussels (zebra and quagga mussels) and associated water quality data spanning a decade of sampling. The research community has expressed strong interest in having these data available to use in analyzing and modeling patterns of mussel invasion.

To share and visualize these data, Reclamation's Technical Service Center (TSC) is developing an open access web-based database of invasive aquatic research and water quality data. TSC and RDLES are collaborating with Reclamation's Information Resources Office on this effort.

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More Information

S&T Program Research Project
(Project ID 7105):

www.usbr.gov/research/projects/detail.cfm?id=7105

This Reclamation Science and Technology (S&T) Program research project involves integrating the data into a searchable web-based relational database that will be made open access and available to researchers and the public. The database can be used to support analysis of factors that promote or inhibit mussel establishment in new water bodies and can provide a basis for managing resources to minimize the possibility of new invasions.

The web-based database will serve as an extensible platform that will be designed to incorporate data on other invasive species of concern that are expected to threaten Reclamation in the future.

Partnerships to Help Maximize the Potential of Open Data

Open data happens within a community—collecting data, transforming them into open data, and using data in innovative ways to support economic growth and create social value. Partnerships between communities that create data and those who use them invigorate open data, and three components in particular support open data: public datasets, citizen scientists, and prize competitions. Reclamation’s commitments to opening public datasets allows citizens, academics, and others to analyze and understand data, leading to stronger return on taxpayer investments, better products to support more efficient mission accomplishments, and civic engagement in priority activities. Moreover, citizen scientists can work within Reclamation’s Water Prize Competition Center to find new ways of collecting and disseminating data by participating in prize competitions. The Water Prize Competition Center invites industry, nonprofit organizations, and venture capital representatives to participate as partners and/or official judges of these prize competitions and seek potential business deals with prize competition participants. (See “more information” and the “Technology Prize Competitions” segment in this issue.)



Engineers use mobile apps for water and environmental data collection.

One of Reclamation’s major data requirements benefitting from these partnerships is developing global positioning system (GPS)/geographic information system (GIS)-enabled tablet applications to help Reclamation collect and use data from the field. Reclamation collects and validates field data for a wide variety of studies, such as cultural resources management, environmental monitoring and assessment, infrastructure condition monitoring and inspections, and water delivery management. Noting field data on paper does not capture the three-dimensionality and geographic locations critical to understanding the data and monitoring Reclamation facilities. Current mobile technologies, when coupled with GPS/GIS capabilities, can help efficiently capture new data, complete inspection checklists, query and compare previous inspections, and take photographs, which could even be used for photogrammetric analysis.

While Reclamation’s Science and Technology Program research has investigated apps and devices for collecting data in the field, existing technology does not provide the functionality and flexibility needed to support the broad range of water and environmental monitoring needs. For example, most existing apps are unable to interface with field instruments (e.g., sensors and data loggers), and many have limited options for exporting data. Custom apps can address some of these needs, but these are expensive and time-consuming to build and, typically, are not transferrable to other programs or open data.

A prize competition for solutions that will help Reclamation develop common protocols and standards for data collection, management, and sharing by using open source software and facilitate collecting field data will be launched in spring/summer 2017 (see “more information”). Solutions sought would result in a flexible, extensible, and open source data collection framework for mobile devices that will facilitate using the devices for field data collection. Anticipated benefits include improved data collection efficiency; lower data collection costs; and improved data quality, transparency, and dissemination.

More Information

Reclamation’s Water Prize Competition Center website:

www.usbr.gov/research/challenges

Mobile App Framework for Field Data Capture for Engineering and Science Information Prize Competition:

www.usbr.gov/research/challenges/dataapp.html

Contacts

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for more information.

Technology Prize Competitions

Reclamation's Water Prize Competition Center Update

Since the America COMPETES Reauthorization Act of 2010 (15 U.S.C. § 3719), Reclamation's Water Prize Competition Center has the authority to use prize competitions as a tool to seek solutions to challenging problems from beyond the usual sources of potential solvers and experts.

Reclamation's Water Prize Competition Center has launched the following reduction-to-practice prize competitions seeking citizen solvers who can find innovative solutions for some of the most critical water and water-related resource problems facing the Nation.

Water Availability Theme Area **Sub-Seasonal Forecast Rodeo** Closes May 3, 2018

Improving sub-seasonal forecasts of temperature and precipitation (lead-times ranging from 15 to 45 days and beyond) would allow water managers to better prepare for shifts in hydrologic regimes, such as the onset of drought or occurrence of wet weather extremes. In response, Reclamation is launching a forecasting prize competition where solvers will submit forecasts of temperature and precipitation for 1 year, competing in real-time against other teams as well as official forecasts from the National Oceanic and Atmospheric Administration (NOAA). Recognizing NOAA's leadership and role in forecasting, Reclamation has partnered with NOAA on this prize competition. To be eligible for prizes, solvers with skillful performance during the competition will be required to submit documentation of their forecast technique.

Prize Competition Team Lead: Kenneth Nowak | knowak@usbr.gov
Learn more at: www.usbr.gov/research/challenges/forecastrodeo.html

Environmental Compliance Theme Area **Better, Faster, Cheaper: Estimating Reservoir Water Storage Capacity** Closes May 22, 2017

Accumulating sediments pose a significant problem for Reclamation in determining how to measure reservoir storage capacities. Sediment deposition in reservoirs—or the accumulation of particles like pebbles, sand, mud, and salts carried by wind, water, or ice—limits the active life of reservoirs by reducing storage capacities and impacting structures, such as water outlets and intakes. Developing an efficient and accurate indirect estimate model of reservoir storage would result in a significant better, faster, and cheaper solution and support Reclamation in meeting water and power deliveries now and into the future.

Prize Competition Team Lead: Sean Kimbrel | skimbrel@usbr.gov
Learn more at: www.usbr.gov/research/challenges/waterstorage.html

WATER
PRIZE COMPETITION CENTER

\$800,000 in prize \$\$\$!

Saddle up for the Sub-Seasonal Climate Forecast Rodeo!

March 2, 2016 Forecast

usbr.gov/research/challenges

Competition Sponsor: RECLAMATION Managing Water in the West

Competition Partners: NOAA, US Army Corps of Engineers, USGS

WATER
PRIZE COMPETITION CENTER

\$75,000 in prize \$\$\$!

Can YOU tell us how much water storage is available?

usbr.gov/research/challenges

Competition Sponsor: RECLAMATION Managing Water in the West

Competition Partner: US Army Corps of Engineers

Water Prize Competition Center Contact

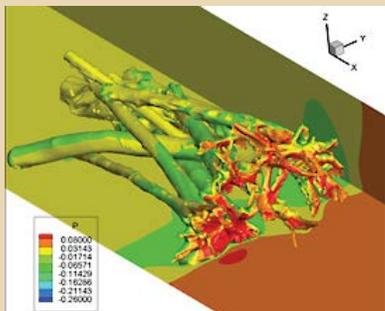
Chuck Hennig
Deputy Chief and
Prize Competitions Coordinator
303-445-2134 | chennig@usbr.gov

More Information

www.usbr.gov/research/challenges

Research Bulletins

The following list of Research Bulletins showcase completed research within Reclamation's Science and Technology Program. Please contact the principal investigators for more information about these final research projects.



Project ID 4495

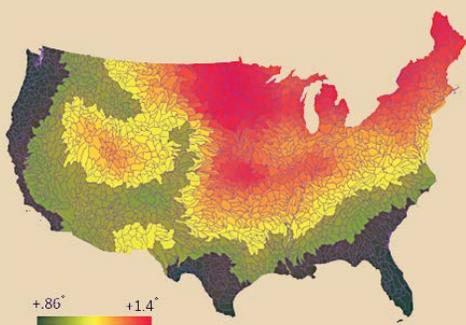
Complex Flows Through Large Woody Structures

Developing semi-automated, three-dimensional modeling tools for predicting complex flows through large woody structures

“State-of-the-art computational fluid dynamics modeling could help us understand how large wood structures work and interact in a river environment.”

Yong Lai, Hydraulic Engineer, Reclamation's Technical Service Center

www.usbr.gov/research/projects/detail.cfm?id=4495



Project ID 2005

Quantifying Projected Changes in Groundwater Recharge in the Upper Colorado River Basin

Groundwater recharge in the Upper Colorado River Basin may hold steady under climate change

“These results are the first step in understanding the quantity of groundwater we can expect in the Upper Colorado River Basin; however, further studies are needed to help more accurately forecast future groundwater availability.”

Fred Tillman, Research Hydrologist/Principal Investigator, U.S. Geological Survey

www.usbr.gov/research/projects/detail.cfm?id=2005



Project ID 7738

ROV Data Collection and Photogrammetry From Trinity Dam Intake Structure

Building a photogrammetric 3D model from ROV-collected data as supplement for underwater condition assessment

“Using an ROV and underwater photogrammetry techniques to perform the inspection likely saved hundreds of thousands of dollars or more compared to the cost of a conventional inspection when the structure is dewatered.”

Matthew Kline, Civil Engineer, Reclamation's Technical Service Center

www.usbr.gov/research/projects/detail.cfm?id=7738



Project ID 7738

UAS Data Collection and Photogrammetry From Elephant Butte Dam

Using unmanned aerial systems data to build a photogrammetric three-dimensional dam model

“UAS and 3D modeling technology will change the way we look at our structures.”

Matthew Kline, Civil Engineer, Reclamation's Technical Service Center

www.usbr.gov/research/projects/detail.cfm?id=7738

Featured Faces

Interview With a 38-Year Reclamation Doyen: Chuck Hennig, R&D Deputy Chief

Describe your career path with Reclamation.

I started in 1979 as a design engineer responsible for the design and construction of dams, dam foundations, and appurtenant structures. It was great work, but Reclamation has many interesting areas of work that I wanted to explore. In 1990, I went to work for Reclamation's Dam Safety Office (DSO). DSO is responsible for managing the risks to the public downstream from Reclamation's dams. I left DSO in 2000 as the Deputy Chief, to take a similar position with Reclamation's Research and Development Office (R&D). Working in R&D has allowed me to develop a strong working knowledge of the full spectrum of water resource management challenges across Reclamation and the broader water resources community of practice, and gave me the opportunity to meet and work with amazing people from many different disciplines.

What do you feel have been the greatest challenges in meeting Reclamation's mission over the years?

I have learned that Reclamation is much bigger than dams; it is also about managing the water resources and the impacts of its dams and operations. Reclamation spent the first part of its history leading the world in the design-build of dams—and did a great job—but now we have to figure out how to manage the resources we have created. The future challenges are how to sustain healthy ecosystems, take care of infrastructure, and maintain abundant water supplies while, at the same time, deliver and manage the water that drives the economy and provides the way of life that we have.

What have been the highlights about your career with Reclamation?

Some of the more memorable projects were in my design life with Reclamation, like the modifications to Theodore Roosevelt Dam and the design and construction of the Brantley and Upper Stillwater Dams. It was also satisfying to spearhead many dam safety modifications and other dam safety actions that made living downstream from Reclamation dams much safer. I also led or co-led the design and implementation of many of the Dam Safety Program practices currently used by Reclamation, including Comprehensive Facility Reviews, Issue Evaluations, and the pioneering of risk analysis approaches to better prioritize agency actions and inform dam safety decisionmaking.

What is a significant accomplishment related to your current role as Deputy Chief of R&D?

I was the primary architect for restructuring the Science and Technology Program into a Reclamation-wide, competitive R&D program driven by priorities, aligned with

Reclamation's core end outcomes of delivering water and power, and involved Reclamation end users in the R&D priority setting and decisionmaking process. I received the 2003 Denver Federal Executive Board Legacy Award for exceptional productivity and process improvement for these accomplishments. More recently, developing and implementing technology prize competitions and technology transfer program elements has brought Reclamation some exciting open innovation tools to solve problems. I have also been able to pull together effective intraagency, interagency, and private sector collaborations to tackle various problems facing water resources.

Last year, Tom Iseman, the U.S. Department of the Interior's Principal Deputy Assistant Secretary of Water and Science, recognized you with the Department's Superior Service Award. What did that honor mean to you?

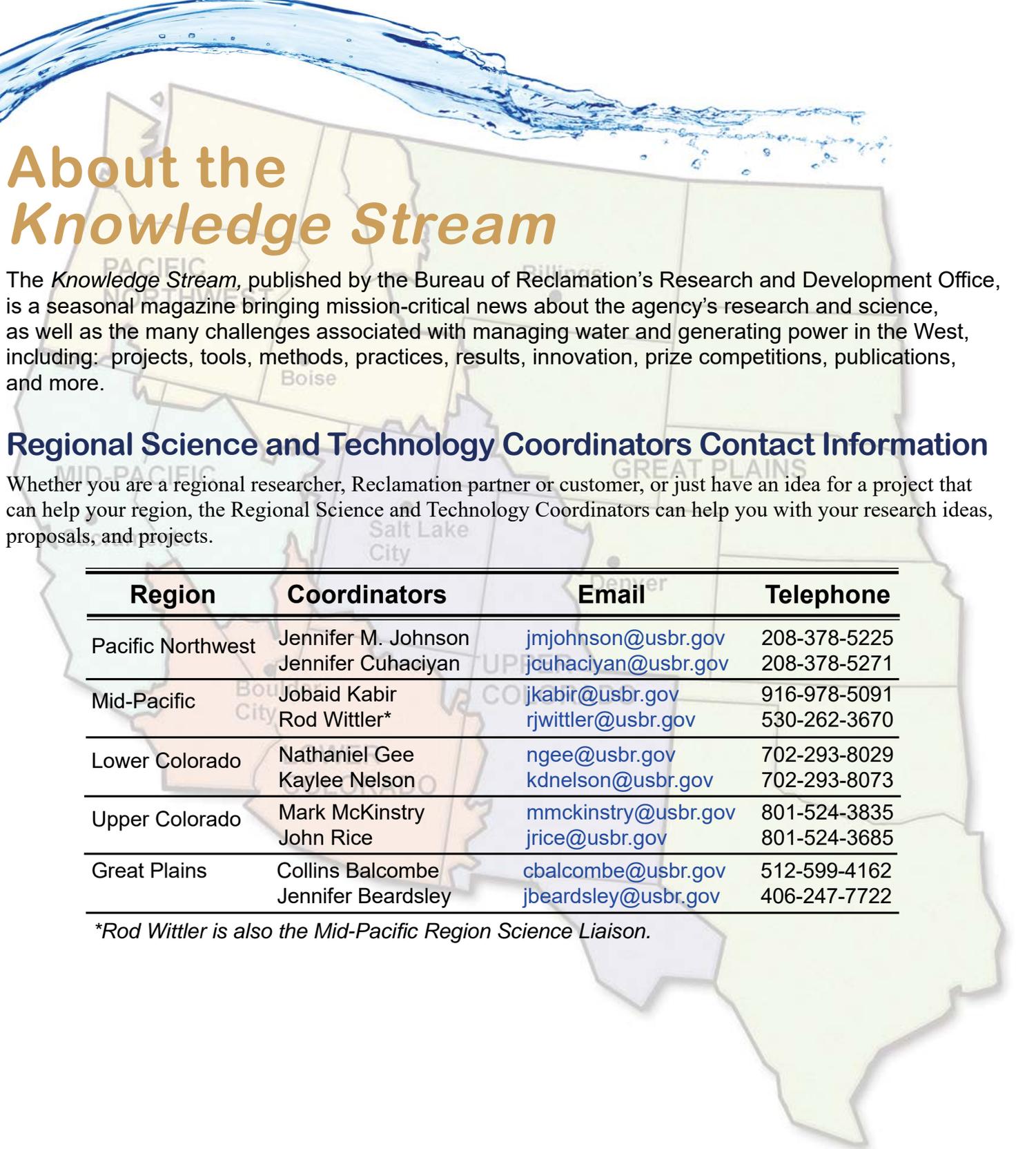
I appreciated the award and the recognition. I think that of all the things I have accomplished and know it has been done with many people. It takes a village and I was fortunate to be able to surround myself with passionate, smart, caring people that were able to help me make good things happen.

Who is your role model and why?

From a career standpoint, my very first supervisor in Reclamation, Ed Rossillion, was always a person I admired a lot and tried to pattern myself after him. He cared a lot about the people that worked for him and wanted to help people in their careers.



Tom Iseman, presents Chuck Hennig with the U.S. Department of the Interior's Superior Service Award on November 28, 2016.



About the Knowledge Stream

The *Knowledge Stream*, published by the Bureau of Reclamation's Research and Development Office, is a seasonal magazine bringing mission-critical news about the agency's research and science, as well as the many challenges associated with managing water and generating power in the West, including: projects, tools, methods, practices, results, innovation, prize competitions, publications, and more.

Regional Science and Technology Coordinators Contact Information

Whether you are a regional researcher, Reclamation partner or customer, or just have an idea for a project that can help your region, the Regional Science and Technology Coordinators can help you with your research ideas, proposals, and projects.

Region	Coordinators	Email	Telephone
Pacific Northwest	Jennifer M. Johnson	jmjohnson@usbr.gov	208-378-5225
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	Jennifer Beardsley	jbeardsley@usbr.gov	406-247-7722

*Rod Wittler is also the Mid-Pacific Region Science Liaison.

On the Covers—

Front Cover: Reclamation Water Information System (RWIS) web portal site location map—how an end user might use open water data.

Back Cover: Open Water Data is a concept where scientific research results should be free and shared for the public good.

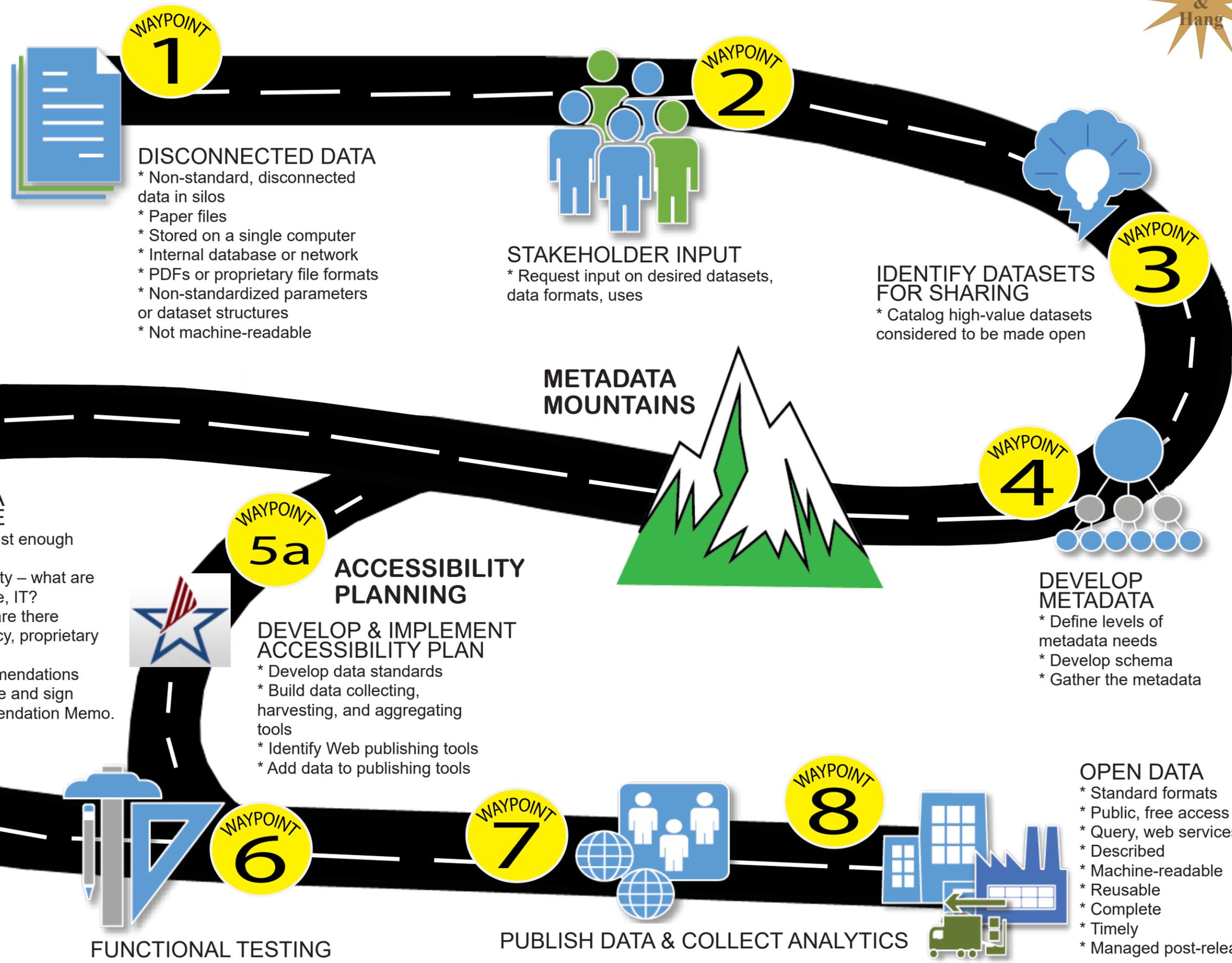
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“Open Data” — scientific research that is free and shared for the public good.



ROAD to OPEN DATA



WAYPOINT 1



DISCONNECTED DATA
* Non-standard, disconnected data in silos
* Paper files
* Stored on a single computer
* Internal database or network
* PDFs or proprietary file formats
* Non-standardized parameters or dataset structures
* Not machine-readable

WAYPOINT 2



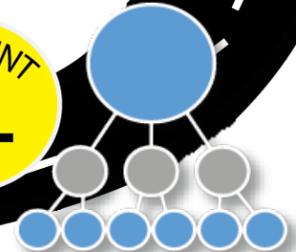
STAKEHOLDER INPUT
* Request input on desired datasets, data formats, uses



WAYPOINT 3

IDENTIFY DATASETS FOR SHARING
* Catalog high-value datasets considered to be made open

WAYPOINT 4



DEVELOP METADATA
* Define levels of metadata needs
* Develop schema
* Gather the metadata

METADATA MOUNTAINS



WAYPOINT 5a

ACCESSIBILITY PLANNING

DEVELOP & IMPLEMENT ACCESSIBILITY PLAN
* Develop data standards
* Build data collecting, harvesting, and aggregating tools
* Identify Web publishing tools
* Add data to publishing tools



WAYPOINT 6



FUNCTIONAL TESTING

WAYPOINT 7



PUBLISH DATA & COLLECT ANALYTICS

WAYPOINT 8



OPEN DATA
* Standard formats
* Public, free access
* Query, web services
* Described
* Machine-readable
* Reusable
* Complete
* Timely
* Managed post-release

SCREENING STEPS

WAYPOINT 5b

SCREEN DATA FOR RELEASE
* Data quality – robust enough to release?
* Facility & IT Security – what are risks to infrastructure, IT?
* FOIA & Privacy – are there confidentiality, privacy, proprietary data impacts?
* Screening Recommendations & Approval – prepare and sign Screening Recommendation Memo.



WAYPOINT 5c

DATA PASSES SCREENING

