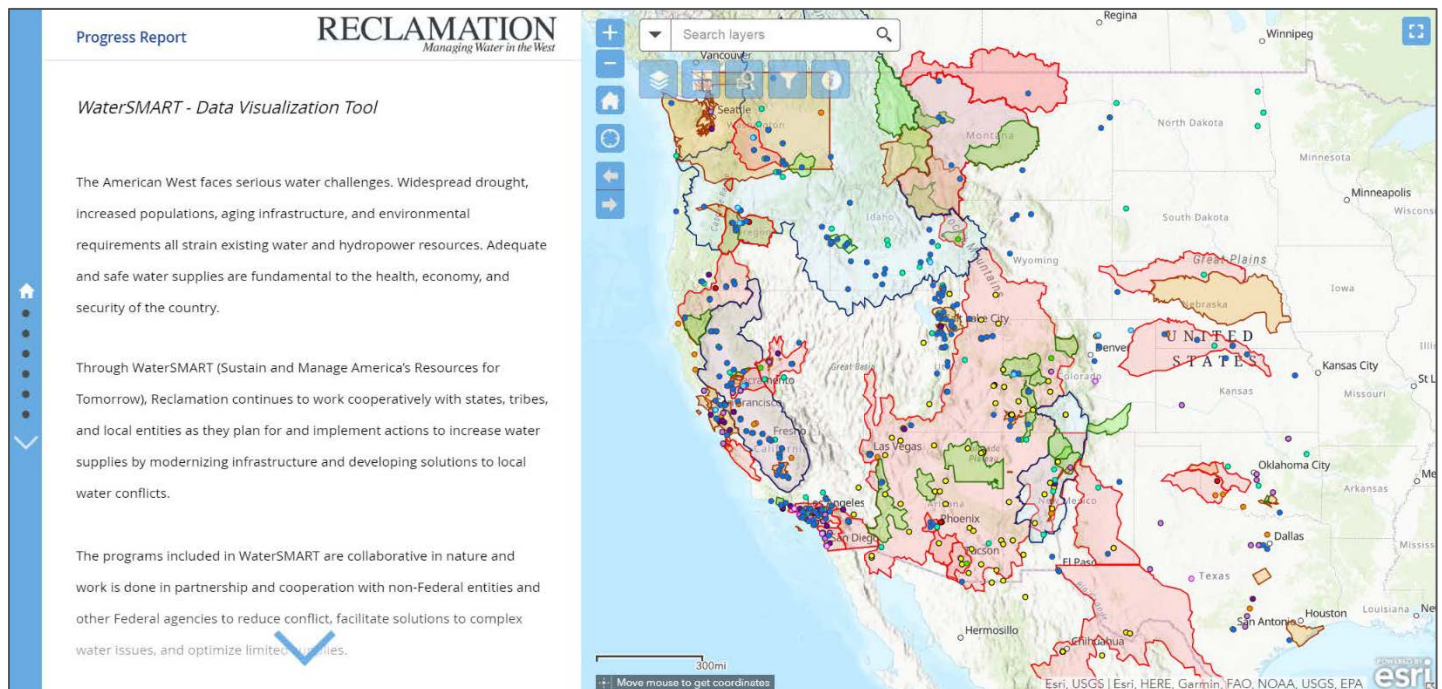


RECLAMATION

Managing Water in the West

WaterSMART Data Visualization

Research and Development Office
Science and Technology Program
(Final Report) ST-2018-A097-01



U.S. Department of the Interior
Bureau of Reclamation
Research and Development Office

September 2018

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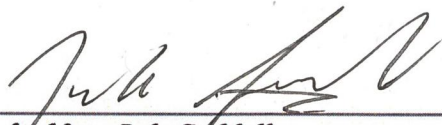
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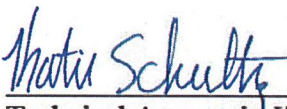
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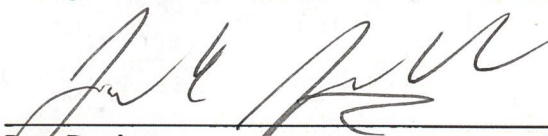
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Acronyms and Abbreviations

| | |
|-------------|--|
| AGOL | ArcGIS Online |
| App(s) | Application(s) |
| DO | Denver Office |
| DOI | Department of the Interior |
| ESRI | Environmental Systems Research Institute |
| FL | Feature Layer |
| GIS | Geographic Information Systems |
| HFL | Hosted Feature Layer |
| P&A | Policy and Administration |
| Reclamation | Bureau of Reclamation |
| WRaP | Water Resources and Planning Division |
| TSC | Technical Service Center |

Executive Summary

In 2009, Congress passed the SECURE Water Act directing the United States Department of the Interior (Interior) to develop a sustainable water management policy. In 2010, Interior established WaterSMART (Sustain and Manage America's Resources for Tomorrow), combining existing programs with new initiatives to create a broad framework to wisely manage the Nation's water supplies. WaterSMART provides opportunities to improve water management through collaboration and cooperation.

The [WaterSMART Progress Report 2010-2016](#) and [Data Visualization Tool](#) details progress made since 2010 to improve water conservation and help water-resource managers narrow the gap between water supply and demand. Through WaterSMART, Interior uses the best available science to improve water conservation and other water-saving strategies.

The Geographic Applications & Analysis Group, Water, Environmental, & Ecosystems Division of the Technical Service Center (TSC GIS) developed an online, interactive visualization companion to the three-year WaterSMART Progress Report using web-based geographic information systems (GIS) technology. Working with the Office of Policy, Water Resources and Planning (P&A WRaP), program datasets associated with the WaterSMART Program and Progress Report were developed in December 2016. This involved compiling data on program accomplishments and developing interactive maps and figures to communicate these data in an electronic format.

WaterSMART data generation led to development of a web-based mapping application with enhanced capability to control GIS layer visibility, information popups, search, query and filter per layer attributes. Programs are represented by different shades and colors, and the Time Slider Visualization animates WaterSMART program progress from 2010-2018. The Data Visualization Tool allows users to interact with map-based data to find information on each project's entity such as relevant funding information, project locations, descriptions, and other summary information. The Tool integrates other web-based resources and links to documents, websites, and the WaterSMART Progress Report.

Data development and workflows enables P&A WRaP staff to better manage program data. Data management provides consistency and enables staff to better answer questions related to project specifics, including funding, project locations and location-based inquiries.

Data visualization also enables the Office of Policy to better communicate WaterSMART activities and program accomplishments to date. WaterSMART Data Visualization provides Reclamation's Federal and non-Federal partners access WaterSMART programmatic data in a meaningful way. Developing a clear and simple visualization of WaterSMART programmatic data has enabled Reclamation's partners to access and interact with this kind of data.

Data visualization enables additional WaterSMART programs to be integrated into the tool. Continuing development to enhance content and context communicating how the WaterSMART program meets challenges for widespread drought, increasing populations, aging infrastructure, and environmental requirements will help water users understand trends and make informed decisions about long-term water management strategies.

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Introduction

In 2016, the Bureau of Reclamation's Science and Technology (S&T) program office requested research proposals that address the Administration's Open Data Policy, and the Assistant Secretary of Water and Science initiatives on sharing water data and making it more interoperable. This research addresses the initiatives on sharing water data and making it more interoperable.

The research aimed at leveraging WaterSMART Program funding with funding from the Open Water Data Initiative through Reclamation's Science and Technology Program to create a more transparent, complete, and user-friendly presentation of program data. Accomplishing this project took place in two phases. Phase I focused on data needs associated with the development of the WaterSMART Progress Report, which was completed in December 2016. This involved compiling data on program accomplishments and developing interactive maps and figures to communicate these data in an electronic format, to accompany the Progress Report.

Phase I served as a starting point for Phase II, which consisted of developing a comprehensive approach to sharing data regarding ongoing and completed projects funded under WaterSMART.

Study Objectives

The following objectives were identified for this project:

- Develop initial data schemas and populate databases
- Work with program staff to determine appropriate spatial and tabular data to include in the data visualization application
- Create and publish initial ArcGIS Online (AGOL) visualization tools
- Develop a comprehensive approach to sharing data regarding ongoing and completed projects funded under WaterSMART
- Expand on AGOL visualization tools to include enhanced data

Project Partners and Participants

This project was internally brokered through Reclamation's S&T program office. Reclamation project participants include staff from the TSC GIS and the office of Policy and Administration (P&A), Water Resources and Planning Division (WRaP).

TSC GIS provided spatial analysis and data optimization and staff to aid in the data development and publishing activities. P&A-WRaP, was tasked with providing coordination and peer review, and policy and analysis.

Background

In 2009, Congress passed the SECURE Water Act directing the United States Department of the Interior (Interior) to develop a sustainable water management policy. In 2010, Interior established WaterSMART (Sustain and Manage America's Resources for Tomorrow), combining existing programs with new initiatives to create a broad framework to wisely manage the Nation's water supplies. WaterSMART provides opportunities to improve water management through collaboration and cooperation. Interior implements the WaterSMART Program through the Bureau of Reclamation and the U.S. Geological Survey.

Reclamation's federal and non-federal partners have historically lacked the ability to access WaterSMART programmatic data in a meaningful way. WaterSMART programs are collaborative in nature and involve federal and non-federal stakeholders across the 17 Western States. Because of the collaborative nature of WaterSMART projects, there is a heightened need for transparency and communication with our stakeholders regarding the projects we fund. Some information about WaterSMART projects is available on the program website; however, important data regarding program accomplishments and benefits, and even the physical location of the projects, is not available. Prior to this research the WaterSMART program had not developed data to fulfill these needs. Additionally, the data that is available regarding funded projects is presented primarily in text format which is difficult to search and sometimes incomplete.

This research developed an online, interactive data visualization companion to the three-year WaterSMART Progress Report using web-based GIS technology. TSC GIS working with P&A, WRaP, program datasets associated with the WaterSMART Program and Progress Report were developed in December 2016. This involved compiling data on program accomplishments and developing interactive maps and figures to communicate these data in an electronic format.

WaterSMART Program Data Development

WaterSMART Program Coordinators identified the need to develop data for projects, grants, and studies based upon project locations. Leveraging TSC GIS, location-based data was compiled using specific information pertaining to each WaterSMART project such as the grant recipient, funding information, project title, location, a representative image and web links to additional resources. WaterSMART program data are shared with the public through ArcGIS Online, a web-based GIS technology was chose as platform and repository to facilitate sharing WaterSMART Program data publicly.

Objectives and factors identified during the interactive process between TSC staff and Water Resources and Planning (WRaP) staff resulted in the compilation of GIS vector layers for all WaterSMART program activities. The maps and associated data were compiled using ESRI (Environmental Systems Research Institute) ArcGIS Pro v. 2.x. All GIS features were converted into a common spatial reference. The projected coordinate system is: WGS 1984 Web Mercator Auxiliary Sphere. This projected coordinate system is based upon the Mercator Auxiliary Sphere projection which covers the world's geographical extent and is the industry standard for web-based GIS mapping. Data was obtained and transformed from publicly available sources and partners. Information was received in a variety of formats such as GIS feature classes or shapefiles, spreadsheets, pdfs, and hardcopy maps.

These data represent ArcGIS feature classes and are stored in a file geodatabase. These vector feature classes are the basis for vector-to-published data conversions used in web mapping and applications. A core data schema was developed to address the data and application needs. The following data fields were identified:

- Program
- Grant
- UNIQUEID
- Project Title
- Entity
- Year
- Start Date
- End Date
- Project Status
- Location
- USBR Region
- Federal Funding
- Non-federal Funding
- Total Project Cost
- Photo & Credits
- Project Description

In addition to the core database schema, several data domains were generated to standardize data within the database. Domains were generated for WaterSMART Programs, Grant or Study Type, and Project Status.

WaterSMART Program domain:

- WaterSMART Grants
- Title XVI Water Reclamation & Reuse
- Basin Study Program
- Drought Response Program
- Cooperative Watershed Management Program

Grant Study Type Domain:

- Applied Science Grants
- Basin Study
- CWMP Phase I
- CWMP Phase II
- Drought Contingency Plans
- Drought Resiliency Projects
- Baseline Water Assessments
- Plan of Study
- Reservoir Operation Pilots
- Title XVI Authorized Projects
- Title XVI Feasibility Studies
- Title XVI Research Studies
- Water and Energy Efficiency
- Small-Scale Water Efficiency Project
- Water Marketing Strategy Grants

Project Status Domain:

- Completed
- Ineligible
- Inactive
- In Progress
- Proposed
- Selected
- Terminated
- Unsuccessful

Stakeholders provided GIS datasets and areas were identified to represent projects. The majority of the data compiled was in tabular format with only project locations identified. TSC GIS georeferenced these point locations into point feature class and applied a newly designed data schema. The GIS datasets that were populated utilized the same data design. The WaterSMART database and schema were transformed into two vector GIS datasets, points and polygons, respectively. The WaterSMART point database is composed of 622 projects, and the polygon database is composed of 94 projects, totaling 716 projects since 2010.

Desktop to web GIS workflows enable publishing locally stored data to Feature Layers hosted in AGOL. Hosted Feature Layers can expose vector data for display, query, and editing on the web. Hosted Feature Layers are most appropriate for visualizing data on top of basemaps. In web

applications, Hosted Feature Layers are drawn by the web browser and support interactive highlighting, queries, and pop-ups.

Two vector GIS data layers were published to represent data, *WaterSMART_POINTS* (points) and *WaterSMART_POLYGONS* (areas). The hosted feature layer data and informational model enables projects to be added every year as the WaterSMART program expands and funds new projects.

The WaterSMART feature layers are shared to create web mapping visualizations. A web map is an interactive map that displays geographic information to tell stories and answer questions. These maps are available to a wide audience and map functionality include multiscale basemaps, feature layers targeted to a specific audience, and information pop-ups that allow users to drill into specific features they are interested in.

Data Visualization Application Development

The [WaterSMART Data Visualization](#) provides an interactive web mapping application that serves as a companion to the [WaterSMART Progress Report: 2010 - 2016](#). Web mapping applications combine maps, text, multimedia, and interactive functions to inform, educate, and communicate a wide variety of topics. WaterSMART Data Visualization Tool was developed by building and refining maps text and incorporating them into the WaterSMART applications. The web mapping application chosen as most appropriate is the Story Map Journal template. This application template is ideal to combine narrative text with maps or other content. A Map Journal template is used to organize and present the resources for this data visualization tool. The Map Journal templates contains sections that the reader scrolls through. Map Journal contains two main parts per section: side panel with narrative text and main stage which contains map, image or web page.

Each WaterSMART Program has its own section which includes Interactive Maps and Featured Project Tours that displays the location of the studies, projects, and related activities. Each program section contains a representative image on the main stage and narrative text about program which also includes external links to the WaterSMART homepage, as well as buttons that allows the user to toggle between the Featured Projects Tour and Interactive Map.

Functionality of WaterSMART interactive maps contains features such as an About button which provides an informational overview, a Legend, Map Layers in which the user can control visibility, several Basemap options, and the ability to search based on WaterSMART Grant Type. Additional functionality includes the ability to select a project point on the map and open an information popup that provides additional information on the project such as project status, and a project description (Figure 1). More detail about map functionality is provided in a later section of this report. Each program map is symbolized by different shades and colors which were established by TSC staff.

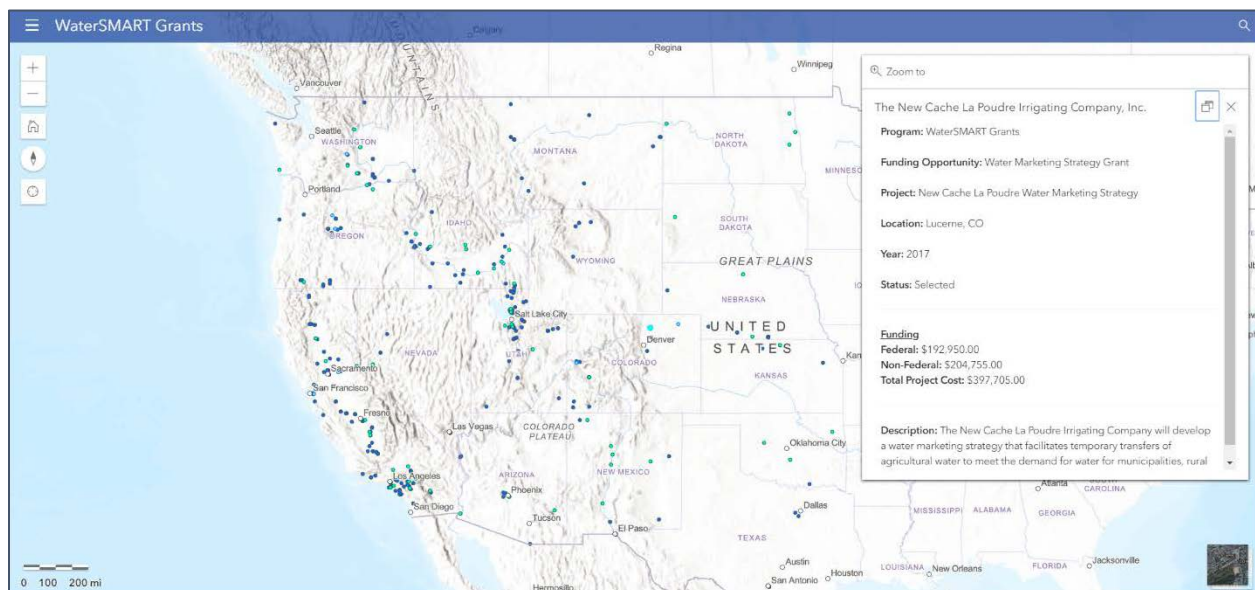


Figure 1. Interactive web map example, information popup opened

A unique feature imbedded into the Map Journal template is the Featured Project Tour. A Featured Project Tour (Figure 2) is an application that highlight projects and case studies for distinguished completed projects, upcoming Reclamation studies, and ongoing efforts. Featured project tours provide a placed-based narrative featuring images or videos, an interactive map, as well as links to partner websites and other resources. You may browse by either interacting with the map or using image carousel.

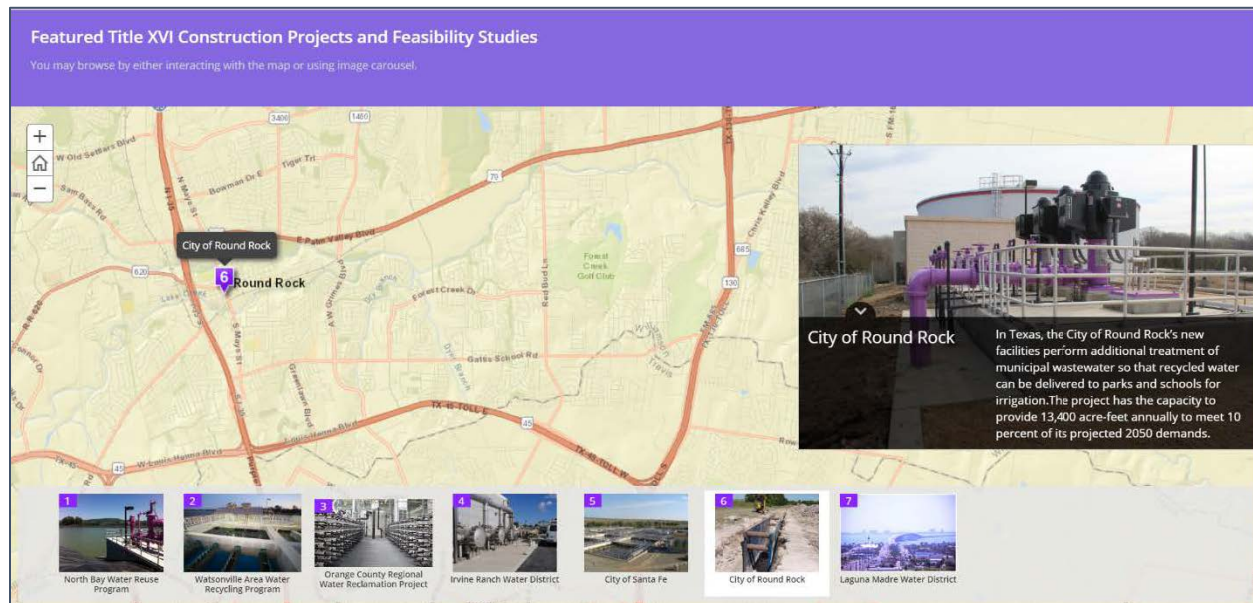


Figure 2. Map Tour example for Explore Featured Projects

The seven sections created for the WaterSMART Data Visualization Tool are:

1. Introduction (Home Section)
2. WaterSMART Grants
3. Title XVI Water Reclamation and Reuse
4. Drought Response Program
5. Basin Study Program
6. Cooperative Watershed Management Program
7. Working with Partners to Increase Water Supply Reliability

WaterSMART Program Introduction Section

The Introduction section (Section one) (Figure 3) side panel provides a narrative introducing users to the WaterSMART Programs. The narrative describes the purpose of the WaterSMART program, challenges of water management, and program achievements. The side panel also acts as a table of contents with links to program sections and the [WaterSMART website](#).

The main stage in the introduction section contains an interactive map which enables the user to control layer visibility, search, query, and filter the data contained within WaterSMART programs. A search bar allows the user to search each feature layer in the map or conduct a place-based search (i.e. by city or state). The user also has the ability and control to zoom in or

out, view a previous or next extent, and reset to the default extent. The Layers allow the user to control layer visibility (turn off or on), zoom to, adjust transparency and adjust layer order within the map. The Basemap gallery offers twelve different basemaps including imagery, navigation, terrain and topographic basemaps. The data visualization tool also includes widgets, which gives the application the ability to apply multiple filters simultaneously, or on and individual filter. An “About” widget which provides a summary of the story map and how to use the map, as well as links to additional information on how to use other widgets that are available. A “Queries” widget allows the user to select from a list of queries per program that are based upon spatial relationships within the map. The spatial filter options for the Queries widget are: return features within current map extent, return features that intersect with the shape user draws on the map, and return features that have a spatial relationship with features in another layer (select other feature in map). The “Filter” widget allows the user to limit the visibility of features in a layer. Only the features that meet the criteria defined by the user in the Filter widget will be displayed within the map. Filters were created based upon the data schema. For example, a user can filter based on project status (Selected, Completed), year (Current year or previous year), region, or total project cost and Federal funding levels.

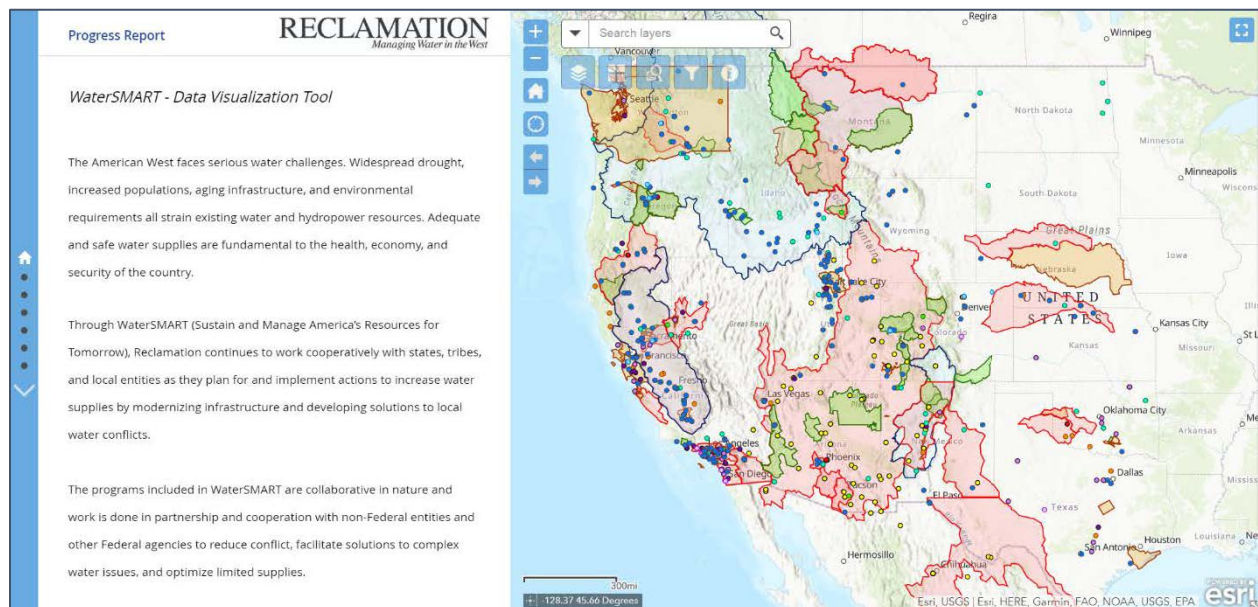


Figure 3. Section One - Introduction narrative and interactive search map

WaterSMART Grants

Section Two of the Data Visualization Tool (Figure 4) represents the WaterSMART Grants Program. There are three WaterSMART Grant Program activities: Water and Energy Efficiency Grants, Small-Scale Water Efficiency Projects, and Water Marketing Strategy Grants. Section Two narrative text describes each program activity, eligibility requirements, and contains links to the respective WaterSMART websites. Beneath the narrative text are buttons to open the interactive WaterSMART Grants map, or Featured Project Tour. Section Two main stage displays a representative image.

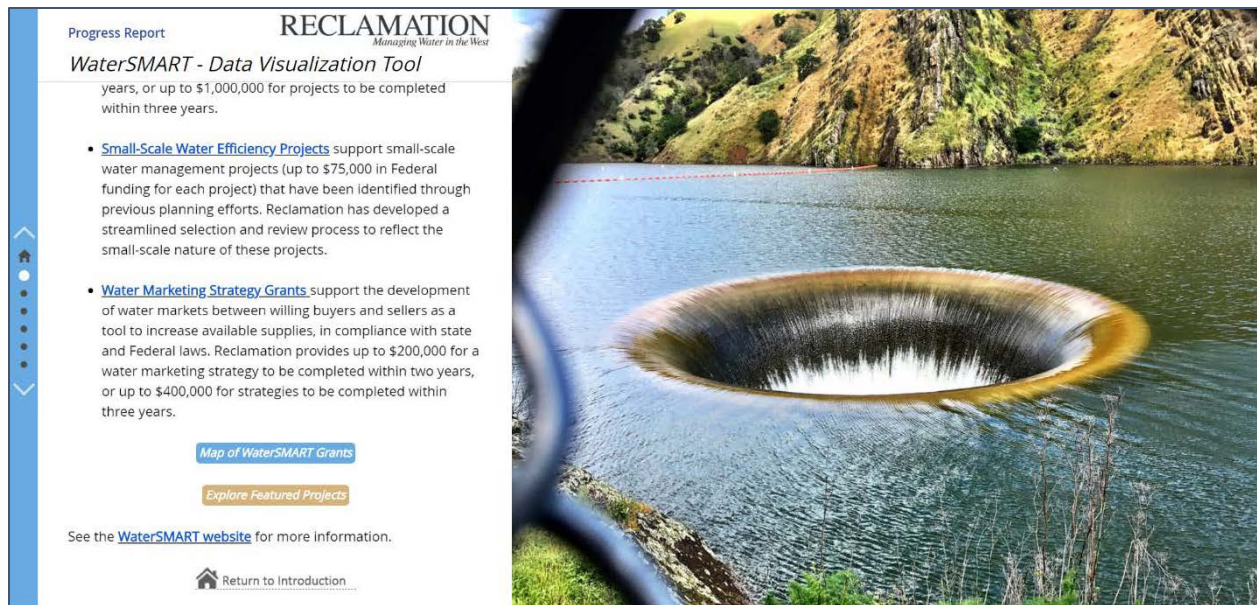


Figure 4. Section Two- WaterSMART Grants Program section

Title XVI Water Reclamation and Reuse

Section Three features the Title XVI Water Reclamation and Reuse program, Figure 5. There are three grant types in program: Title XVI Authorized Projects, Title XVI Feasibility Studies, and Title XVI Research Studies. Section Three narrative text contains links to respective WaterSMART websites, as well as a few program accomplishments. Section Three main stage has a representative image, and buttons to open interactive Map of Map of Title XVI Projects or Explore Featured Projects.

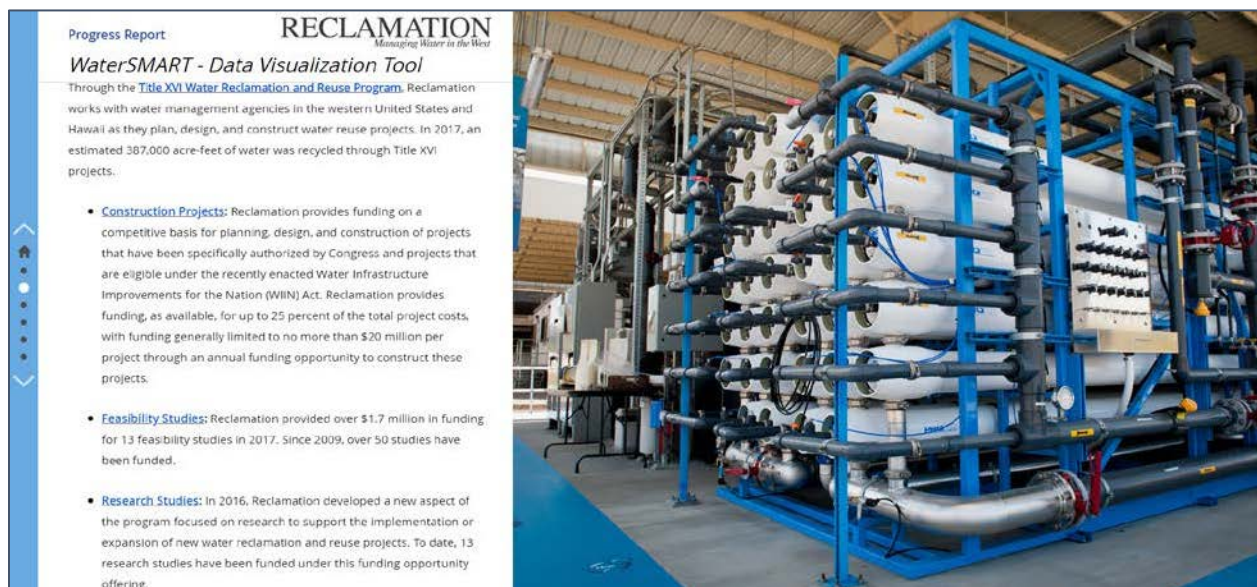


Figure 5. Section Three - Title XVI Water Reclamation and Reuse program

Drought Response Program

Section Four (Figure 6) features the Drought Response Program. There are two program activities under the Drought Response Program: Drought Contingency Plans and Drought Resiliency Projects. Section Four narrative text describes program requirements, eligibility, and contains links to respective WaterSMART websites. Section Four main stage displays a representative image as well as buttons open interactive Map of Drought Plans and Projects, or Explore Featured Projects.

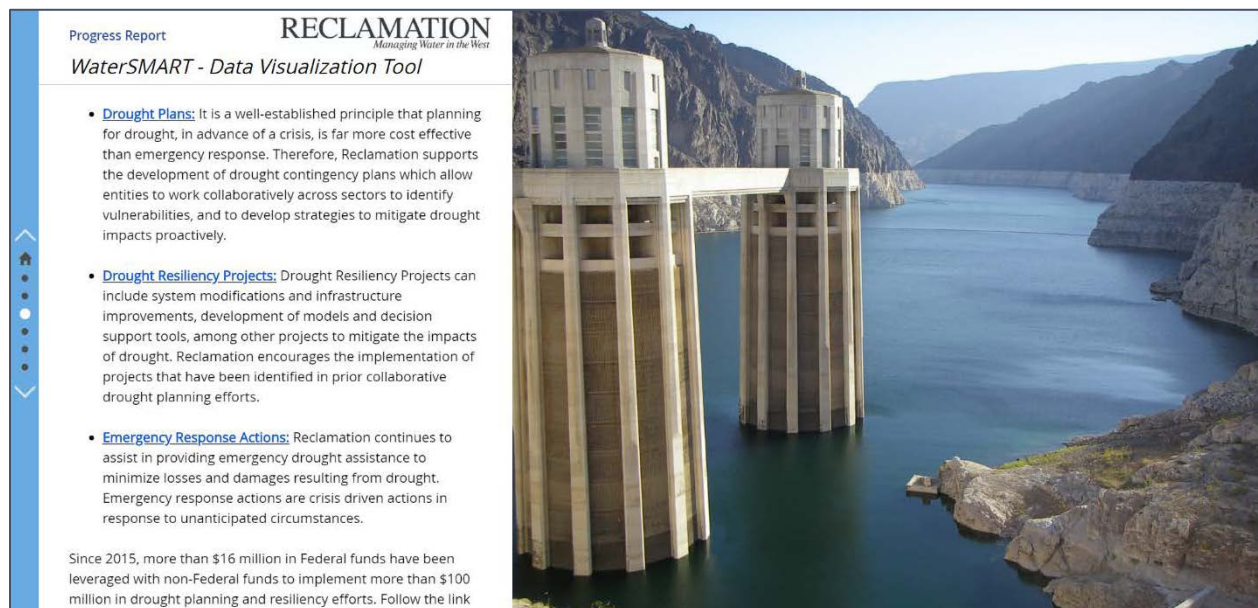


Figure 6. Section Four - Drought Response Program

Basin Study Program

Section Five (Figure 7) features the Basin Study Program which includes four program activities: Basin Studies, Baseline Assessments, Site-Specific Pilots and Applied Science Grants. Section Four narrative text contains links to respective WaterSMART websites, as well as some additional information about each program. Section Five main stage has representative image and button to open interactive Map of Basin Studies Activities.

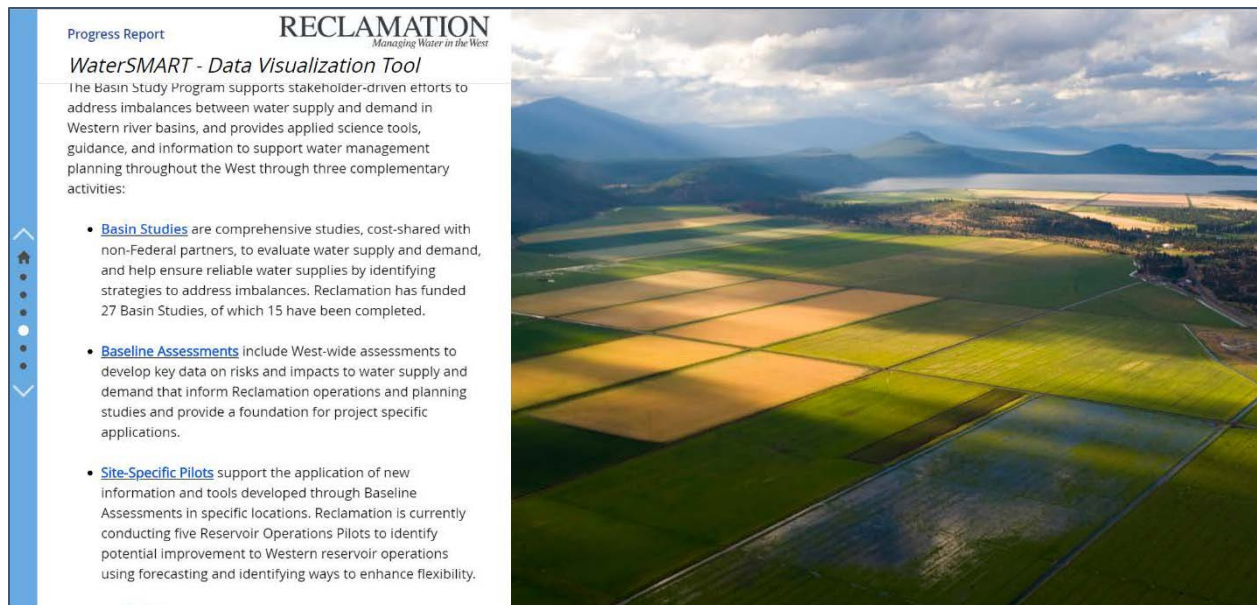


Figure 7. Section 5 - Basin Study Program

Cooperative Watershed Management Program

Section Six features the Cooperative Watershed Management Program, (Figure 7), which includes two program activities: Phase I (Watershed Group Development and Watershed Restoration Planning) and Phase II (Implementation of Watershed Management Projects). Section Six narrative text describes the different phases, project eligibility, and contains links to respective WaterSMART websites. Section Six main stage has a representative image and button to open interactive Map of Cooperative Watershed Management Program and Explore Featured Projects.

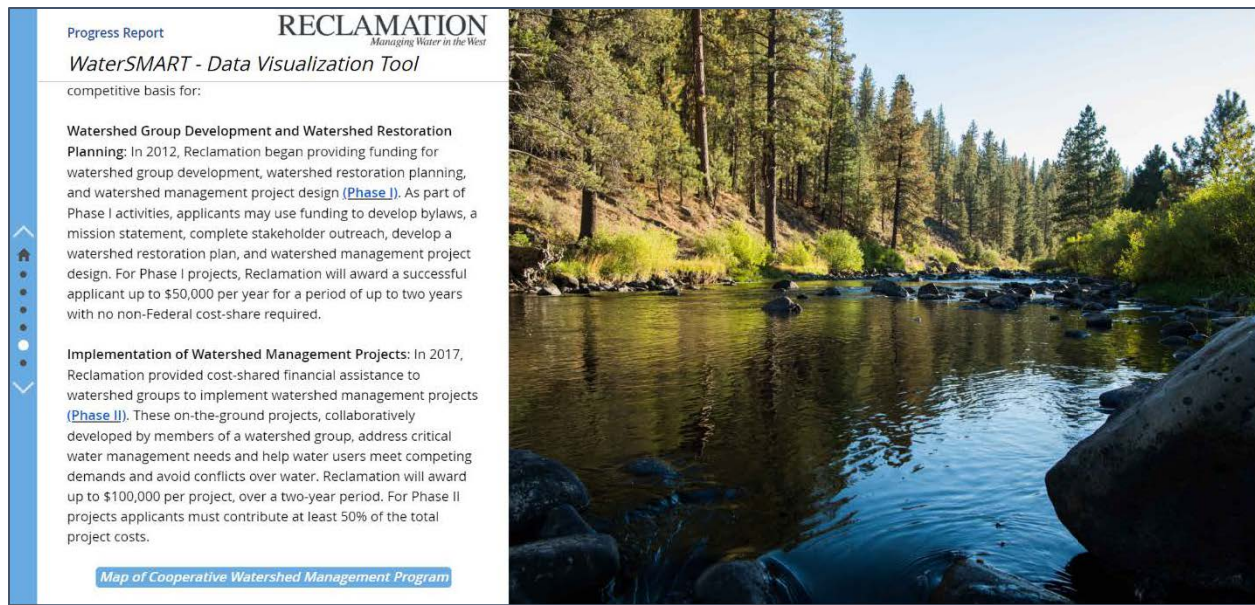


Figure 8. Section Six - Cooperative Watershed Management Program

Working with Partners to Increase Water Supply Reliability

Section Seven features Working with Partners to Increase Water Supply Reliability, Figure 9. This section narrative text highlights how Reclamation's WaterSMART Program supports the Department of the Interior's (DOI) priorities, as well as providing links to respective WaterSMART websites and DOI priorities. Section Seven main stage has a representative image and a button to open interactive Time Slider Visualization.

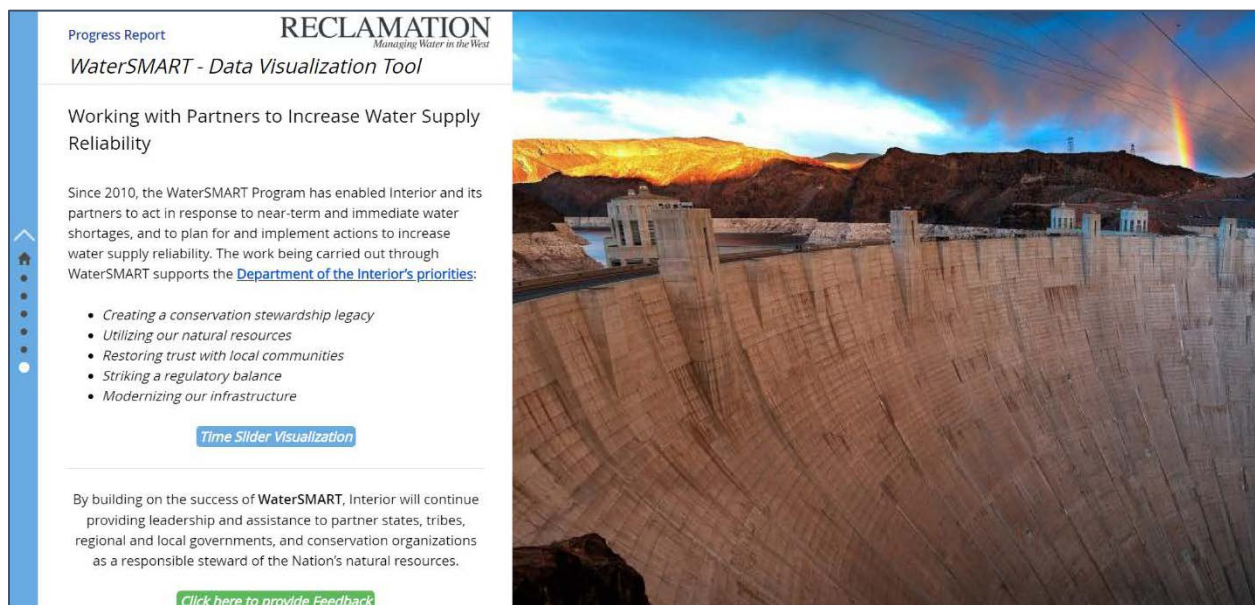


Figure 9. Section Seven - Working with Partners to Increase Water Supply Reliability

The Time Slider visualization feature (Figure 10) animates WaterSMART program progress from 2010 - 2018. The Time Slider visualization allows users to interact with map-based data to find information on each project's entity such as relevant funding information, project locations, descriptions, and other summary information.

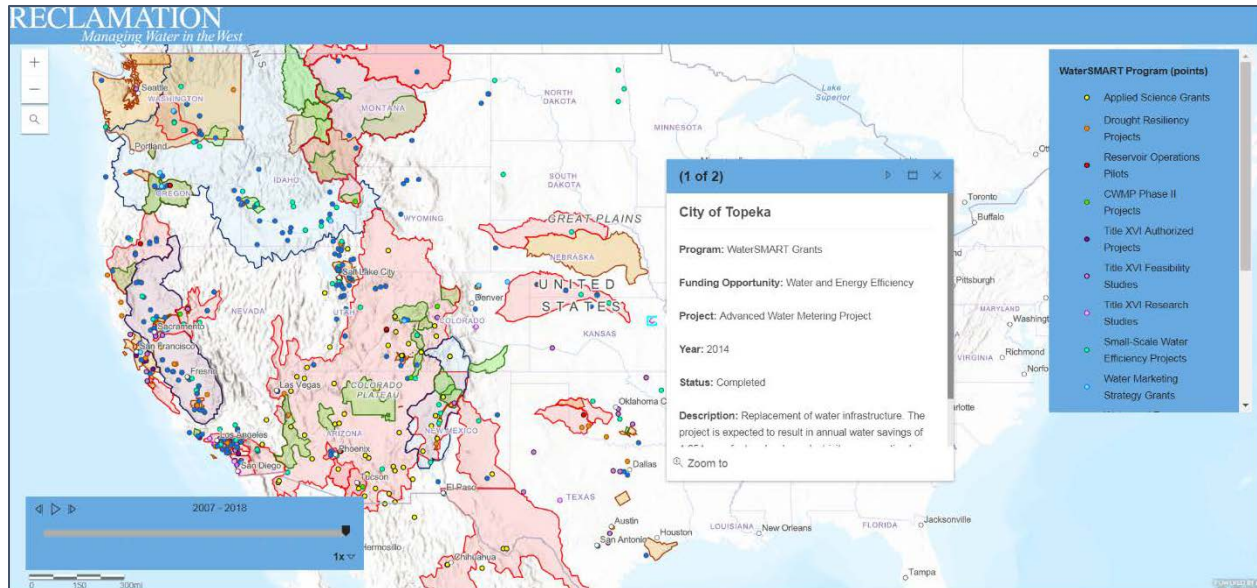


Figure 10. Section Seven - Time Slider with information popup opened

Benefits of the Data Visualization Tool

Data development and workflows enable P&A-WRaP staff to better manage program data. Data management provides consistency and enables staff to better answer questions related to project specifics including funding, project locations, and location-based inquiries. The Data Visualization Tool enables P&A to better communicate WaterSMART activities and program accomplishments to date, and provides enhanced integration and communication of WaterSMART activities between Reclamation and USGS to address current and future water supply needs. The Data Visualization Tool also integrates other web-based resources and links to documents, websites, and the WaterSMART Progress Report.

Objectives identified for this project:

- **Develop initial data schemas and populate databases**
- **Work with program staff to determine appropriate spatial and tabular data to include in the data visualization application**

Interactive processes between TSC GIS and P&A-WRaP produced two WaterSMART program databases. The database development provided utility in the development of the WaterSMART Progress Report, completed in August, 2016. The compilation of programmatic data and developing interactive maps and figures to communicate accomplishments in an electronic format. Interactive process determined appropriate spatial and tabular data to include in the visualization.

WaterSMART Data Visualization Tool provides Reclamation's federal and non-federal partners access WaterSMART programmatic data in a meaningful way. Developing a clear and simple visualization of WaterSMART programmatic data enabled Reclamation's partners to access and interact with this kind of data.

- **Create and publish initial AGOL visualization tools**

The TSC GIS team provided technical guidance related to production and publication of the Data Visualization Tool. TSC GIS researched and mastered best practices to use AGOL to produce effective visualizations, and developed an application and data framework that is scalable and incorporates annual updates of projects and application aspects.

- **Develop comprehensive approach to sharing data regarding ongoing and completed projects funded under WaterSMART**

The TSC GIS team provided technical guidance related to the best approaches to develop data, enabling internal review to the sharing with publicly accessible maps and apps within the Data Visualization Tool. TSC-Water, Environmental, & Ecosystems Division determined best practices to share and optimize visualization for effective public use. Internal data management best practices were developed to solidify roles, responsibilities and workflows for the ongoing and annual update of programmatic data. The Data

Visualization Tool creates a more transparent, complete, and user-friendly presentation of WaterSMART program data.

- **Expand on AGOL visualization tools to include enhanced data**

TSC GIS working jointly with P&A WRaP staff, and following workflows and best practices, it was determined which elements of the Three-Year Progress Report should be narrated and included in the visualization tool. The WaterSMART Data Visualization Tool was reviewed prior to public release by the Public Affairs Office (DO and DC), and P&A WRaP.

Data visualization application development is being expanded to other WaterSMART activities with other agencies specifically the Natural Resources Conservation Service (NRCS) and U.S. Geological Survey. These expanding collaborations help inform partners, stakeholder and public of the benefits of WaterSMART program activities and efforts.

Closing

The TSC-Water, Environmental, & Ecosystems Division team appreciates the opportunity to work on this interesting research project. The WaterSMART Data Visualization Tool demonstrates process, and that well organized and managed data can be employed by staff in Reclamation's regional and area offices, as well as Reclamation Programs, and can provide a method to improving programmatic data development and sharing. The TSC-Water, Environmental, & Ecosystems Division looks forward to supporting others in implementing and developing data management workflows that can be shared as visualizations.

Data Sets that Support the Final Report

- WaterSMART_Program_All_projects
- <https://www.arcgis.com/home/item.html?id=71164709e142479280550c964906c0c1>
- WaterSMART Program (points) and WaterSMART Program Areas (polygons) configured to render for time aware and search applications. Displays projects and studies within programs progress from 2008 - 2018.
- Keywords: Time Aware, WaterSMART, WaterSMART Grants, WEEG, Drought, Basin Studies, Title XVI,

Approximate total size of all files: 20 MB

