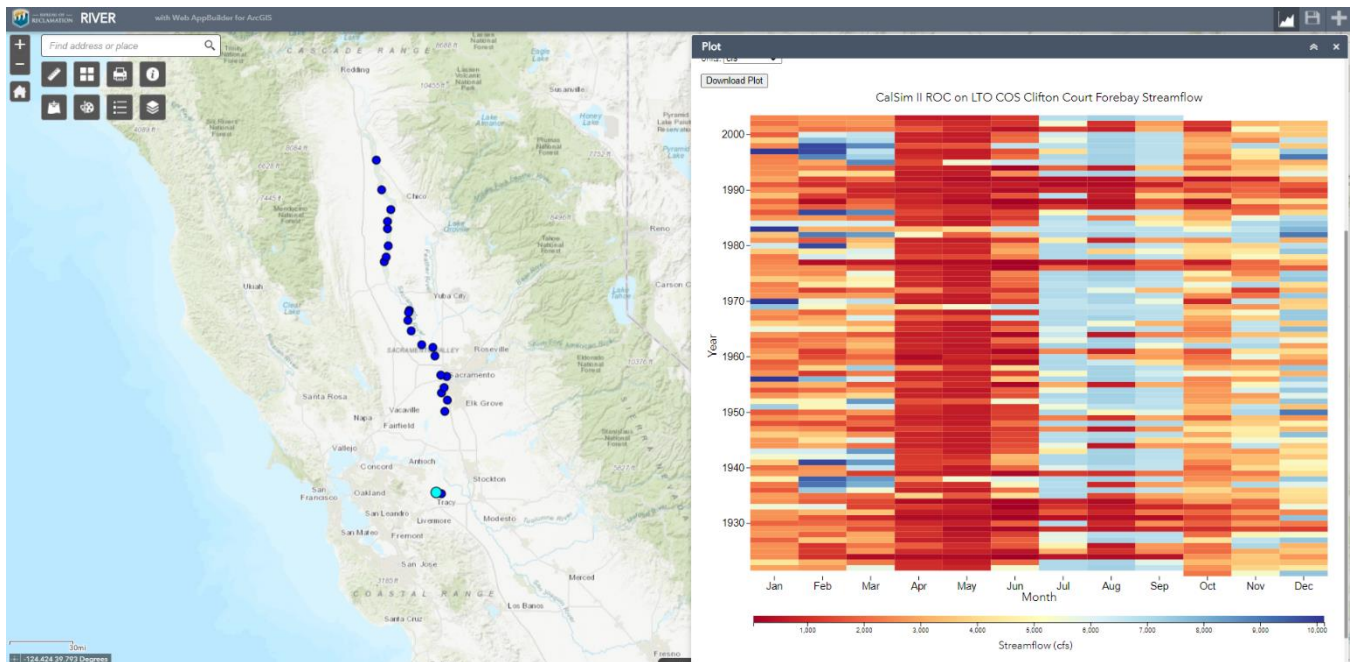




— BUREAU OF —
RECLAMATION

Reclamation Interactive Visualization and Exploration Resource (RIVER): A model scenario visualization tool for RWIS/RISE

Science and Technology Program
Research and Development Office
Final Report No. ST-2023-19221-01



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Mission Statements

The Department of the Interior (DOI) conserves and manages the Nation's natural resources and cultural heritage for the benefit and enjoyment of the American people, provides scientific and other information about natural resources and natural hazards to address societal challenges and create opportunities for the American people, and honors the Nation's trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities to help them prosper.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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prepared by

**California Great-Basin Region
Resource Management Division
Vanessa King, Hydrologist**

Peer Review

Bureau of Reclamation
Research and Development Office
Science and Technology Program

Final Report ST-2023-19221-01

**Reclamation Interactive Visualization and Exploration Resource (RIVER): A
model scenario visualization tool for RWIS/RISE**

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Acronyms and Abbreviations

API	Application Programming Interface
CORS	Cross-origin Resource Sharing
JSON	JavaScript Object Notation
PI	Principal Investigator
Reclamation	Bureau of Reclamation
RISE	Reclamation Information Sharing Environment
RWIS	Reclamation Water Information System

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Executive Summary

An interactive web visualization platform entitled Reclamation Interactive Visualization and Exploration Resource (RIVER) was developed to allow users to visualize results from Reclamation modeling efforts. The goal of this platform was to allow managers, stakeholders, and modelers to produce visualizations for any time series model results in a standardized way and without requiring any specialized knowledge. RIVER was built using ArcGIS Web AppBuilder Developer Edition with custom widgets written in JavaScript, and uses data hosted in Reclamation Interactive Sharing Environment (RISE). RIVER is publicly available at <https://data.usbr.gov/river>.

Guidance from a community of Reclamation stakeholders was a key factor in guiding the development of RIVER. The primary components of RIVER include: (1) a data loading interface, which allows users to query the time series data stored in RISE to select time series to load into RIVER, (2) a map, which displays the location of each time series that has been loaded, and (3) a plot widget, which allows users to generate and interact with a variety of charts, graphs, and tables, including bar charts, box plots, scatter plots, trace difference plots, probability exceedance plots, covariance plots, raster plots, and monthly average tables.

While RIVER made significant process in developing an application to visualize modeling results, additional work past the end of this research project is needed to make it into a fully viable product, including publishing additional model results in RISE and some additional coding work to maintain and update it. Additionally, for RIVER to remain viable past 2025, it would need to be transitioned to another framework, as Esri Web AppBuilder is nearing the end of its lifecycle.

Introduction

Bureau of Reclamation (Reclamation) staff conduct a variety of modeling in order to support Reclamation's mission of managing water in the West, including water operations, water quality, environmental, and biological modeling. While Reclamation offices maintain various tools to visualize modeling results, these tools generally require specialized knowledge and/or software to use. As a result, managers and stakeholders who rely on modeling results to support their decision-making often have to rely on modelers to produce visualizations for them, which can be a slow, iterative process.

The goal of this project was to build an interactive visualization platform that allows managers, stakeholders, and modelers to produce visualizations for any time series modeling results in a standardized way and without requiring any specialized knowledge. This platform is entitled Reclamation Interactive Visualization and Exploration Resource (RIVER). This research builds on a previous S&T Project, West-wide Resource Assessment and Management Planning User' Platform (Tansey, 2017), which was a scoping project to determine how best to address the "need to effectively communicate outcome of water resource assessment and management planning studies."

The Reclamation Interactive Sharing Environment (RISE), along with its predecessor Reclamation Water Information System (RWIS), have endeavored to standardize the format in which data is shared across Reclamation. As many of Reclamation's key mission-related datasets are time series data, particular attention has been paid to this data format. In RISE, time series data are stored in a standardized format and with standardized metadata. These data can be queried, downloaded, and plotted through the RISE website (<https://data.usbr.gov>). Additionally, they can be accessed through the RISE Application Programming Interface (API) (<https://data.usbr.gov/API>).

This report briefly describes the methods used to develop RIVER and a summary of the functionality, along with lessons learned and a conclusion. The bulk of the report is the RIVER User Guide, which forms Appendix A.

Methods

Several approaches to development were considered, including building an R-shiny application or a fully custom application in Python or Javascript using open-source libraries. Ultimately, it was decided to use Esri's ArcGIS Web AppBuilder Developer Edition (Web AppBuilder). Web AppBuilder allows developers to create map-based applications and to add a number of out-of-the-box widgets. Additionally, developers can create custom widgets in JavaScript, and can modify the out-of-the-box widgets or any other aspects of the code as needed. While Web AppBuilder is a licensed product, Reclamation already owned a sufficient number of licenses. Additionally, the Esri suite of products, including ArcGIS Enterprise, ArcMap, ArcGIS Pro, and ArcGIS Storymaps, is in

widespread use through Reclamation, so it was considered unlikely that Reclamation would stop supporting Web AppBuilder in the near future.

RIVER uses data from the RISE API. The RISE API provides time series data (both modeled and observed), as well as metadata for all data types, in JavaScript Object Notation (JSON) format. RIVER is also hosted on the RISE server, in part because the RISE server does not yet support Cross-Origin Resource Sharing (CORS), which limits the ability for web applications hosted on other servers to access the RISE API. CORS support is anticipated to be implemented in early 2023. In addition to the production, publicly available version of RIVER, there is also an internal test version, which is hosted on the internal test RISE server and accesses the test version of the RISE database. This version is used for development and testing.

A stakeholder group was formed which included one or more members from each Reclamation region, as well as the Denver office, and which included modelers, managers, and members of the RISE team. Stakeholder meetings were held approximately once per quarter in 2019, 2020, and early 2021. The goals of these meetings were to inform development progress and build engagement with the potential user base. In each meeting, the PI demonstrated the current application functionality (or mock-ups, in the early phases before a functional prototype had been completed), and solicited feedback on development priorities and next steps. Additional meetings were held with smaller groups, such as CalSim modelers, to learn more about how their model results are currently visualized.

Data Loading

One of the first steps in developing RIVER was to develop a workflow for users to select and load data from RISE into RIVER. The selected workflow contains three steps: first, the user views a list of models with available data and select one or more models. Second, the user selects one or more model runs associated with the selected model(s). Third, they view and select the time series associated with the selected model run(s), and then click “Finish” to load those time series. While this creates a user-friendly workflow, generating a list of model runs and time series with the desired metadata (locations and parameters for each time series) requires a large number of requests to the RISE API, due to the structure of the RISE database and API endpoints. Accordingly, the process of locating and selecting data is relatively slow. Future changes to the API endpoints are planned, which may provide opportunities for speeding up this process.

While RIVER was only originally intended to support modeling results, stakeholders expressed the wish to also be able to load observed time series in order to compare observed and modeled results. This functionality was added, using a slightly different workflow, where users first select the location they are interested in, then select time series associated with that location. To keep the focus on modeling results, users are required to select at least one modeled time series, while the selection of observed time series is optional.

The initial data loading widget is a splash widget, which disappears after it is closed. It was recognized that users may want to add additional time series after closing the splash screen without starting over, so an “Add Time Series” widget was added to allow users to select and add additional time series in a panel widget using a similar workflow.

Stakeholders also expressed a desire to be able to share results with others (for example, by emailing a link that would have time series pre-loaded into the application), or to quickly reload the same set of time series. While generating links that would load time series was found not to be feasible, a solution was identified through the Save Session widget. This widget allows users to save the time series they have loaded, as well as any graphics that have been added to the map, as a JSON file, which can then be shared with others or reused at a later date. The user can then click a “Close without loading data” link in the data loading widget to bypass the data loading process, and instead load the JSON file through the Save Session widget. This widget used code from an open-source Web AppBuilder widget of the same name, sponsored by the City of Garland, TX, and published in GitHub at <https://github.com/softwhere/SaveSession-Widget>. This widget was modified to support saving and reloading time series, as well as to remove unneeded functionality.

Data Visualization

The next main component of the application is visualization of the time series. Through stakeholder communications, various priorities were identified. RIVER was originally intended to provide map-based visualizations as well as graphs and charts. However, stakeholders identified a much greater need for interactive graphs and charts than for map-based visualization. Many stakeholders expressed a need to first be able to replicate the existing graphs/charts that they were currently producing or consuming before considering other visualizations.

Plotting capability was implemented in a custom in-panel plot widget. The initial set of graphs/charts included scatter plots, bar charts, box plots, and probability exceedance plots. These types of graphs are all commonly used for visualizing many model result types in Reclamation. A table option showing monthly averages was also implemented. Following input from stakeholders, additional graph types were added, including trace difference plots (which plot the difference from a reference time series), raster plots and covariance plots. Additional options to customize and interact with plots were also added as a result of stakeholder feedback, such as the ability to separate bar charts and box plots by month or water year type, show the difference between two time series in a raster plot, show only a subset of months on an exceedance plot, and zoom in on and download all plot types. Additional details about the available plot options are available in the RIVER User Guide (Appendix A).

The process for converting units and displaying time series with differing units was subject to several iterations, as stakeholders found initial attempts to be too confusing. Time series in RISE are stored in units defined by the data steward who shares the dataset, and may differ between similar datasets. Keeping in line with the goal of RIVER to standardize the workflow for visualizing modeling results, it was important that users be able to plot multiple time series with the same dimension but different native units on a single plot, and to be able to convert to another unit that they preferred. For example, there are datasets in RISE with units of acre-feet and units of thousand acre-feet (TAF); both measurements of volume. Users may also want to view volumes in other units, including cubic meters, million acre-feet (MAF), liters, or milliliters. The solution implemented in RIVER is to provide users with a dropdown box to select a dimension, such as length, volume, or flow rate. All time series that the user has imported with that dimension are available to be plotted, while time series with a different dimension are grayed out. Another dropdown box is then displayed

with the available units that can be selected for that time series. Scatter plots also have an option to add a second y-axis, which can display the same or a different dimension.

Time series are also linked back to their respective Item Details page in RISE, allowing users to view metadata and access other RISE functionality. Users can also download the time series in csv or JSON format. The download features uses the RISE Download API, which ensures that users receive a consistent product as they would if they accessed the data through the RISE time series query interface.

Other Features

In addition to the custom widgets described above, several standard Web AppBuilder widgets are available. These widgets primarily provide additional functionality for the map, and include:

- Zoom widget: Allows users to zoom in and out on the map
- Home widget: Returns the map to the original extent (in RIVER, the map is initially set to the full extent of the locations associated with all time series that have been loaded).
- Measurement widget: Allows users to measure distances or areas on the map
- Print widget: Allows users to generate a PDF of the map and any annotations that have been added.
- Basemap Gallery widget: Allows users to change the basemap.
- Add Reference Geospatial Data widget: Allows users to add geospatial layers to the map from ArcGIS Online, a URL, or a file.
- Draw/Annotate widget: Allows users to annotate the map with graphics and/or text.
- Legend widget: Displays the legend for all layers that have been added to the map.
- Layer list widget: Displays a list of layers that have been added to the map and allows users to access various options for each layer, such as displaying the attribute table, enabling or disabling popups, or reordering the drawing order on the map.
- Attribute Table widget: Displays attributes for each layer on the map in a table.

User Testing and Release Process

In June 2020, all members of the RIVER stakeholder group were invited to participate in user testing. Five stakeholders participated, and they provided a total of 36 pieces of feedback on the application functionality, including requests to add new features, requests to modify existing features, identification of bugs, and areas of poor performance. All of the identified bugs were subsequently fixed. The requests to add new features and modify existing features were prioritized according to their need, applicability to other users, and ease of implementation, and the highest priority requests were implemented.

While the PI is able to directly update the test version of the application as needed, updates to the RIVER production site are managed through the RISE deployment process. RISE deployments occur approximately once per quarter, and follow a defined process for testing, security scanning, approval, and deployment.

Discussion and Conclusion

While RIVER is currently available on the public web (<https://data.usbr.gov/river/>), it has not yet been adopted into widespread use. One factor affecting that is the limited availability of modeled data in RISE. As of 11/9/2022, there are only two models available in RISE: CalSim II and the Pecos River Basin Operational Model. CalSim II is a model that is in widespread use in California, including in Reclamation's California Great-Basin region, for long-term water operations planning. However, the two model runs shared in RISE are both from a completed study that is no longer of significant active interest to most stakeholders. The Pecos River Basin Operational Model was developed for the Pecos River Basin Study, which was completed in 2021. Efforts to share other models in RISE are ongoing, and multiple other models are anticipated to be published in 2023.

Additional coding may also be necessary to make RIVER fully viable. While data stewards can define either a point, line, or polygon location in RISE, the production version currently only supports adding point locations to the map. Support for polygon locations has been implemented in the test version, and work on support for line locations has begun, but these enhancements have not been deployed to the production version. Additional work to more thoroughly identify and address bugs, as well as to improve the speed of data loading, would also be desirable. Adding additional user guidance on how to large load amounts of data, ideally within the application, would also be desirable.

Esri Web AppBuilder is also approaching the end of its lifecycle. While Web AppBuilder is still in the General Availability phase, it relies on the ArcGIS API for JavaScript version 3. Version 3 entered extended support on November 10, 2022. It will enter mature support in December 2024, meaning that software updates and patches will no longer be issued, and will be retired in December 2025 (Esri, 2022b). If it is desired to maintain the viability of RIVER long term, it may be necessary to transition to another framework. ArcGIS Experience Builder is Esri's successor to Web AppBuilder, and relies on version 4 of the ArcGIS API for JavaScript, which will likely still be supported for several years. For reference, version 3 was released in 2012, and version 4 was released in 2016. If version 4 followed a similar 13-year lifecycle as version 3, it would be retired in 2029. Experience Builder contains various enhancements relative to Web AppBuilder, such as the ability to build multi-page applications and native mobile applications. However, transitioning RIVER from Web AppBuilder to Experience Builder would not be trivial, and would require acquiring knowledge of TypeScript, React, and JSX (Esri, 2022a).

In conclusion, RIVER has made significant process in fulfilling its goal of developing a web application that managers, stakeholders, and modelers can use to visualize modeling results in an interactive way. However, additional work past the end of this research project would be required to make RIVER into a fully viable product that could be widely used by Reclamation staff and stakeholders. It is unknown whether resources will be identified in the future to complete this work.

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Appendix A: User Guide

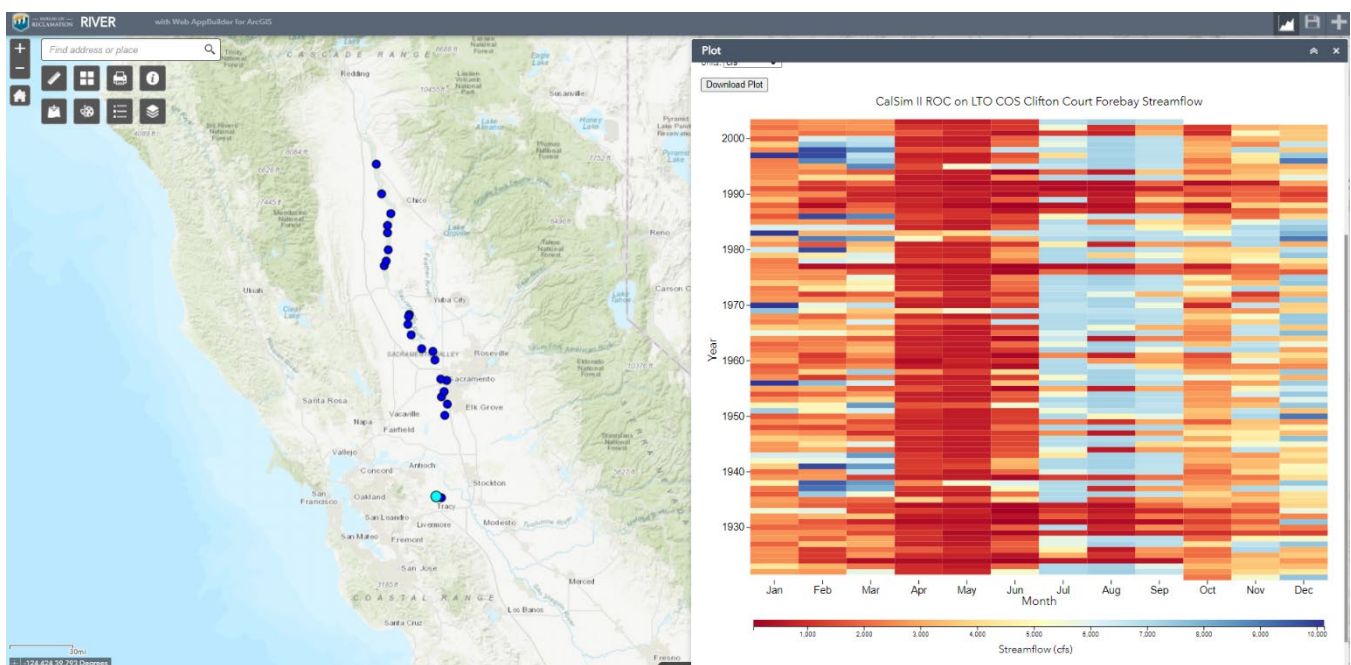
The RIVER user guide is attached. This guide provides instructions on how to use each of the key features of RIVER.



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Reclamation Interactive Visualization and Exploration Resource (RIVER) User Guide, v. 1.0

Science and Technology Project #19221



Mission Statements

The Department of the Interior (DOI) conserves and manages the Nation's natural resources and cultural heritage for the benefit and enjoyment of the American people, provides scientific and other information about natural resources and natural hazards to address societal challenges and create opportunities for the American people, and honors the Nation's trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities to help them prosper.

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Reclamation Interactive Visualization and Exploration Resource (RIVER) User Guide, v. 1.0

Science and Technology Project #19221

prepared by

**California Great Basin Region, Planning Division
Vanessa King, Hydrologist**

Cover Image: A screenshot from the RIVER application.

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Introduction

Reclamation Interactive Visualization and Exploration Resource (RIVER) is a model results visualization application. The application allows users to load time series data that are stored in Reclamation Information Sharing Environment (RISE), view the locations associated with each time series on a map, and create various plots and charts of the time series data, including bar charts, box plots, covariance plots, exceedance plots, raster plots, scatter plots, and tables.

RIVER is an ongoing research project, funded by Reclamation's Science and Technology program (S&T project #19221). Please contact Vanessa King, Principal Investigator, with any questions, at vking@usbr.gov.

Access the site by navigating to <https://data.usbr.gov/RIVER>. It is recommended to use Google Chrome or Microsoft Edge; RIVER has not been tested for compatibility with other browsers.

Loading Data from the Splash widget

Use the Splash widget to load data that is stored in RISE into RIVER.

Select Modeled Data

When you first load the application, a splash widget will appear (Figure 1). Click "Step 1: Select model". Use Ctrl + click to select multiple models.

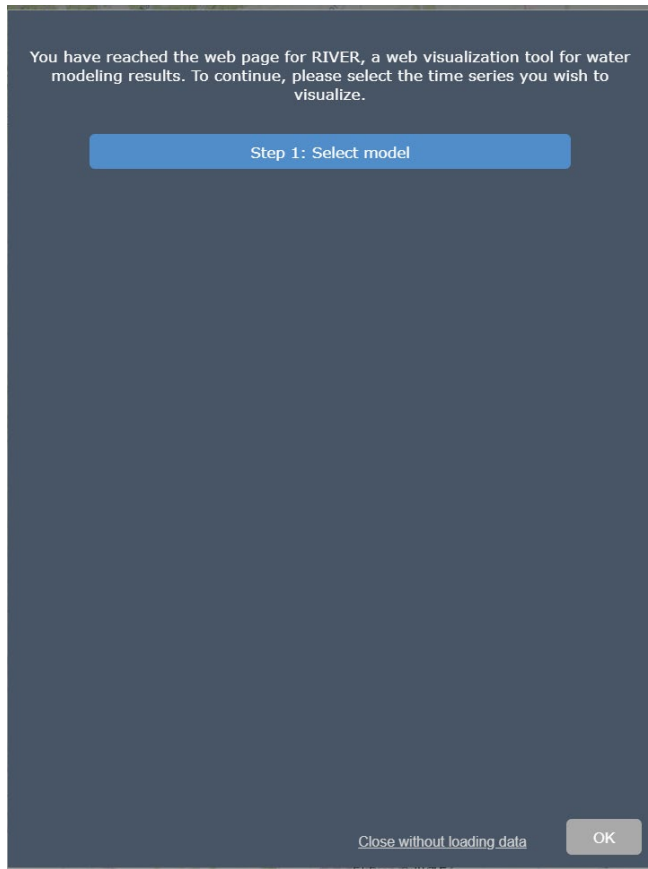


Figure 1. The splash widget, as it appears on initial load.

After selecting a model, the model run selection options will appear. Select one or more model runs using the dropdown menu. When one or more model runs have been selected, the “Load” button will be active. Click this button to load the time series associated with the selected model runs.

Click the dropdown arrow next to the “View all time series” box to view a list of all time series or start typing in the “View all time series” box to filter the list of available time series. Since the name of every time series begins with the model run name, the filter option is most useful when you have loaded time series from multiple model runs, and want to view the time series associated with a particular model run.

Alternatively, type a search string in the “Search time series” and press the magnifying glass icon. This will display a dialog box with a list of all time series whose names include the search string. Select one or more time series from the dialog box, then click the “x” to close the dialog box.

If you wish to remove a time series that you have selected, click the “Del” button next to the time series name.

When you have finished selecting data, click the “OK” button in the bottom right corner to close the splash widget and load the selected data. Data may take several seconds to load, or potentially up to 1-2 minutes, depending on your connection speed and how much data you have selected.

Select Observed Data (optional)

After you have selected one or more modeled time series following the instructions above, you can optionally add observed time series as well. Note: RIVER is intended to be a model results visualization application, which is why it is required to load at least one modeled time series. However, users may wish to compare their modeled data to observed data, so observed data stored in RISE is also available.

Click the dropdown arrow under “Select locations” to view all locations or start typing in the box to filter the list of available locations. After selecting one or more locations, click “Load.” This will load all available time series associated with the selected locations. Click the dropdown arrow under “Select observed time series” and select one or more time series.

If you wish to remove a time series that you have selected, click the “Del” button next to the time series name.

When you have finished selecting data, click the “OK” button in the bottom right corner to close the splash widget and load the selected data. Data may take several seconds to load, or potentially up to 1-2 minutes, depending on your connection speed and how much data you are loading.

Data Loading Errors

When you click “OK” on the splash widget, the selected data will be loaded into the application from the RISE API. In certain circumstances, you may receive one or more of the following messages:

- “[time series name] has no associated data.” Some time series accessible from the RISE API may have only metadata, with no associated data. If you select one of these time series, you will receive a warning message, and nothing will be loaded for this time series.
- “[x] pages of [y] pages failed to load.” If you try to load a large amount of data, some pages of data may fail to load. Typically, you can load about 150,000 data points (about 1500 pages) without error, but this amount may be reduced if you have a slow network connection. Each page of data contains up to 100 data points. Time series that had one or more pages of data fail to load will be displayed in red in the Plot widget. You can use the Add Additional Time Series widget to reload the failed time series.

Understanding the Application Layout

After closing the Splash widget (either by selecting some time series, and clicking “OK”, or by closing the Splash widget without loading the data), the application will consist of three main parts: a map, a group of custom widgets (developed for this project), and a group of standard widgets (developed by Esri). The custom widgets are near the top right, and the standard widgets are near the top left (Figure 2). The zoom buttons, home button, and search widget are off-panel widgets,

meaning that they function without opening another panel. The rest of the widgets are in-panel widgets, meaning that they open in a new panel. Click a widget icon to open that widget. Click the “x” in the panel’s top right corner to close the widget.

Panels for custom widgets open on the right side of the screen and have fixed locations. Panels for standard widgets open on the left side of the screen and can be moved by clicking on the panel and dragging.

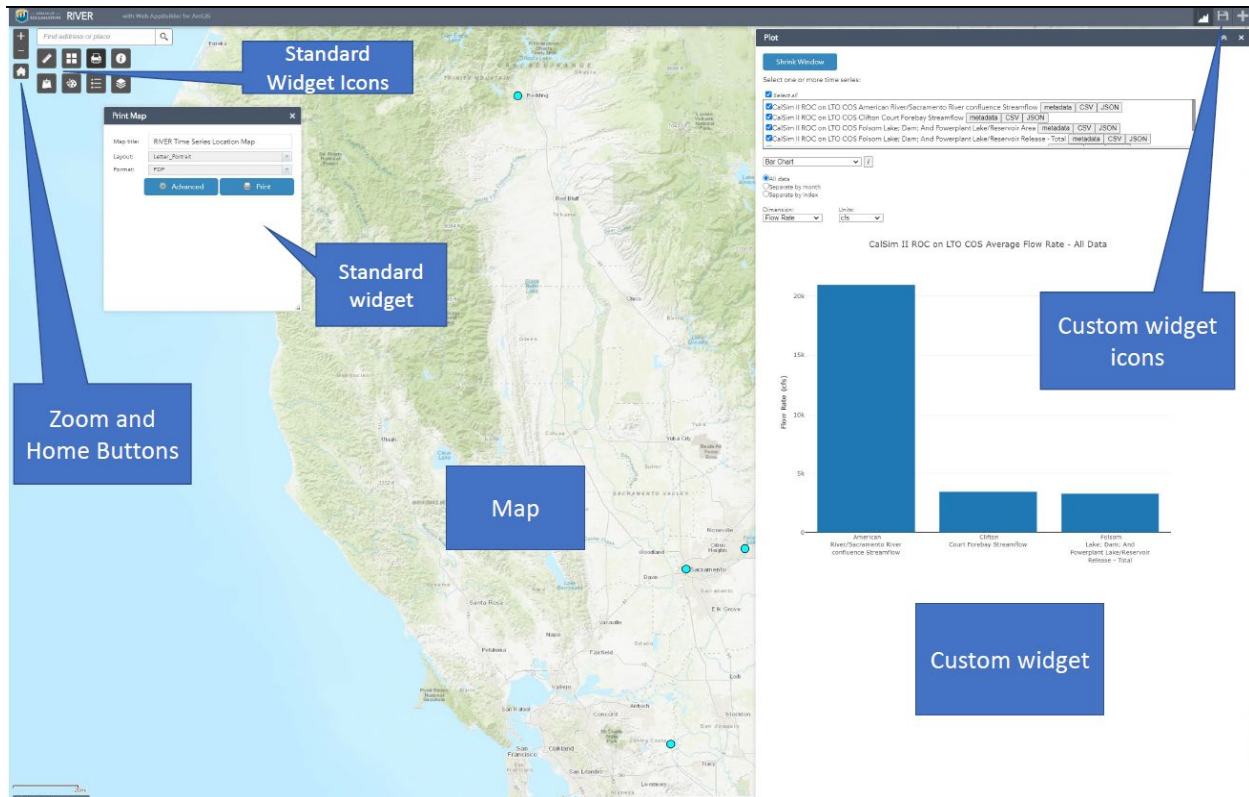


Figure 2. A view of the RIVER user interface, with the main features annotated.

Interacting with the Map

After loading data, a layer will be added to the map, indicating the locations of the data that has been loaded, and the map will zoom to the extent of all data that has been loaded. Click on a point to bring up a popup with the location name. Click the ‘x’ on the popup to close it.

To zoom in, scroll up on your mouse’s scroll wheel, click the ‘+’ button on the zoom slider widget (near the top left corner), or use the ‘+’ key on your keyboard.

To zoom out, scroll down on your mouse’s scroll wheel, click the ‘-’ button on the zoom slider widget (near the top left corner), or use the ‘-’ key on your keyboard.

To pan, click on the map and drag, or use the arrow keys on your keyboard.

Click the Home button (the button with an image of a house, near the top left corner) to return the map to its default extent.

Adding Additional Time Series

Use the Add Additional Time Series widget to load additional time series after closing the Splash widget. Open this widget by clicking the Add Additional Time Series widget icon in the header bar (Figure 3).



Figure 3. Add Additional Time Series widget icon.

This widget functions similarly to the Splash widget. However, because in most cases you will have already loaded one or more modeled time series, there is no requirement to add modeled time series before adding observed time series. Use the checkboxes to indicate whether you wish to add modeled time series, observed time series, or both. See the Loading Data from the Splash Widget section for information on selecting data.

Time series that have already been loaded into the application will not be available for selection, unless one or more pages did not correctly load the first time the time series was loaded.

Plotting Time Series Data

Use the Plot widget to plot the data you have loaded. Open this widget by clicking the Plot widget icon in the header bar (Figure 4).



Figure 4. Plot widget icon.

Select one or more of the loaded time series to plot by clicking the checkbox next to each time series name. You can also use the “Select all” checkbox to select all time series.

Click the “Expand Window” button to increase the width of the Plot widget window. When the window is expanded, click “Shrink Window” to return the window to its original width.

The “metadata”, “CSV”, and “JSON” buttons next to each time series name can be used to open the RISE page for that time series, download the data in CSV format, or download the data in JSON format, respectively.

Select a chart type from the dropdown box. Hover over the “?” button next to the dropdown box to view information about the selected chart type. The available options will vary based on what chart type is selected.

Bar Chart

The default option is to show an average of all data for each selected time series of the specified dimension. Select a dimension from the “Dimension” dropdown box to change which time series are displayed. Time series that are not of the selected dimension will be shown in gray in the time series selection box. Use the “Units” dropdown box to change the displayed units.

Click the “Download Plot” button to download the plot as a PNG image. Hover over the chart to view the values on each bar.

Use the radio buttons to separate data by month or by index.

When data is separated by month, uncheck the “Select all months” checkbox to select only a subset of months to display. Use the “Order by” radio buttons to display months in calendar year (January-December) order or water year (October-September) order.

When data is separated by index, two commonly used indices are available – the Sacramento River Hydrological Index or San Joaquin River Hydrological Index. These indices are commonly used in California and are based on historical climate (they do not incorporate climate change). They divide water years (October-September) into five types – wet, above normal, below normal, dry, and critical. Click the name of either index to bring up an informational page on the index. Select one of these indices. Uncheck the “Select all water year types” to select a subset of water year types to display. In addition to the five water year types, there is also an option to show a combination of dry and critical years.

In addition to the predefined water year indices, there is also an option to select a user-defined index. However, there are currently (as of 3/11/21) no data in RISE to support this option. The user-defined index must be stored in RISE as a time series and must have only integer values and no more than 10 unique values.

Box Plot

The box plot options are similar to those of the bar chart. The default option is to show a box plot of all data for each selected time series of the specified dimension. Select a dimension from the “Dimension” dropdown box to change which time series are displayed. Time series that are not of the selected dimension will be shown in gray in the time series selection box. Use the “Units” dropdown box to change the displayed units.

Click the “Download Plot” button to download the plot as a PNG image. Hover over the chart to view the minimum (or minimum fence), maximum (or maximum fence), mean, median, 1st quartile, and 3rd quartile for each box, as well as values for any outliers.

By default, the minimum and maximum fences are defined as 1.5 times the interquartile range, and outliers are defined as values outside the fences. Users can also select to use minimum and maximum fences of 3 times the interquartile range, or to use the minimum and maximum values as the fence values.

Use the radio buttons to separate data by month or by index.

When data is separated by month, uncheck the “Select all months” checkbox to select only a subset of months to display. Use the “Order by” radio buttons to display months in calendar year (January-December) order or water year (October-September) order.

When data is separated by index, two commonly used indices are available – the Sacramento River Hydrological Index or San Joaquin River Hydrological Index. These indices are commonly used in California and are based on historical climate (they do not incorporate climate change) and divide water years (October-September) into one of five types – wet, above normal, below normal, dry, and critical. Click the name of either index to bring up an informational page on the index. Select one of these indices. Uncheck the “Select all water year types” to select a subset of water year types to display. In addition to the five water year types, there is also an option to show a combination of dry and critical years.

In addition to the predefined water year indices, there is also an option to select a user-defined index. However, there are currently (as of 3/11/21) no data in RISE to support this option. The water year index must be stored in RISE as a time series and must have only integer values and no more than 10 unique values.

Covariance Plot

The covariance plot shows the value of one time series versus the value of another time series at a given time. Use the dropdown boxes to select which of the selected time series to display on each axis. Unlike the other chart types, the selected time series do not need to have the same dimension. However, the option to show a 1:1 line is only available if the two selected time series have the same dimension and units. Use the “Units” dropdown boxes to change the units for each time series.

The two time series will be interpolated to the same time step over the time period that they overlap.

Click the “Download Plot” button to download the plot as a PNG image. Hover over the plot to view the values on the plot.

Position the mouse over the x axis or y axis to zoom that axis. Use your mouse's scroll wheel or two-finger scroll on a touchpad to zoom in or out. Click and drag on the axis to pan. Use the "Reset Axes" button to return to the original zoom level.

Exceedance Plot

The exceedance plot shows the percentage of time steps for which the values exceed a given value. Select a dimension from the “Dimension” dropdown box to change which time series are displayed.

Time series that are not of the selected dimension will be shown in gray in the time series selection box. Use the “Units” dropdown box to convert the units.

Click the “Download Plot” button to download the plot as a PNG image. Hover over the plot to view the values on the plot.

Position the mouse over the x axis or y axis to zoom that axis. Use your mouse's scroll wheel or two-finger scroll on a touchpad to zoom in or out. Click and drag on the axis to pan. Use the "Reset Axes" button to return to the original zoom level.

Click the “Reverse x-axis” checkbox to toggle the direction of the x-axis (displaying the probability from 0% to 100% or from 100% to 0%).

By default, all data are shown, with no aggregation. Use the radio buttons to aggregate data by year or show only a subset of months.

Data can be aggregated by calendar year (January-December), water year (October-September) or Central Valley Project contract year (March-February). The default aggregation type is average, which is appropriate for time series such as flow rate, elevation, or storage. Aggregating by summing the data over the year may be appropriate for time series such as deliveries or releases (if releases are presented as volumes, not rates).

Raster Plot

The raster plot shows the average values in each month included in the time series. Values are represented using colors. You can plot either a single time series or the difference between two time series.

Use the radio buttons to select whether to plot a single time series or the difference between two time series.

To take the difference between two time series, first select a dimension. Time series that are not of the selected dimension will be shown in gray in the time series selection box. You must have at least two time series selected of the same dimension to make a raster difference plot. Use the “Time Series 1” and “Time Series 2” dropdown boxes to select the first and second time series. The plot will show the first time series minus the second time series. Use the “Units” dropdown box to change the displayed units.

Click the “Download Plot” button to download the plot as a PNG image. Hover over the plot to view the values on the plot.

Position the mouse over the x axis or y axis to zoom that axis. Use your mouse's scroll wheel or two-finger scroll on a touchpad to zoom in or out. Click and drag to pan. Use the "Reset Axes" button to return to the original zoom level.

Scatter Plot

The scatter plot shows the value of the time series versus time. This is sometimes known as a spaghetti plot, particularly when used to show a set of modeling scenarios. Select a dimension from the “Dimension” dropdown box to change which time series are displayed. Time series that are not of the selected dimension will be shown in gray in the time series selection box. Use the “Units” dropdown box to change the displayed units.

Click the “Download Plot” button to download the plot as a PNG image. Hover over the plot to view the values on the plot.

Position the mouse over the x axis, y axis, or second y axis (if enabled) to zoom that axis. Use your mouse's scroll wheel or two-finger scroll on a touchpad to zoom in or out. Click and drag on the axis to pan. Use the "Reset Axes" button to return to the original zoom level.

Toggle the checkboxes to toggle displaying all selected traces, displaying the mean of all selected traces, and shading between the minimum and maximum values.

Click the “Add second y-axis” checkbox to display a second y-axis on the right side of the plot, allowing you to overlay plots with two different dimensions. Select a dimension and units for the second y-axis. When the second y-axis option is selected, the option to shade between minimum and maximum values is disabled.

Trace Difference

The trace difference plot is a scatter plot that shows the difference between a set of time series and a reference time series. You must have two or more time series selected with the selected dimension in order to generate this type of plot. All selected time series of the selected dimension will be displayed. Select a dimension from the “Dimension” dropdown box to change which time series are displayed. Time series that are not of the selected dimension will be shown in gray in the time series selection box. Use the “Units” dropdown box to change the displayed units

Select one time series to be the reference time series. For example, you might choose a time series from a baseline modeling scenario as the reference trace, and compare it to time series from various other modeling scenarios.

Click the “Download Plot” button to download the plot as a PNG image. Hover over the plot to view the values on the plot.

Position the mouse over the x axis or y axis to zoom that axis. Use your mouse's scroll wheel or two-finger scroll on a touchpad to zoom in or out. Click and drag on the axis to pan. Use the "Reset Axes" button to return to the original zoom level.

Table

Currently, there is only one type of table available, which shows the monthly average values for all selected time series. Click a column heading to sort by that column. Click the column heading again to toggle between ascending and descending sort order.

To resize a column, hover over the border between two columns. When the cursor appears as a double-sided arrow, click and drag to resize. If the table width exceeds the window width, click and drag the scroll bar at the bottom of the table to scroll.

Click the “Download CSV” or “Download JSON” button to download the data displayed on the table in CSV or JSON format, respectively.

Saving Sessions to a File, and Loading Sessions from a File

Use the Save/Load Session widget to save your session to a file, or to load data from a file. Sessions are saved to a JSON file, which can be shared with others, or used to load the same set of data at a later date. If you repeatedly use the same set of data, saving data to a file will allow you to load it more quickly, both by eliminating the need to locate and select the time series again, and by increasing the speed of data loading.

In addition to saving the time series that were loaded, this widget will also save any graphics that were added to the map using the Draw/Annotate widget.

Open the Save/Load Session widget by clicking the Save/Load Session icon in the header bar (Figure 5).



Figure 5. Save/Load Session widget icon.

If you plan to load data from a file, you can click “Close without loading data” on the Splash widget to skip selecting data from that widget. Note that loading data from a file will replace any data that was previously loaded.

To save your session to a file, type a name for the session in the input box and click “Save”.

To restore a session from a file, click “Choose File”, navigate to the file on your computer, and click “Open”.

Using Standard Widgets

The previous sections (other than the Interacting with the Map section) all describe custom functionality that has been developed for the RIVER application. In addition, several standard Esri-developed widgets are available for use. These widgets are all located near the top left corner of the map and are described briefly below.

Search Widget

Type an address or place name (such as a city or county name) in the Search box (Figure 6) and click the magnifying glass icon or press Enter on your keyboard to zoom to that location.



Figure 6. Search Box.

Measurement Widget

Use the Measurement widget to measure areas or distances on the map, or to determine the latitude and longitude of a location. Open this widget by clicking the Measurement widget icon (Figure 7).



Figure 7. Measurement widget icon.

Hover over the three icons at the top of the widget to view their names. Click the area icon (left) to measure an area. Use the dropdown arrow next to the units to select a different unit. Click on the map to draw a polygon. Double-click to finish the polygon. The area will be displayed in the Measurement widget. Click “Clear” to remove the polygon.

Click the distance icon (middle) to measure a distance. Use the dropdown arrow next to the units to select a different unit. Click on the map to draw a line. Double-click to finish the line. The distance will be displayed in the Measurement widget. Click “Clear” to remove the line.

Click the Location icon (middle) to determine the latitude and longitude of a location. Use the dropdown arrow next to the unit to select a different unit. The options are Degrees (decimal degrees) or DMS (degrees, minutes, seconds). Click the location on the map. The location will be displayed in the Measurement widget. Click “Clear” to remove the location.

Basemap Gallery Widget

Use the Basemap Gallery widget to select a different basemap. Open this widget by clicking the Basemap Gallery widget icon (Figure 8). Click on a basemap to select it.



Figure 8. Basemap Gallery widget icon.

Print Map Widget

Use the Print Map widget to generate a file for printing. Open this widget by clicking the Print Map widget icon (Figure 9).



Figure 9. Print Map widget icon.

Enter a map title and select a layout and format. Optionally, click the “Advanced” button to access additional options for customizing your print. When you have finished selecting options, click the “Print” button. This will generate a file. Click the file to open it in your browser, and use your browser’s tools to print or download it.

Click the “Clear prints” button to clear all prints that have been generated.

About Widget

Use the About widget to view basic information about RIVER. Open this widget by clicking the About widget icon (Figure 10).



Figure 10. About widget icon.

Add Reference Geospatial Data Widget

Use the Add Data widget to add reference data to the map. You can add ArcGIS Online data shared by Reclamation, public ArcGIS Online data, or data from a URL or file. Open this widget by clicking the Add Reference Geospatial Data widget icon (Figure 11).



Figure 11. Add Reference Geospatial Data widget icon.

To add data from ArcGIS Online, type a search string in the Search bar then click the magnifying glass icon to search, or press Enter on your keyboard. Use the arrows at the bottom of the widget to page through results. Click “ADD” to add a dataset to the map, or “DETAILS” to view the dataset’s ArcGIS Online Item Details page.

Click the “Within map” toggle switch to show only dataset that overlap with the current map extent. Click the dropdown arrow next to “Type” to filter the available data types. Click the dropdown arrow next to “Relevance” to change the sort order.

To add data from a URL, select the “URL” option at the top. Select a URL type, enter a URL of that type in the input box, and click “ADD”.

To add data from a file, select the “File” option at the top. Click the “?” button to view the allowable file types. Click “BROWSE” and select a file from your computer.

Click the “LAYERS” button at the bottom of the widget to view and delete the layers that have been added through this widget.

Draw/Annotate

Use the Draw/Annotate widget to add graphics or text to the map. Open this widget by clicking the Draw/Annotate widget icon (Figure 12).



Figure 12. Draw/Annotate widget icon.

To add text annotation to the map, select the Text mode (“A”), type your text in the “Text” input box, and adjust the font color or font size if desired. Click on the map to place your text.

To add a graphic to the map, select a draw mode, then select from the available style options. Hover over the map to view instructions for drawing a shape of the selected type, then draw the shape.

Click “Undo” to remove the last drawn graphic or annotation, or “Clear” to remove all graphics and annotations.

Legend Widget

Use the legend icon to view the symbology for all layers that are currently displayed on the map, including the Time series locations as well as any layers that have been added from the Add

Reference Geospatial Data widget or selected in the Layer List widget. Open this widget by clicking the Legend widget icon (Figure 13). The basemap symbology is not included in the legend.



Figure 13. Legend widget icon.

Layer List Widget

Use the Layer List widget to show or hide and interact with the layers. Open this widget by clicking the Layer List widget icon (Figure 14). The layer list will contain a layer for the time series locations (if time series data has been loaded), for selected time series locations (if time series have been selected in the Plot widget), the basemap, and any layers that have been added from the Add Reference Geospatial Data widget.



Figure 14. Layer List widget icon.

Toggle the checkbox to the left of the layer name to show or hide a layer. Click the “...” button to the right of the layer name to zoom to the layer, adjust the layer’s transparency, enable/disable popups, change the drawing order by moving the layer up or down in the layer list, or view the layer’s Attribute Table.

