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Integration of Invasive Mussel Detection Data in RISE

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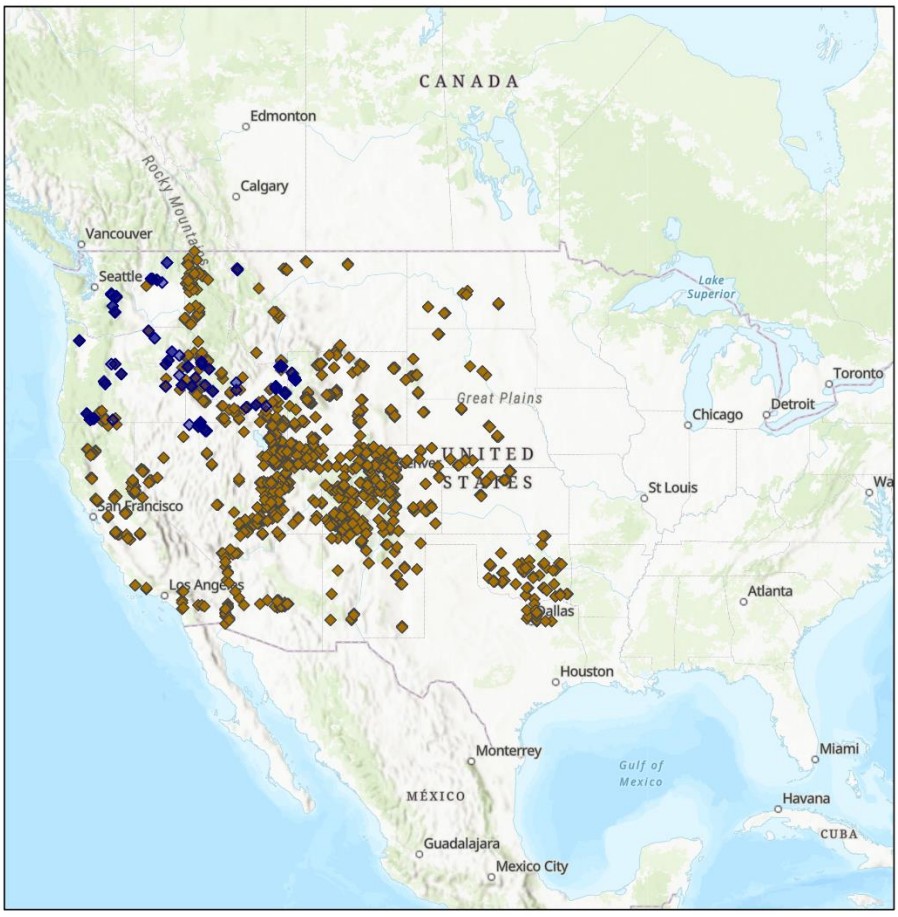

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14. ABSTRACT
Data on detection and monitoring of invasive dreissenid (quagga and zebra) mussels from Reclamations Ecological Research Laboratory and the CPN Interior Region 9 Laboratory were added the Reclamation Information Sharing Environment (RISE) to make them publicly available. Data included geospatial data on sample collection for dreissenid mussel early detection and time-series data on veliger numbers and densities from reservoirs with established quagga mussel populations.

15. SUBJECT TERMS
Invasive mussels, dreissenid mussel, quagga mussel, GIS, RISE

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The Science and Technology Program, Bureau of Reclamation, sponsored this research. Alison Odell provided substantial guidance advice, and organization over the course of the project. Vanessa King provided expertise on GIS and developed scripts to format geospatial data for importation to ArcGIS software.

Integration of Invasive Mussel Detection Data in RISE

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Acronyms and Abbreviations

C-PN Lab	Columbia-Pacific Northwest Regional Soil and Water Laboratory
CSV	Comma-separated values (file format)
EcoLab	Ecological Research Laboratory
GeoJSON	Geographic JSON (file format)
GIS	Geographic information system
ID	Identification number (in reference to RISE unique identifiers)
JSON	JavaScript Object Notation (file format)
KML	Keyhole Markup Language (file format)
PNG	Portable Network Graphics (file format)
Reclamation	Bureau of Reclamation
RISE	Reclamation Information Sharing Environment
SVG	Scalable Vector Graphics (file format)
XLS	Microsoft Excel Binary File Format

Measurements

C	total veliger count in a sample
D	density of veligers per cubic meter in sampled water
L	total length of plankton tows, in meters, collected in a sample
r	radius of the plankton tow net opening, in meters
veligers/m^3	veligers per cubic meter

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Executive Summary

Since the discovery of quagga mussels in Lake Mead in 2007, Reclamation has dedicated significant resources to early detection of invasive dreissenid mussels (quagga and zebra mussel). Dreissenid mussels can have major impacts on Reclamation operations, and can disrupt food webs or cause other ecological perturbations. Early detection of dreissenid mussels is critical to provide lead time for managers to plan for and mitigate the impact of a potential infestation. Monitoring of established populations is also important for Reclamation operations, providing insight into seasonal variations and populations, and identifying long-term trends that may affect planning. The Ecological Research Laboratory (EcoLab) in the Technical Service Center and the Columbia-Pacific Northwest Regional Soil and Water Laboratory (C-PN Lab) have both maintained early detection programs covering reservoirs and other waterbodies across Reclamation's territory in the Western United States. The goal of the current project was to make information on these early detection and monitoring efforts publicly available through the Reclamation Information Sharing Environment (RISE). Open access to data on mussel early detection sampling will provide a valuable resource for future projects, aiding with the identification of sites that may require additional sampling effort in the future. Data on veliger counts can improve our understanding of populations, allowing identification of potential links to environmental variation and informing the design of future control efforts.

Sampling data for mussel early detection was added to RISE as two geospatial datasets, one for sampling data from the EcoLab, and the other for sampling data from the C-PN Lab. Both datasets contain sampling locations where mussel early detection samples have been collected. For each sampling location, a list off all sample collection dates at that location is included in the dataset, and these can be displayed in a pop-up dialogue box. Together these two geospatial datasets encompass sampling data from 2352 discrete locations, with sampling dates extending from 2008 through 2021.

Veliger monitoring data were added to RISE as time series datasets for 38 locations with established quagga mussel populations, including: Lake Mead, Lake Mohave, Lake Havasu, and Imperial Reservoir on the Lower Colorado River; Lake Powell on the Upper Colorado River; Apache Lake, Canyon Lake, and Saguaro Lake on the Salt River in Arizona; and from several non-impounded sampling locations along the Colorado River. Data for these entries includes total veliger counts from samples collected by plankton tow net, as well as calculated veliger densities in the sampled waters.

Methods

Data sources

Data for this project was derived from dreissenid mussel early detection and monitoring programs conducted by the Ecological Research Laboratory (EcoLab) in Reclamation's Technical Service Center (TSC) in Denver, Colorado and by the Columbia-Pacific Northwest Regional Soil and Water Laboratory (C-PN Lab) in Reclamation's regional office in Boise, Idaho. Both laboratories have conducted ongoing programs for early detection of dreissenid mussels since quagga mussels were first identified in Lake Mead in 2007. Data from both these efforts are housed on secure local databases and had not previously been made available in an open access format.

Geospatial datasets for mussel detection sample collection

Geospatial datasets of sample collection sites used in dreissenid mussel early detection were generated from both laboratories' databases. Sample location sites are described as points based on a reference latitude and longitude. Each location is defined as encompassing a circle with a radius of 200 meters surrounding the reference point. This convention was established during development of EcoLab's mussel detection and monitoring database to account for variation in the precise location of field sample collection and to avoid the proliferation of named locations within a given waterbody (as described in Passamaneck, 2019). For each location a list of all sample collection dates is included in the dataset. Sample collection dates are grouped by year.

For addition of geospatial sample collection data to RISE, datasets were first exported from their respective EcoLab and C-PN Lab databases as comma-separate value (CSV) or Microsoft Excel (XLS) file formats. Exported datasets included location name, reference latitude and longitude, and all sample collection dates. Vanessa King (California-Great Basin Region, Division of Planning) developed scripts to transform these datasets for importation into ArcGIS, including addition of a reference elevation for each location. Resultant formatted datasets were in .csv format, with data for each location on a single line. Sample collection dates for each year were clustered as comma-separated groups, and multiple dates within a given year were separated by semicolons. Addition of geospatial datasets to RISE was performed following guidance in the Reclamation Information Sharing Environment (RISE) Data Publication Process Manual v2.0 (Odell, 2020). Briefly, a Catalog Record and Item were created in RISE for each dataset. The formatted .csv for the dataset was then imported into ArcGIS, and the resultant GIS layer was annotated with metadata matching the RISE Catalog Item description. The GIS layer was then exported and provided to the RISE Data Manager Review group for review prior to publication.

Time series datasets for mussel population monitoring

Time series datasets were established in RISE for locations with established quagga mussel populations where the EcoLab has performed monitoring of mussel veliger population dynamics. As described above, data were retrieved from the EcoLab's mussel detection and monitoring database. The primary datatype from the database were total veliger counts measured from field samples, which were collected and analyzed following the EcoLab's standard operating procedures. A secondary datatype was a calculated veliger density in the sampled waters, based on the total

veliger count and the calculated volume of water filtered through a plankton tow net during sample collection. The density (***D***) of veligers per cubic meter (veligers/m^3) was calculated as:

$$D = \frac{C}{\pi r^2 \times L}$$

where ***C*** is the total count of veligers in the sample, ***r*** is the radius, in meters, of the opening on the tow net used for sampling, and ***L*** is the total length, in meters, of the tow(s) used for sample collection. When more than one tow was performed to collect a single sample, ***L*** should be the aggregate length of all tows.

Veliger density was calculated for all cases where the volume of water sampled could be reliably determined. For samples collected from lotic systems, such as along non-impounded regions of the Colorado River, it was not possible to accurately calculate the volume of water filtered through the plankton tow net. In these cases, only total veliger numbers in the sample were added to RISE.

For publication in RISE, each mussel monitoring sample location was assigned a unique Catalog Record. Each Catalog Record contains a Catalog Item for total veliger counts and, when applicable, a Catalog Item for veliger densities.

Results

Geospatial datasets

Geospatial data on mussel early detection sample collection data from the EcoLab has been published in RISE and is publicly available. The Catalog Record for the data is titled "Ecological Research Laboratory Invasive Mussel Early Detection Sampling" (https://data.usbr.gov/catalog/4630) and the Catalog Item is titled "Western US EcoLab Invasive Mussel Early Detection Sampling Geospatial Data" (https://data.usbr.gov/catalog/4630/item/11486). The Catalog Item contains the GIS layer, which is composed of 2252 point locations, with sampling date data extending from 2008 through 2021.

Geospatial data on mussel early detection sample collection data from the C-PN Lab has likewise been published in RISE and is publicly available. The Catalog Record for the data is titled "C-PN Regional Soil and Water Laboratory Invasive Mussel Early Detection Sampling" (https://data.usbr.gov/catalog/4638) and the Catalog Item is titled "Columbia-Pacific Northwest Region Invasive Mussel Early Detection Sampling Geospatial Data" (https://data.usbr.gov/catalog/4638/item/11504). The Catalog Item contains the GIS layer, which is composed of 100 point locations, with sampling date data extending from 2010 through 2021.

Within RISE the data can be accessed through the online mapping system, allowing mapping and visualization, as well the ability to overlay these data with other geospatial datasets available in RISE. Adding either of these geospatial layers to the RISE Web Mapping tool will display all the point locations in the dataset (Figure 1;Figure 2). Associated data for any of the point locations can be viewed by clicking on the point's symbol on the map. A dialogue box will then be displayed, which

includes the Waterbody, Location Name, Latitude, Longitude, Elevation, and all sample collection dates, by year, for the location (Figure 3). The data can also be opened in ArcGIS (Online or Desktop versions) and can be exported for a variety of formats, including CSV, KML, and GeoJSON, allowing additional exploration and analysis of the data with other application software.

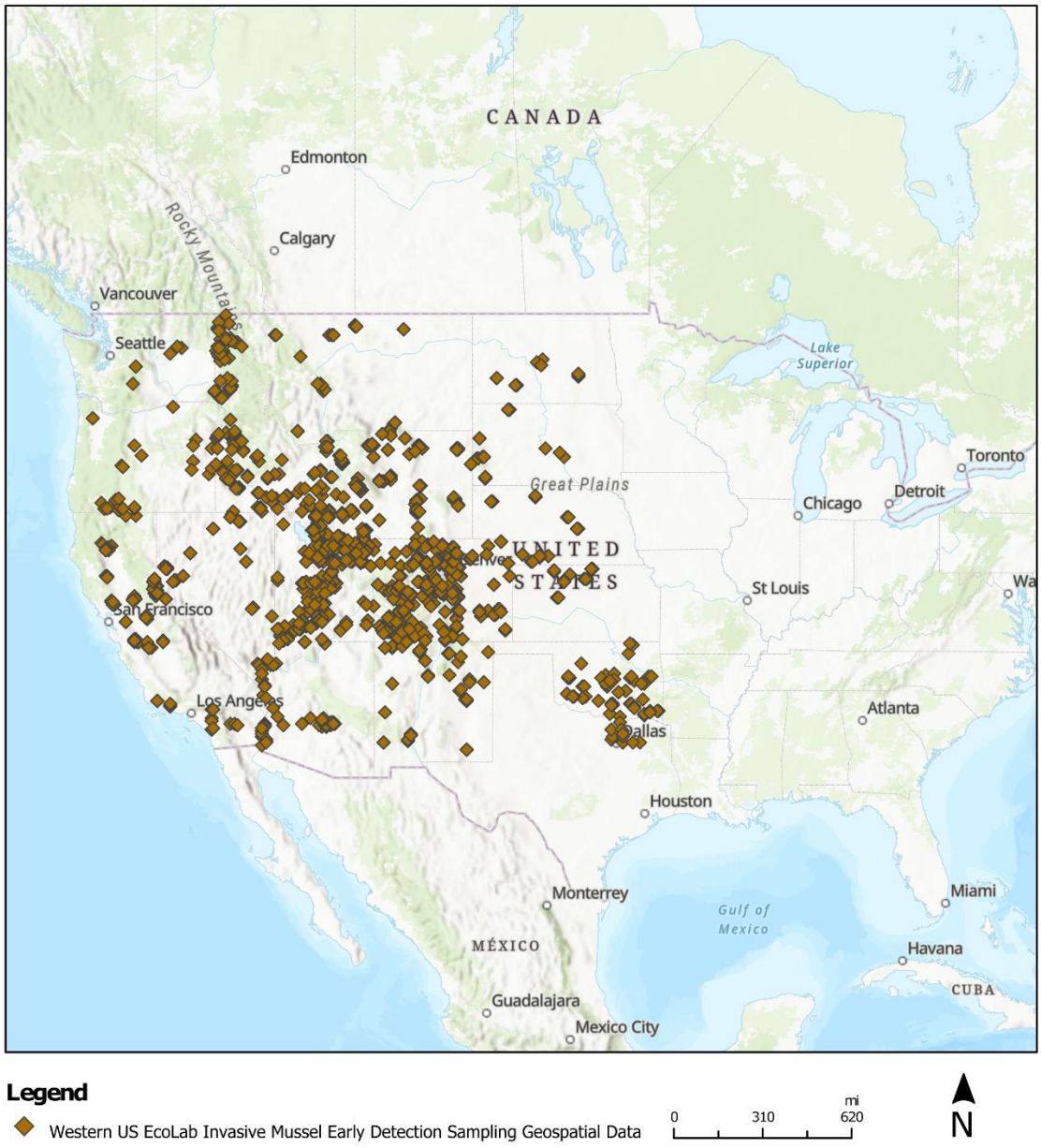

Figure 1. Map of the Western United States with all point locations from the Ecological Research Laboratory Invasive Mussel Early Detection Sampling geospatial dataset displayed as brown diamonds. Note that many point location markers overlap one another at the display. The map was generated in the RISE Web Mapping interface. The image was exported as an SVG file, and formatted for this report using Inkscape v0.92.4 open source software.

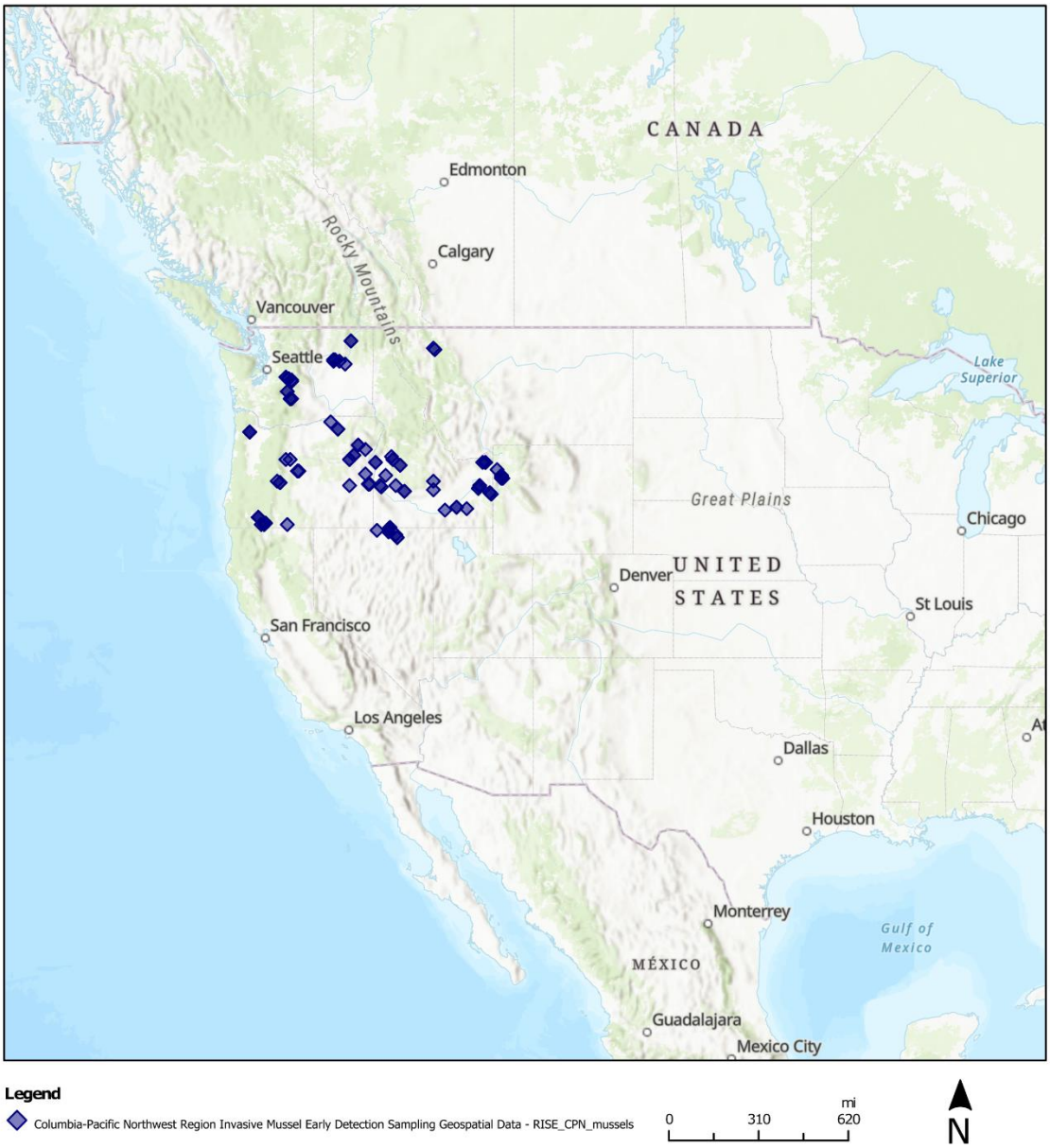

Figure 2. Map of the Western United States with all point locations from the Columbia-Pacific Northwest Region Invasive Mussel Early Detection Sampling geospatial dataset displayed as blue diamonds. Note that many point location markers overlap one another at the display. The map was generated in the RISE Web Mapping interface. The image was exported as an SVG file, and formatted for this report using Inkscape v0.92.4 open source software.

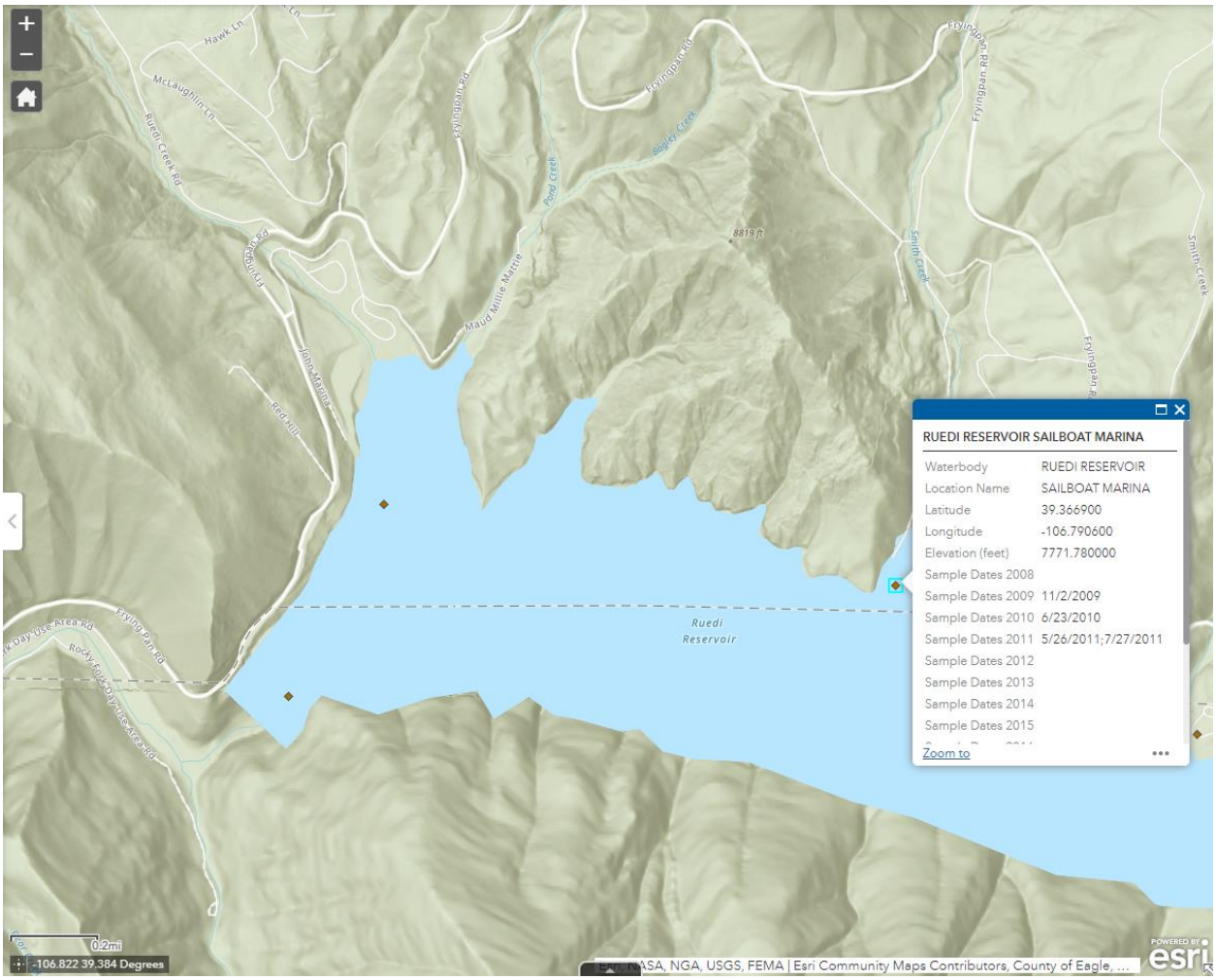

Figure 3. Screenshot of the Ruedi Reservoir region from the Ecological Research Laboratory Invasive Mussel Early Detection Sampling geospatial dataset displayed in the RISE Web Mapping interface. The pop-up dialog box for the point location Sailboat Marina is shown, displaying site information, including sample collection dates.

Time Series datasets

Data on quagga mussel veliger population monitoring are publicly available in RISE as time series datasets. Data from each location have been published in RISE as separate datasets, with unique Catalog Record and Item names and identification numbers (ID) (listed in Table AA 1). In total 44 Catalog Records were generated for time series datasets. All 44 have Items with veliger count data, and 39 also have Items with veliger density data.

Quagga mussel veliger population data in these datasets can be accessed through the RISE Time Series Query tool. This tool allows the user to specify the time period of interest, and the filtered data can then be downloaded in CSV or JSON formats for analysis in other application software. The Time Series Query tool also allows for plotting of data on the RISE website, with generated plots available for download as PNG format image files in a variety of resolutions (Figure 4; Figure 5).

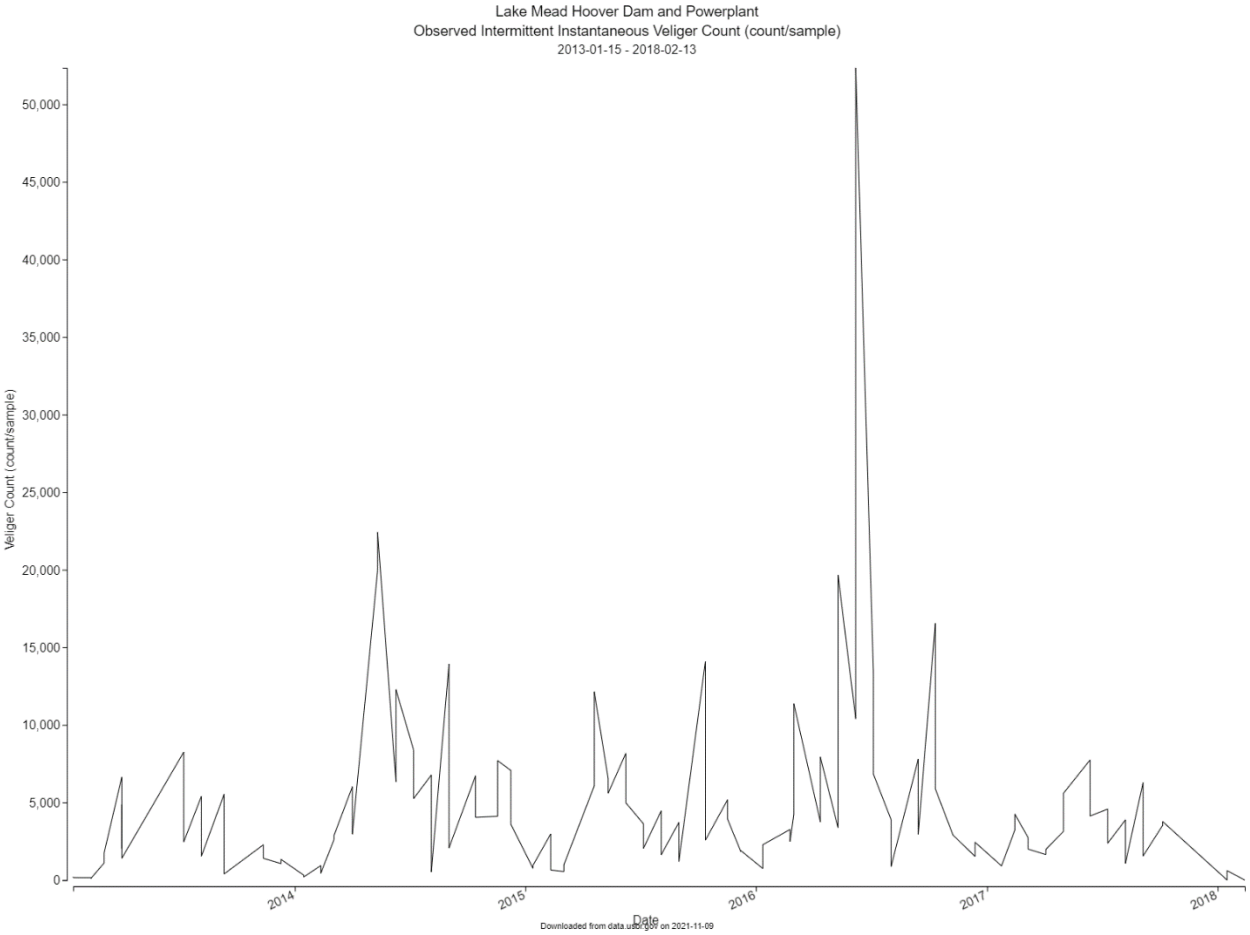

Figure 4. Plot of veliger count time series data from the Hoover Dam site location in Lake Mead. The plot was generated by and exported from the RISE Data Query tool.

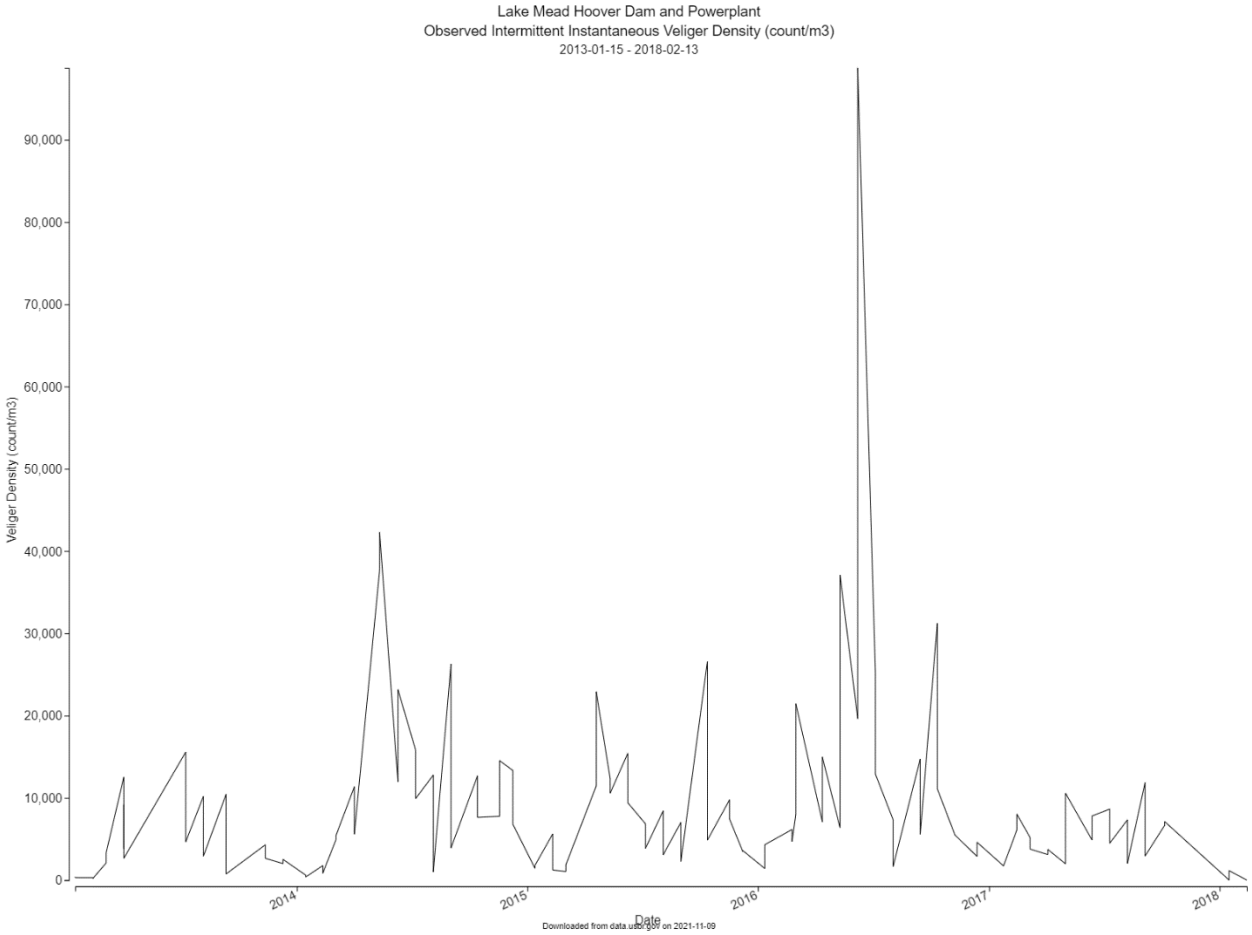

Figure 5. Plot of veliger density time series data from Hoover Dam site location in Lake Mead. The plot was generated by and exported from the RISE Data Query tool.

References

Odell, Allison. "Reclamation Information Sharing Environment (RISE) Data Publication Process Manual v2.0." Bureau of Reclamation, September 11, 2020.

Passamaneck, Yale J. "Open Access Web-Based Database of Invasive Mussel Research." Final Report. Bureau of Reclamation, 2019. https://www.usbr.gov/research/projects/download_product.cfm?id=2838. Accessed 11/15/2021.

Glossary

Lotic. Moving water systems, such as in a river, stream, or canal. In contrast to "lentic" systems, such as lakes and reservoirs, which are characterized by non-flowing water.

Appendix A

Table AA 1 RISE Catalog Record and Item IDs and titles for veliger count and veliger density time series datasets

CATALOG RECORD ID	RECORD TITLE	ITEM ID Veliger Count	ITEM TITLE	ITEM ID Veliger Density	ITEM TITLE
7	Lake Mead At Echo Bay/Virgin River Invasive Mussel Early Detection Monitoring Data	877	Lake Mead At Echo Bay/Virgin River Intermittent Veliger Count Time Series Data	10986	Lake Mead At Echo Bay/Virgin River Intermittent Veliger Density Time Series Data
8	Lake Mead At Hoover Dam and Powerplant Invasive Mussel Early Detection Monitoring Data	878	Lake Mead Hoover Dam and Powerplant Intermittent Veliger Count Time Series Data	10919	Lake Mead Hoover Dam and Powerplant Intermittent Veliger Density Time Series Data
10	Lake Mead At Sandy Point Invasive Mussel Early Detection Monitoring Data	880	Lake Mead At Sandy Point Intermittent Veliger Count Time Series Data	10920	Lake Mead At Sandy Point Intermittent Veliger Density Time Series Data
11	Lake Mead At Temple Bar Invasive Mussel Early Detection Monitoring Data	881	Lake Mead At Temple Bar Intermittent Veliger Count Time Series Data	10921	Lake Mead At Temple Bar Intermittent Veliger Density Time Series Data
12	Lake Mohave At Cottonwood Cove Marina Invasive Mussel Early Detection Monitoring Data	882	Lake Mohave At Cottonwood Cove Marina Intermittent Veliger Count Time Series Data	10922	Lake Mohave At Cottonwood Cove Marina Intermittent Veliger Density Time Series Data
13	Lake Mohave At Davis Dam and Powerplant Invasive Mussel Early Detection Monitoring Data	883	Lake Mohave Davis Dam and Powerplant Intermittent Veliger Count Time Series Data	10923	Lake Mohave Davis Dam and Powerplant Intermittent Veliger Density Time Series Data
14	Lake Mohave At Katherine Landing Marina Invasive Mussel Early Detection Monitoring Data	884	Lake Mohave At Katherine Landing Marina Intermittent Veliger Count Time Series Data	10924	Lake Mohave At Katherine Landing Marina Intermittent Veliger Density Time Series Data

15	Lake Mohave At Placer Cove Invasive Mussel Early Detection Monitoring Data	885	Lake Mohave At Placer Cove Intermittent Veliger Count Time Series Data	10925	Lake Mohave At Placer Cove Intermittent Veliger Density Time Series Data
16	Lake Mohave At Willow Beach Marina Invasive Mussel Early Detection Monitoring Data	886	Lake Mohave At Willow Beach Marina Intermittent Veliger Count Time Series Data	10926	Lake Mohave At Willow Beach Marina Intermittent Veliger Density Time Series Data
17	Lake Powell At Bullfrog Marina Invasive Mussel Early Detection Monitoring Data	887	Lake Powell At Bullfrog Marina Intermittent Veliger Count Time Series Data	10927	Lake Powell At Bullfrog Marina Intermittent Veliger Density Time Series Data
18	Lake Powell At Glen Canyon Dam and Powerplant Invasive Mussel Early Detection Monitoring Data	888	Lake Powell Glen Canyon Dam and Powerplant Intermittent Veliger Count Time Series Data	10928	Lake Powell Glen Canyon Dam and Powerplant Intermittent Veliger Density Time Series Data
19	Lake Powell At Glen Canyon Dam Outflow Invasive Mussel Early Detection Monitoring Data	889	Lake Powell At Glen Canyon Dam Outflow Intermittent Veliger Count Time Series Data	10929	Lake Powell At Glen Canyon Dam Outflow Intermittent Veliger Density Time Series Data
21	Lake Powell At Halls Crossing Marina Invasive Mussel Early Detection Monitoring Data	891	Lake Powell At Halls Crossing Marina Intermittent Veliger Count Time Series Data	10930	Lake Powell At Halls Crossing Marina Intermittent Veliger Density Time Series Data
24	Apache Lake At Burnt Horse Corral Invasive Mussel Early Detection Monitoring Data	894	Apache Lake At Burnt Horse Corral Intermittent Veliger Count Time Series Data	10931	Apache Lake At Burnt Horse Corral Intermittent Veliger Density Time Series Data
26	Apache Lake At Horse Mesa Dam Invasive Mussel Early Detection Monitoring Data	896	Apache Lake At Horse Mesa Dam Intermittent Veliger Count Time Series Data	10932	Apache Lake At Horse Mesa Dam Intermittent Veliger Density Time Series Data
27	Apache Lake At Marina Invasive Mussel Early	897	Apache Lake At Marina Intermittent	10933	Apache Lake At Marina Intermittent

	Detection Monitoring Data		Veliger Count Time Series Data		Veliger Density Time Series Data
28	Apache Lake At Three Mile Island Invasive Mussel Early Detection Monitoring Data	898	Apache Lake At Three Mile Island Intermittent Veliger Count Time Series Data	10934	Apache Lake At Three Mile Island Intermittent Veliger Density Time Series Data
29	Canyon Lake At Beach Below Horse Mesa Dam Invasive Mussel Early Detection Monitoring Data	899	Canyon Lake At Beach Below Horse Mesa Dam Intermittent Veliger Count Time Series Data	10935	Canyon Lake At Beach Below Horse Mesa Dam Intermittent Veliger Density Time Series Data
30	Canyon Lake At Beer Can Flats Invasive Mussel Early Detection Monitoring Data	900	Canyon Lake At Beer Can Flats Intermittent Veliger Count Time Series Data	10936	Canyon Lake At Beer Can Flats Intermittent Veliger Density Time Series Data
31	Canyon Lake At Marina Invasive Mussel Early Detection Monitoring Data	901	Canyon Lake At Marina Intermittent Veliger Count Time Series Data	10937	Canyon Lake At Marina Intermittent Veliger Density Time Series Data
32	Canyon Lake At Mormon Flats Dam Invasive Mussel Early Detection Monitoring Data	902	Canyon Lake At Mormon Flats Dam Intermittent Veliger Count Time Series Data	10938	Canyon Lake At Mormon Flats Dam Intermittent Veliger Density Time Series Data
33	Canyon Lake At No Wake Buoy Invasive Mussel Early Detection Monitoring Data	903	Canyon Lake At No Wake Buoy Intermittent Veliger Count Time Series Data	10939	Canyon Lake At No Wake Buoy Intermittent Veliger Density Time Series Data
34	Canyon Lake At North East Point Invasive Mussel Early Detection Monitoring Data	904	Canyon Lake At North East Point Intermittent Veliger Count Time Series Data	10940	Canyon Lake At North East Point Intermittent Veliger Density Time Series Data
35	Canyon Lake At Laguna Boat Ramp Invasive Mussel Early Detection Monitoring Data	905	Canyon Lake At Laguna Boat Ramp Intermittent Veliger Count Time Series Data	10941	Canyon Lake At Laguna Boat Ramp Intermittent Veliger Density Time Series Data
36	Saguaro Lake At Boat Ramp Invasive Mussel Early Detection Monitoring Data	906	Saguaro Lake At Boat Ramp Intermittent Veliger Count Time Series Data	10942	Saguaro Lake At Boat Ramp Intermittent Veliger Density Time Series Data

37	Saguaro Lake At Boaters Campground Invasive Mussel Early Detection Monitoring Data	907	Saguaro Lake At Boaters Campground Intermittent Veliger Count Time Series Data	10943	Saguaro Lake At Boaters Campground Intermittent Veliger Density Time Series Data
38	Saguaro Lake At Butcher Jones Campground Invasive Mussel Early Detection Monitoring Data	908	Saguaro Lake At Butcher Jones Campground Intermittent Veliger Count Time Series Data	10944	Saguaro Lake At Butcher Jones Campground Intermittent Veliger Density Time Series Data
39	Saguaro Lake At Marina And Dam Invasive Mussel Early Detection Monitoring Data	909	Saguaro Lake At Marina And Dam Intermittent Veliger Count Time Series Data	10945	Saguaro Lake At Marina And Dam Intermittent Veliger Density Time Series Data
40	Saguaro Lake At Mormon Flats Dam Bouy Line Invasive Mussel Early Detection Monitoring Data	910	Saguaro Lake At Mormon Flats Dam Bouy Line Intermittent Veliger Count Time Series Data	10946	Saguaro Lake At Mormon Flats Dam Bouy Line Intermittent Veliger Density Time Series Data
43	Colorado River Below Parker Dam Invasive Mussel Early Detection Monitoring Data	913	Colorado River Below Parker Dam Intermittent Veliger Count Time Series Data	n/a	n/a
44	Colorado River At Cibola Gage Invasive Mussel Early Detection Monitoring Data	914	Colorado River At Cibola Gage Intermittent Veliger Count Time Series Data	10947	Colorado River At Cibola Gage Intermittent Veliger Density Time Series Data
45	Colorado River Below Davis Dam Invasive Mussel Early Detection Monitoring Data	915	Colorado River Below Davis Dam Intermittent Veliger Count Time Series Data	n/a	n/a
46	Colorado River At Davis Dam Gage Invasive Mussel Early Detection Monitoring Data	916	Colorado River At Davis Dam Gage Intermittent Veliger Count Time Series Data	10948	Colorado River At Davis Dam Gage Intermittent Veliger Density Time Series Data
49	Colorado River Below Interstate Bridge Invasive Mussel Early	919	Colorado River Below Interstate Bridge Intermittent	10949	Colorado River Below Interstate Bridge Intermittent

	Detection Monitoring Data		Veliger Count Time Series Data		Veliger Density Time Series Data
50	Colorado River At Martinez Gage Invasive Mussel Early Detection Monitoring Data	920	Colorado River At Martinez Gage Intermittent Veliger Count Time Series Data	n/a	n/a
52	Colorado River Below Mcintyre Park Invasive Mussel Early Detection Monitoring Data	922	Colorado River Below Mcintyre Park Intermittent Veliger Count Time Series Data	10950	Colorado River Below Mcintyre Park Intermittent Veliger Density Time Series Data
54	Colorado River At Needles Gage Invasive Mussel Early Detection Monitoring Data	924	Colorado River At Needles Gage Intermittent Veliger Count Time Series Data	10951	Colorado River At Needles Gage Intermittent Veliger Density Time Series Data
55	Colorado River Below Oxbow Bridge Invasive Mussel Early Detection Monitoring Data	925	Colorado River Below Oxbow Bridge Intermittent Veliger Count Time Series Data	10952	Colorado River Below Oxbow Bridge Intermittent Veliger Density Time Series Data
56	Colorado River At Pilot Knob Invasive Mussel Early Detection Monitoring Data	926	Colorado River At Pilot Knob Intermittent Veliger Count Time Series Data	n/a	n/a
65	Colorado River At River Section 41 Gage Invasive Mussel Early Detection Monitoring Data	935	Colorado River At River Section 41 Gage Intermittent Veliger Count Time Series Data	n/a	n/a
66	Colorado River At Senators Wash Reservoir Invasive Mussel Early Detection Monitoring Data	936	Colorado River At Senators Wash Reservoir Intermittent Veliger Count Time Series Data	10953	Colorado River At Senators Wash Reservoir Intermittent Veliger Density Time Series Data
68	Colorado River At Taylor Ferry Invasive Mussel Early Detection Monitoring Data	938	Colorado River At Taylor Ferry Intermittent Veliger Count Time Series Data	10954	Colorado River At Taylor Ferry Intermittent Veliger Density Time Series Data
72	Imperial Reservoir at Imperial Dam	939	Imperial Reservoir at Imperial Dam	10955	Imperial Reservoir at Imperial Dam

	Invasive Mussel Early Detection Monitoring Data		Intermittent Veliger Count Time Series Data		Intermittent Veliger Density Time Series Data