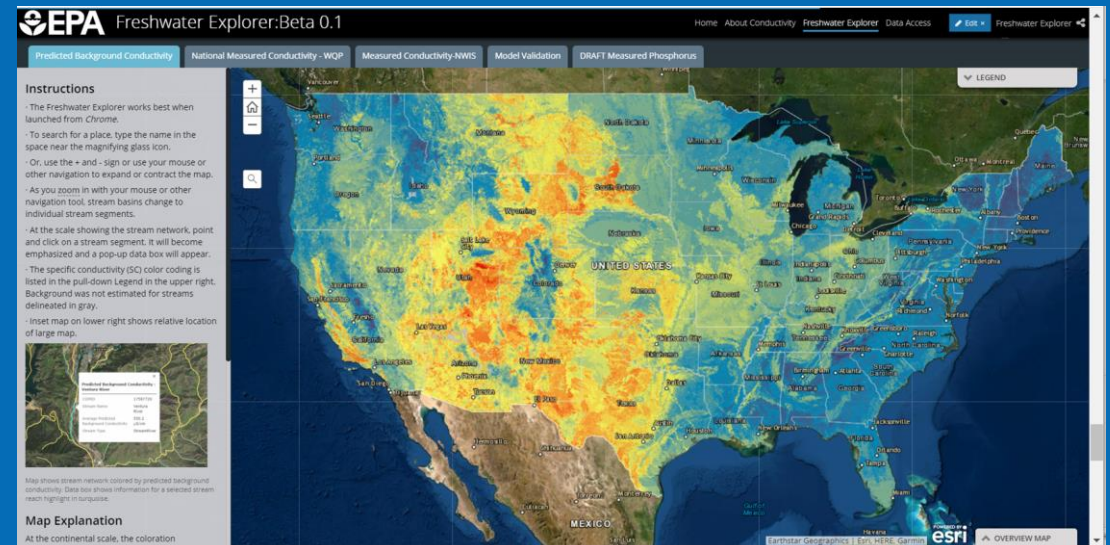


# EPA Science Training Webinar: Freshwater Explorer of water quality parameters

Susan Cormier, PhD  
*US EPA Office of Research and Development*

November 19, 2020



# Webinar map

- Why?—to provide easier access and visualization of aquatic information
- What is it?
  - Stream network color-coded for background conductivity
  - Point locations of measured conductivity and total phosphorous
- Development
  - Protocols to remove and tag questionable data submitted to Water Quality Exchange
  - Random forest model to predict background conductivity
  - Overlay background and measured total phosphorous and conductivity
- Navigation and Examples
  - National
  - State-level
- What's next?
  - Enhanced Freshwater Explorers

# Overview

- Problem

- Higher levels of minerals in the water can cause harmful algal blooms, affect aquatic wildlife, and increase costs for making water suitable for drinking and other purposes.

- Approach

- Design an accessible and intuitive interface to visualize and explore water quality in a map format.

- Result

- EPA's Freshwater Explorer exhibits a network of streams in the U.S color-coded for measured freshness (i.e., low salt and nutrient mineral content).

- Impact

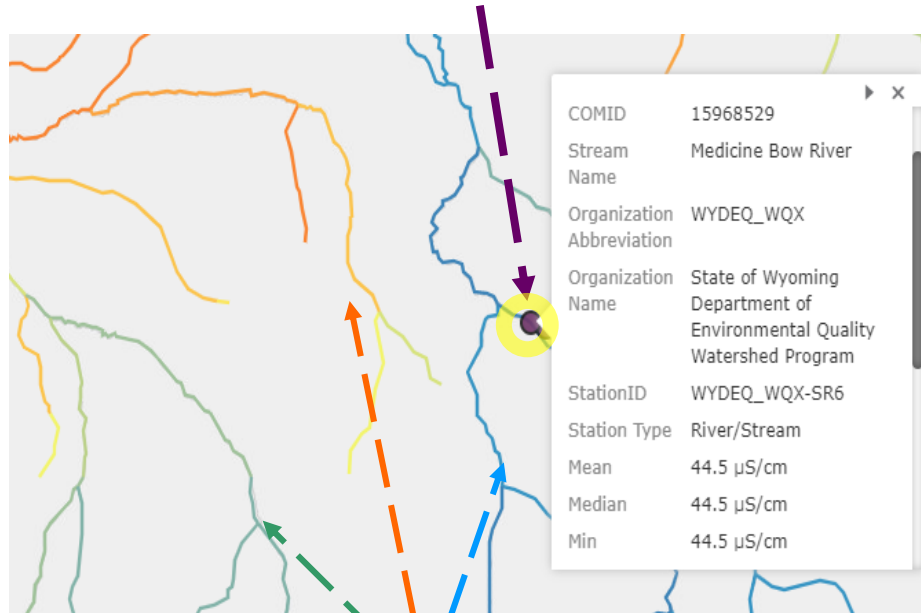
- This tool is useful for states to work with communities and regulated entities to find the right balance of protection and use of fresh water.

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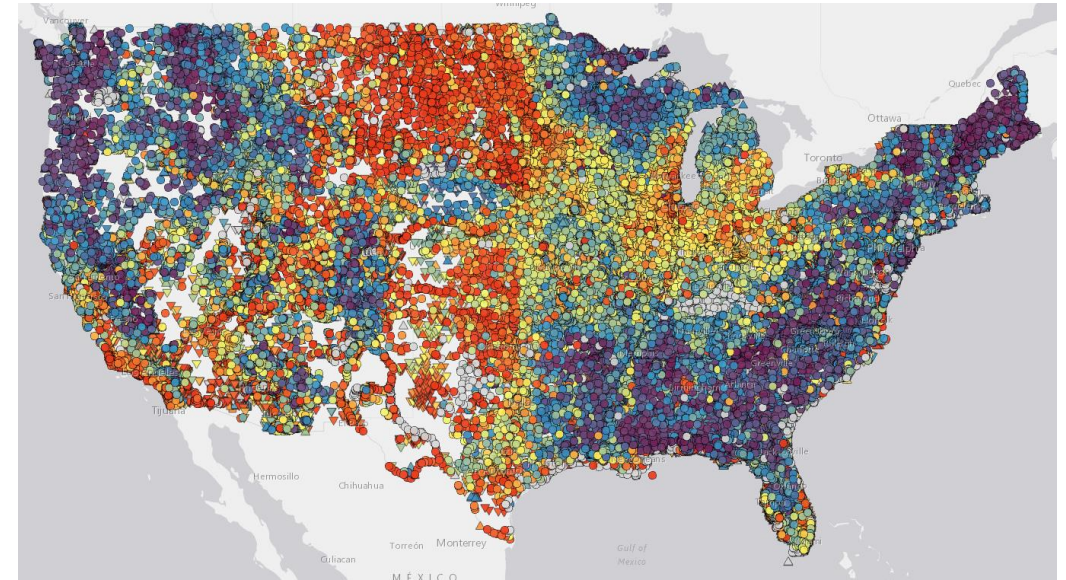
# What it is

Site measurements  
shown as a dot

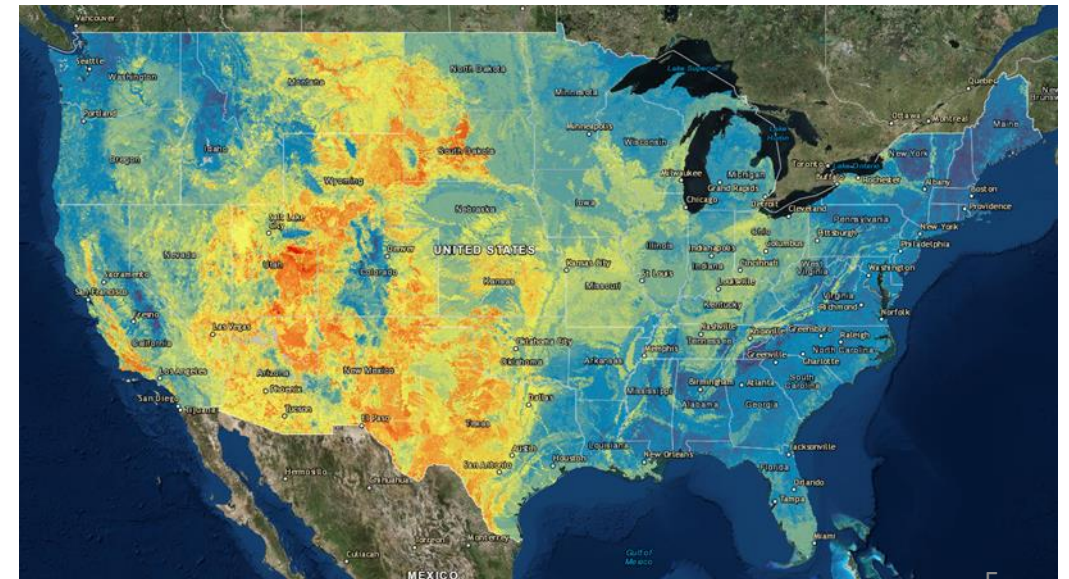


Background stream  
segments shown as  
colored network

## Measured Site Data



## Predicted Background Reach Estimate





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# Water Quality Portal (WQP) Measured Conductivity Data: Clean-up process

Issue	Action Taken
Specific Conductivity (SC) values are positive and cannot be negative	Remove SC values $\leq 0$
Ambiguous units (e.g., SC reported as NTU, or °C)	Remove SC values reported with units different from Siemens or mho
Dissimilar reporting units, cannot directly comparison among samples	Convert remaining SC values to $\mu\text{S}/\text{cm}$ (e.g., values as $\text{mS}/\text{cm}$ were multiplied by 1000)
Data reported as $\mu\text{S}/\text{cm}$ but likely measured as $\text{mS}/\text{cm}$	Flag sites with SC values $< 10 \mu\text{S}/\text{cm}$ as uncertain (gray circles)
Data reported as $\text{mS}/\text{cm}$ but likely measured as $\mu\text{S}/\text{cm}$ , brine or marine	Flag SC values $> 5000 \mu\text{S}/\text{cm}$ (gray circles)

Methi	CharacteristicName	ResultSampleFraction	ResultMeasureValue	ResultMeasure/Me	MeasureQualifie
<Null>	Specific conductance	<Null>	0	<Null>	<Null>
<Null>	Conductivity	Total	101.8	mS/cm	<Null>
<Null>	Conductivity	Total	105.1	mS/cm	<Null>
<Null>	Conductivity	Total	93.2	mS/cm	<Null>
<Null>	Conductivity	Total	114.7	mS/cm	<Null>
<Null>	Conductivity	Total	92.3	mS/cm	<Null>
<Null>	Conductivity	Total	108.9	mS/cm	<Null>
<Null>	Conductivity	Total	123.4	mS/cm	<Null>
<Null>	Conductivity	Total	135.5	mS/cm	<Null>
<Null>	Conductivity	Total	111.4	mS/cm	<Null>
<Null>	Conductivity	Total	168.6	mS/cm	<Null>
<Null>	Conductivity	Total	165.7	mS/cm	<Null>
<Null>	Conductivity	Total	152.3	mS/cm	<Null>
<Null>	Conductivity	Total	248.5	mS/cm	<Null>
<Null>	Conductivity	Total	211.2	mS/cm	<Null>
<Null>	Conductivity	Total	220.1	mS/cm	<Null>
<Null>	Conductivity	Total	175.2	mS/cm	<Null>
<Null>	Conductivity	Total	130.3	mS/cm	<Null>
<Null>	Conductivity	Total	172	mS/cm	<Null>
<Null>	Conductivity	Total	160.1	mS/cm	<Null>
<Null>	Conductivity	Total	152.4	mS/cm	<Null>
<Null>	Conductivity	Total	140.7	mS/cm	<Null>
<Null>	Conductivity	Total	290.2	mS/cm	<Null>
<Null>	Conductivity	Total	290.6	mS/cm	<Null>
<Null>	Conductivity	Total	311.8	mS/cm	<Null>
<Null>	Conductivity	Total	190	mS/cm	<Null>
<Null>	Conductivity	Total	160	mS/cm	<Null>

In this state data set,  
 ~7500 entries mS/cm  
 but clearly should be  
 μS/cm

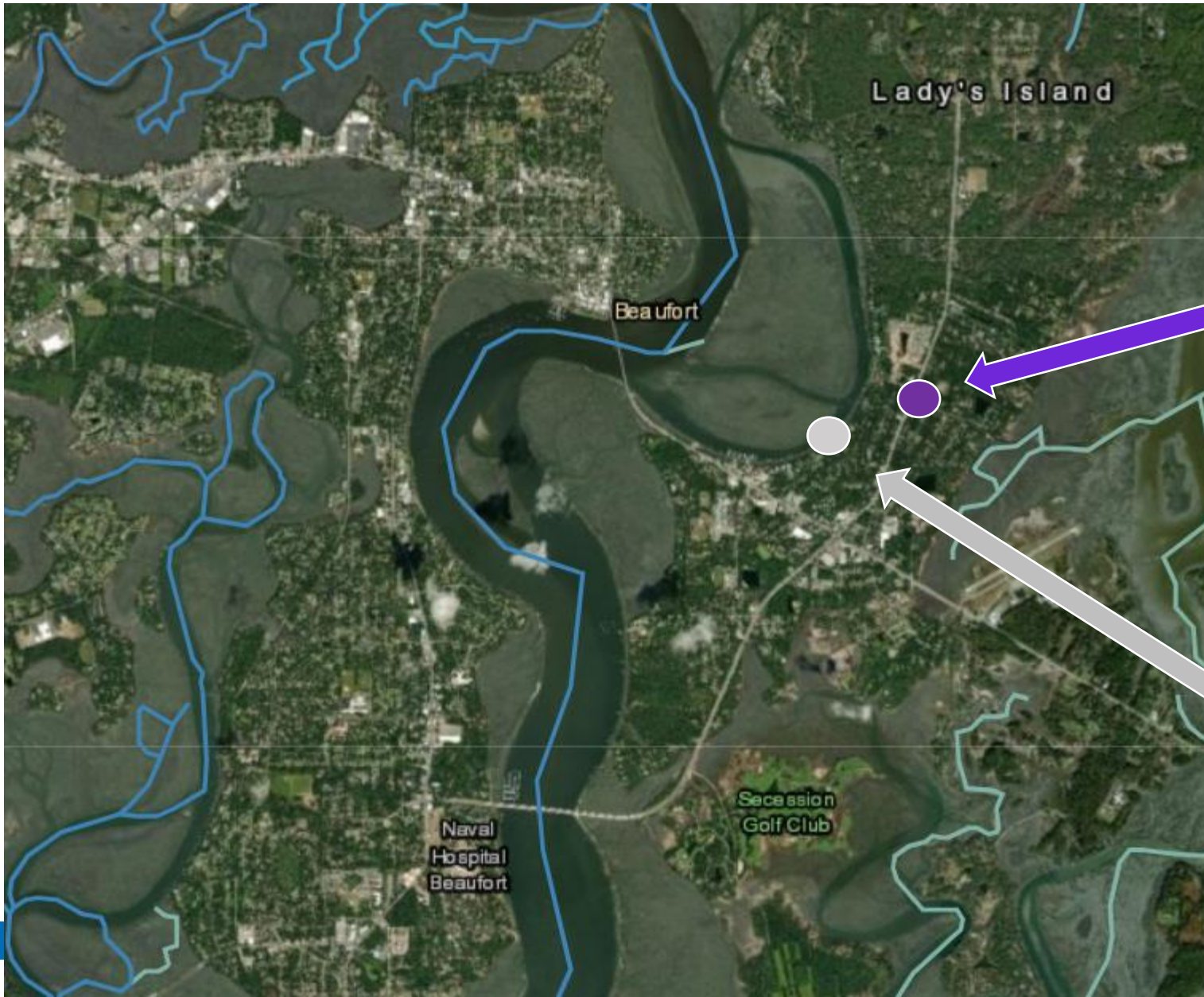
152 mS/cm  
 equals  
 152,000 μS/cm

Uncertain entries appear as  
 grey dots; contributors can  
 correct in Water Quality  
 Exchange

This state corrected the units.



# Check water body type: Local knowledge matters



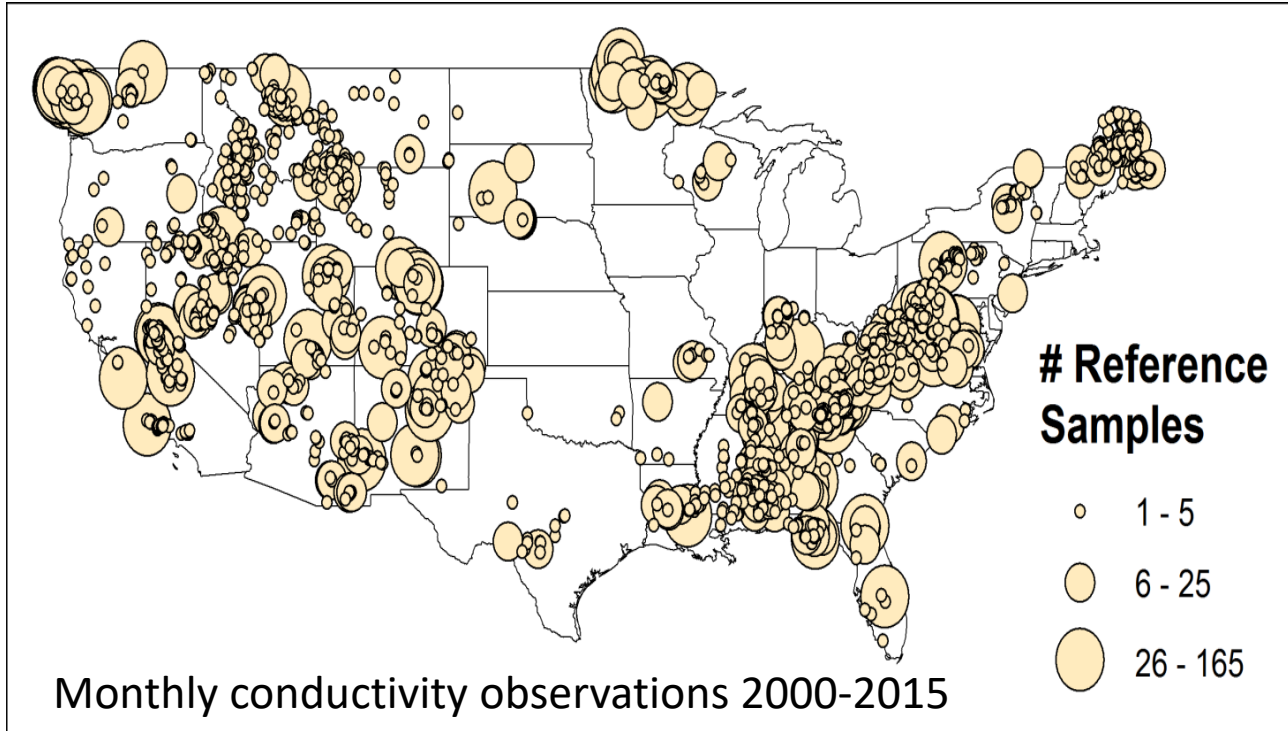
	Station Type	<b>Stream</b>
	Mean	75 $\mu\text{S}/\text{cm}$
	Median	70 $\mu\text{S}/\text{cm}$
	Min	19 $\mu\text{S}/\text{cm}$
	Max	152 $\mu\text{S}/\text{cm}$
	Conductivity Samples	22
	Last Measurement Date	9/18/2006
	Last Measured Conductivity	33 $\mu\text{S}/\text{cm}$

	Station Type	<b>Estuary</b>
	Mean	53557.6 $\mu\text{S}/\text{cm}$
	Median	51112 $\mu\text{S}/\text{cm}$
	Min	45426 $\mu\text{S}/\text{cm}$
	Max	69255 $\mu\text{S}/\text{cm}$
	Conductivity Samples	13
	Last	12/4/2007

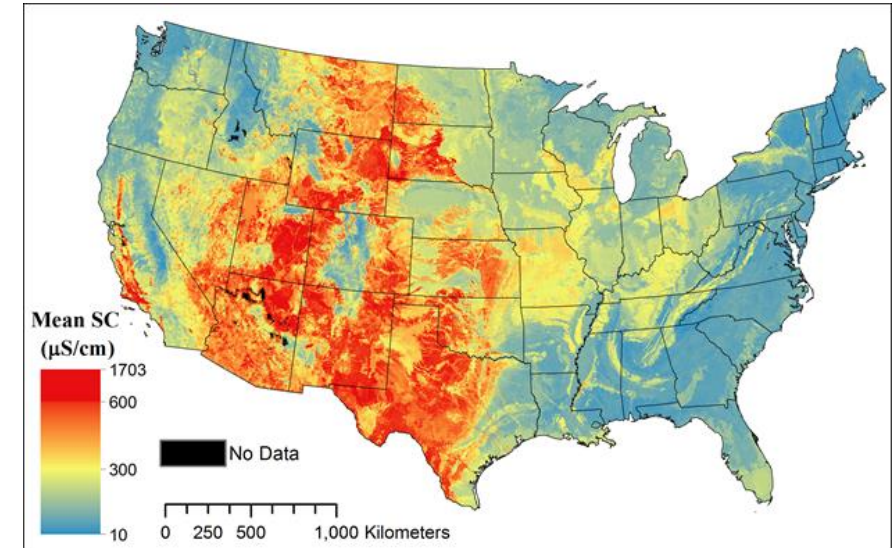
# Webinar map

- Why?—easier access and visualization of aquatic information
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## Data set we used to make the model



to color these stream catchments and segments



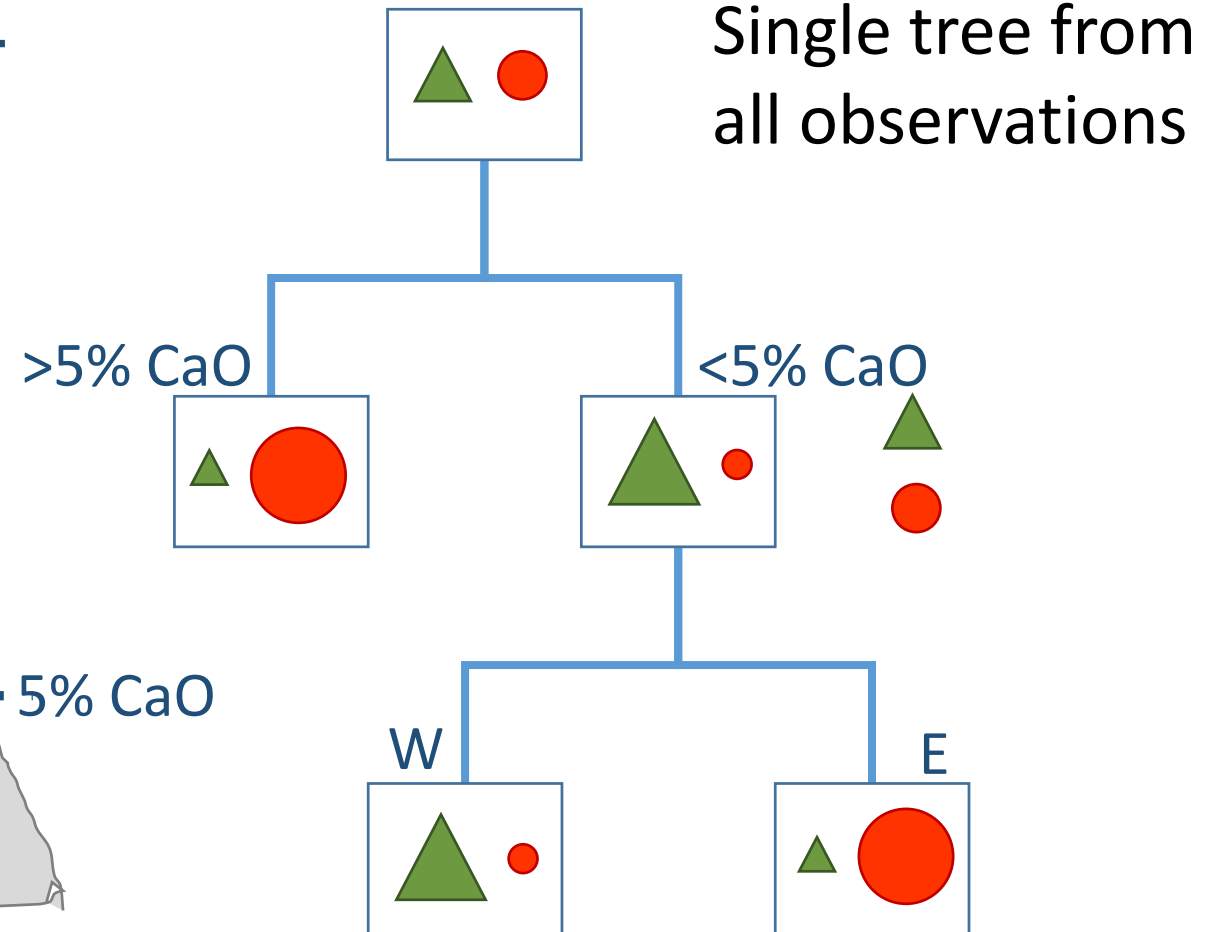
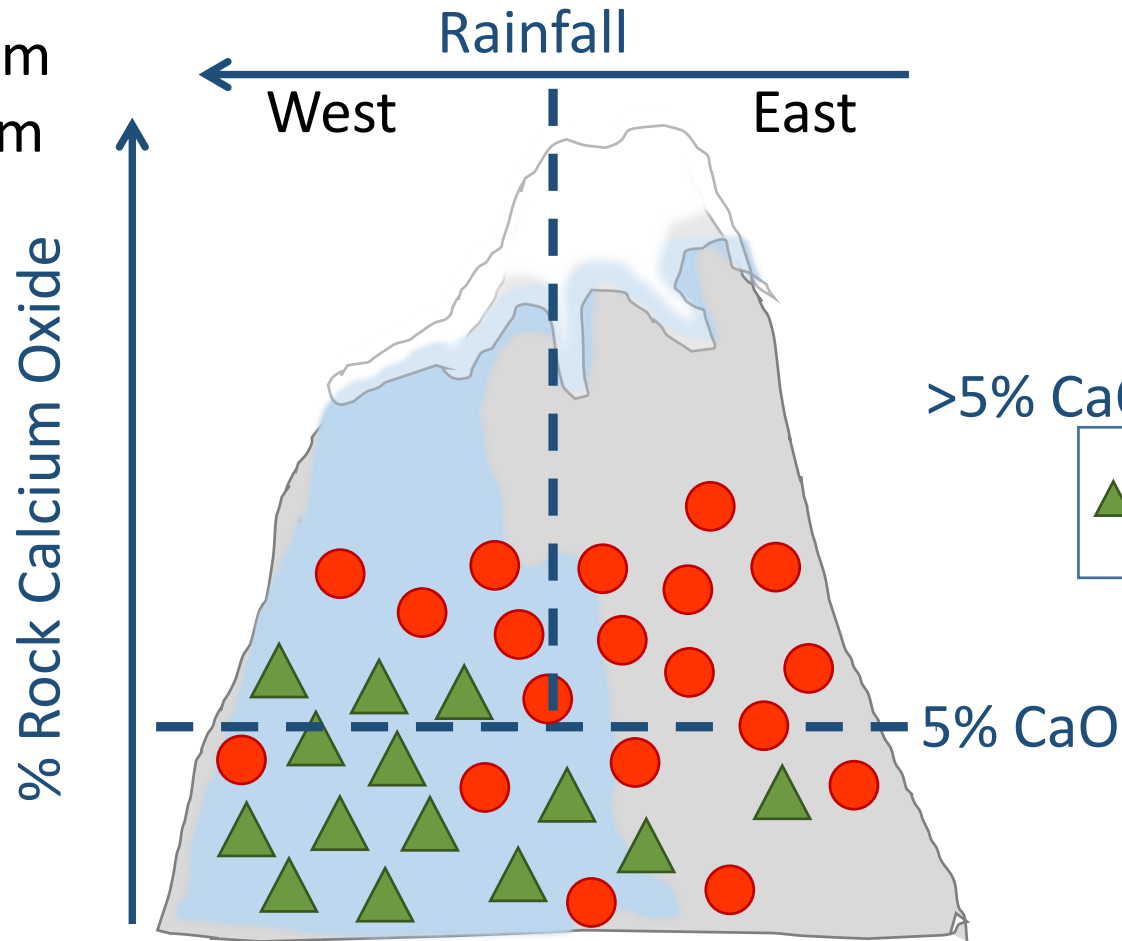
	<b>Training</b>	<b>Validation</b>
Sites	1,785	95
Observations	11,796	785

Starting data set had  
2,466,719 observations  
for 173,319 sites



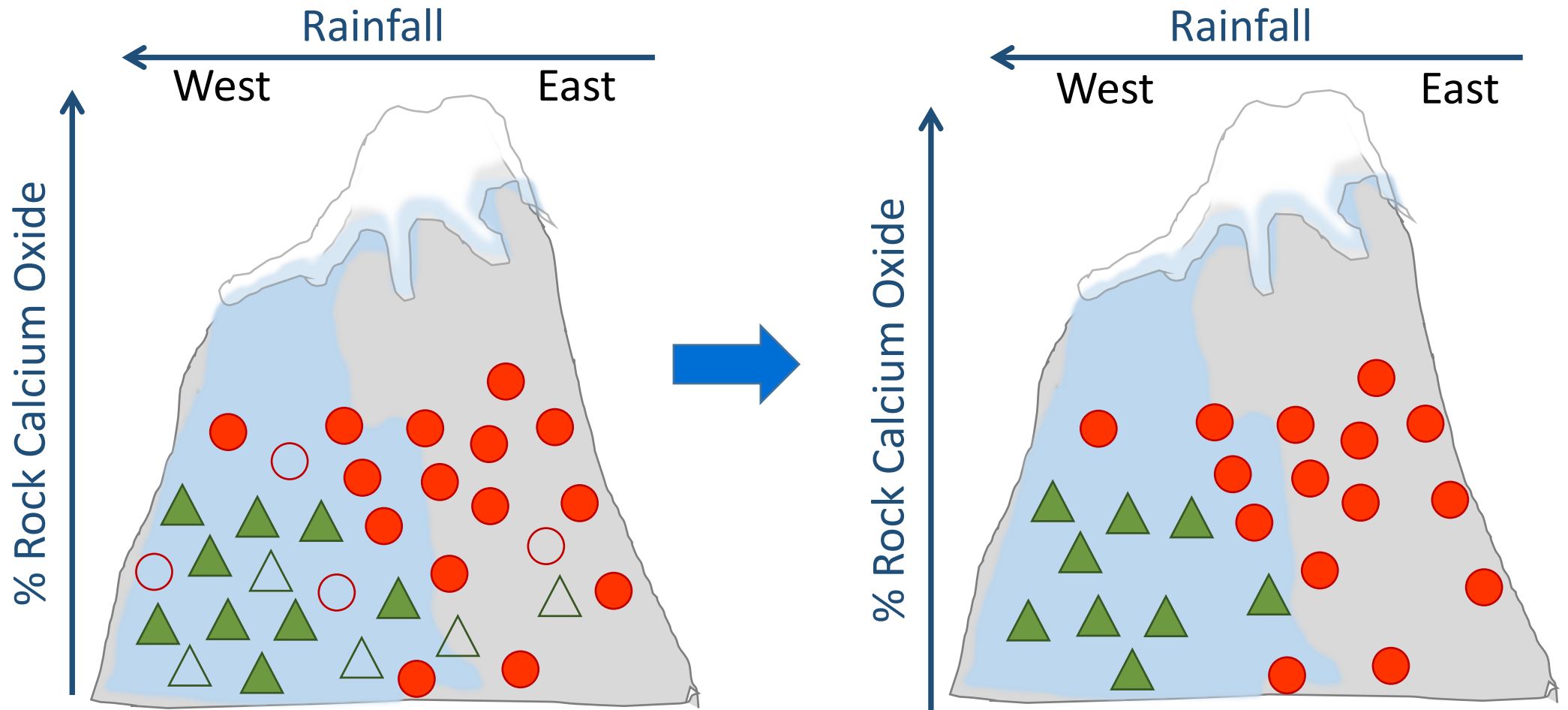
# Random Forest Modeling

< 200  $\mu\text{S}/\text{cm}$   
> 200  $\mu\text{S}/\text{cm}$

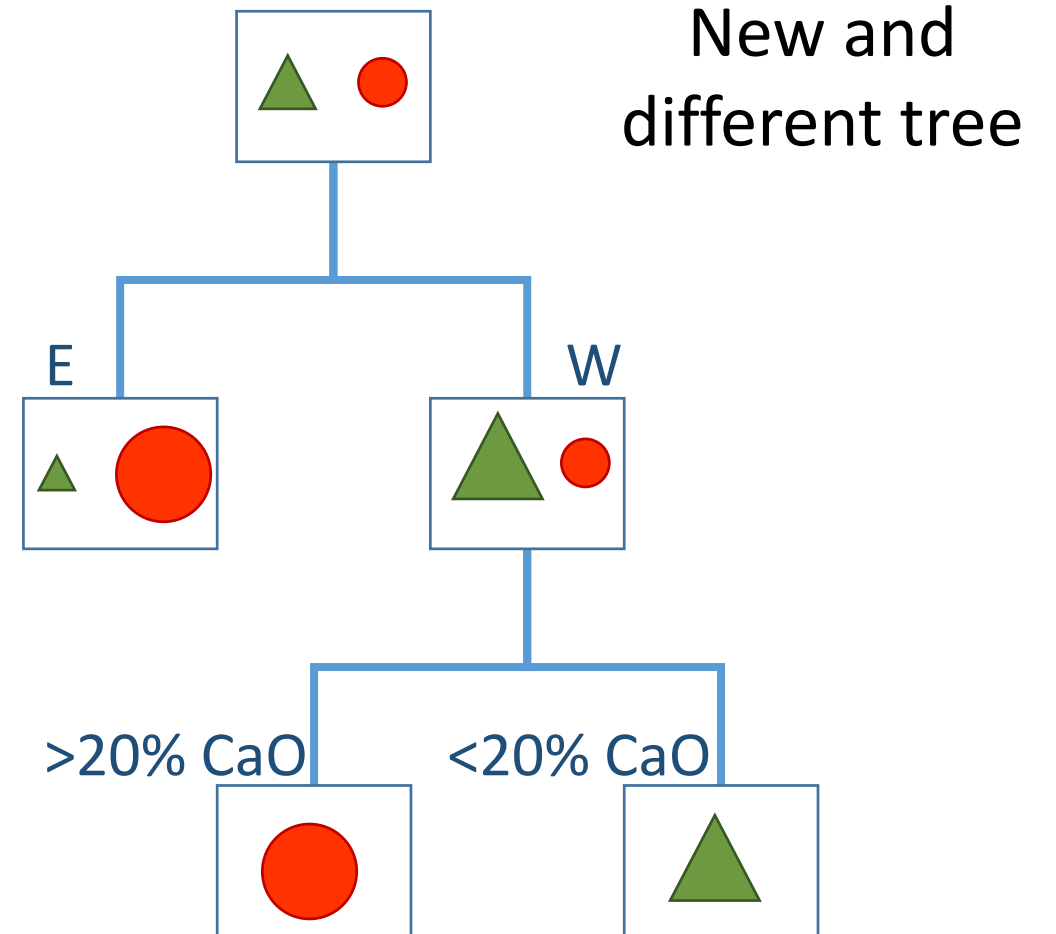
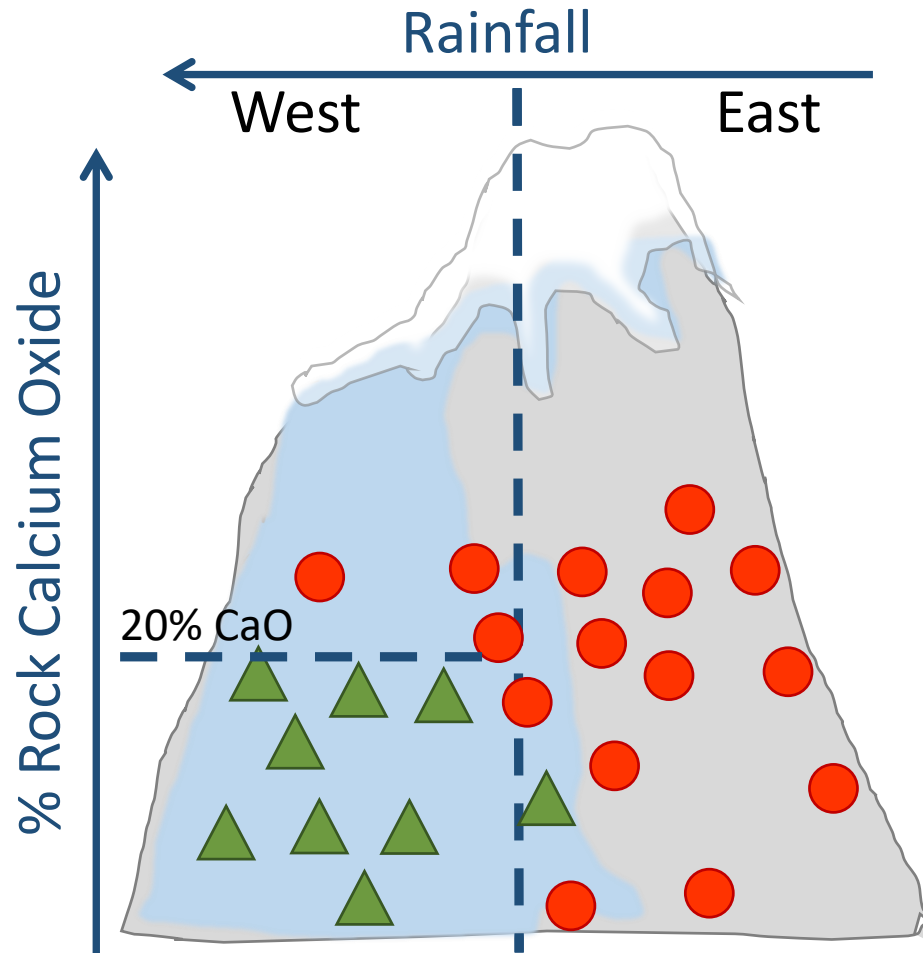


# Random Forest Modeling

From the original data set randomly remove some sites



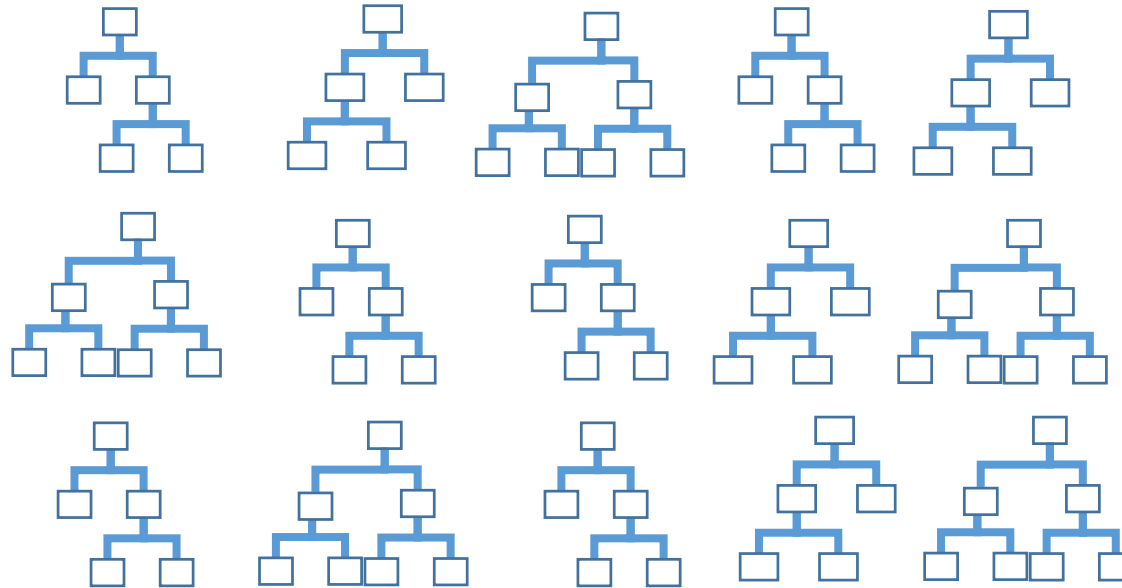
# New model with some samples removed





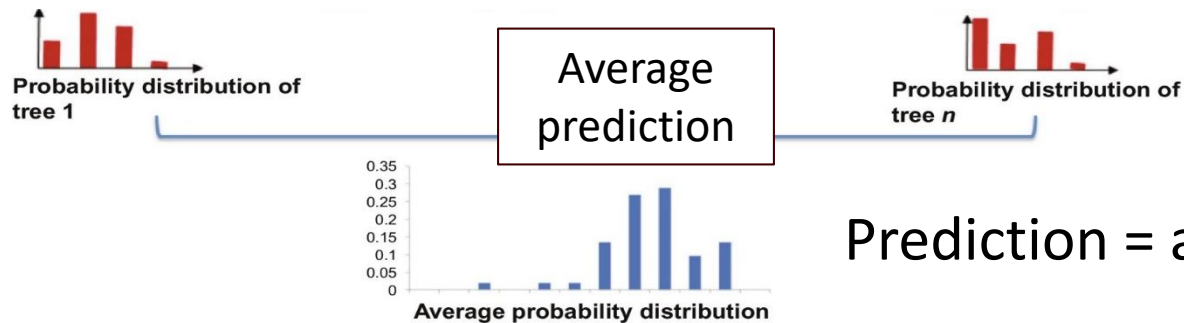
# Random Forest Modeling

Build many trees with randomized subsets of original data



Random forest fits many classification trees to a data set

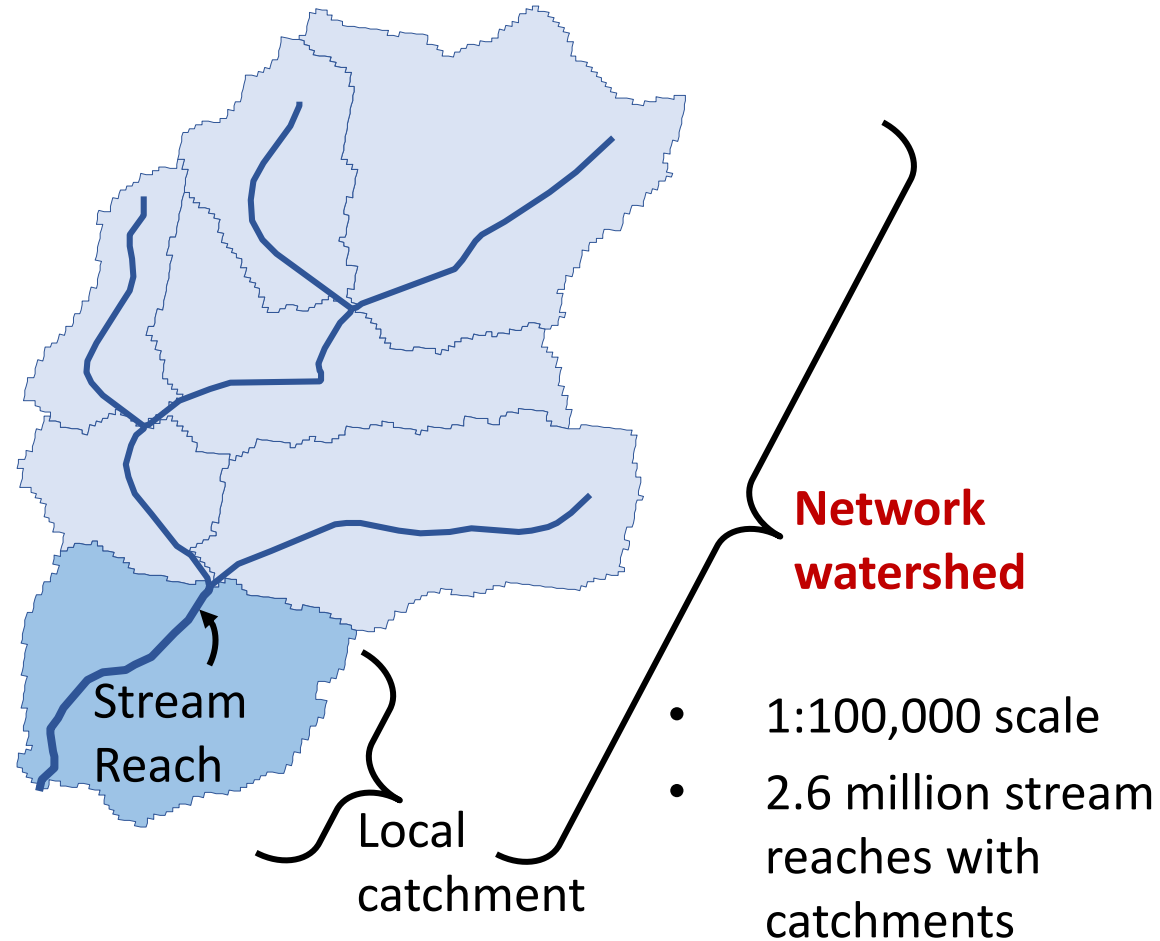
and then combines the predictions from all the trees



Prediction = aggregation of predictions from all trees

# Random Forest Modeling

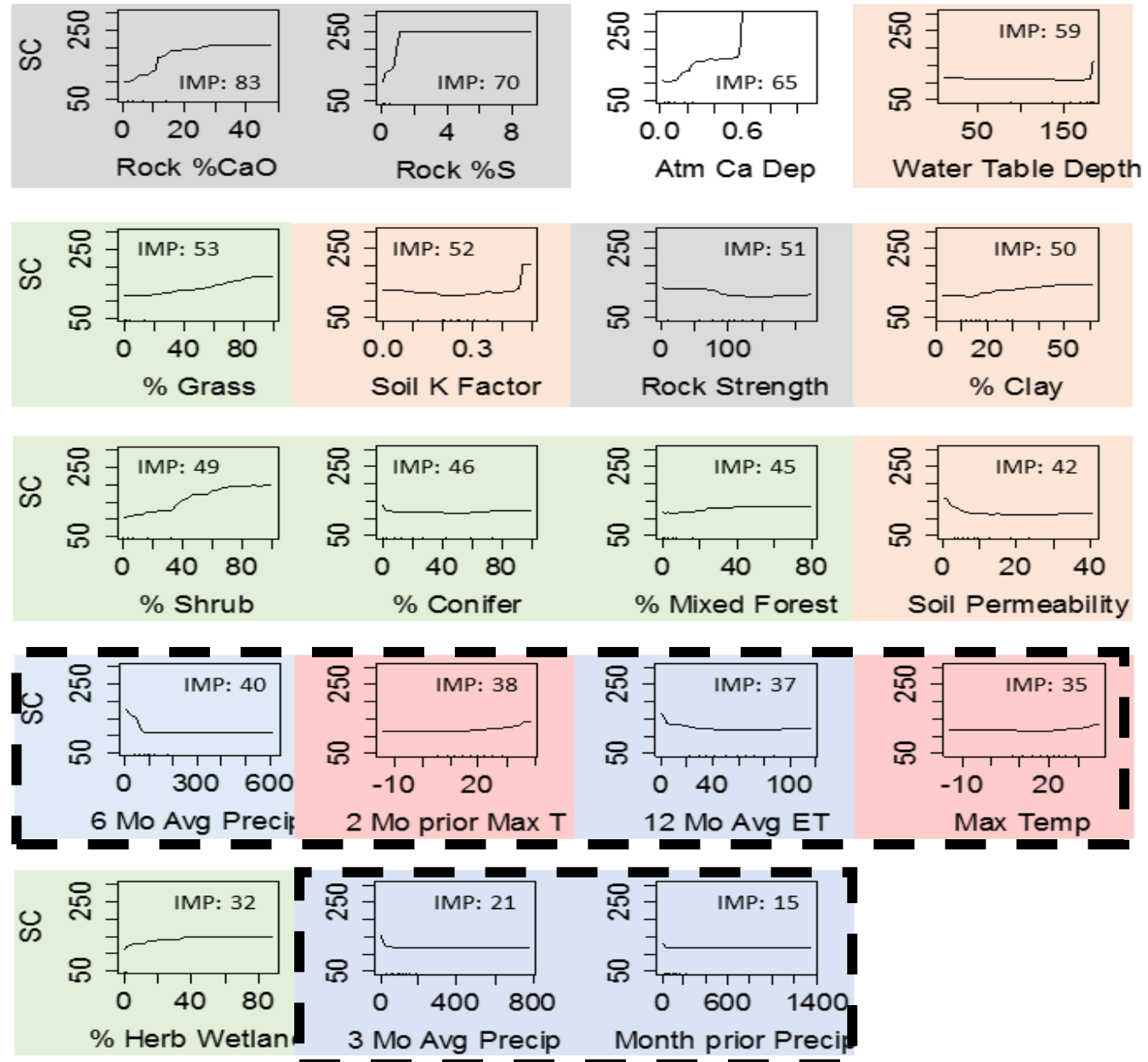
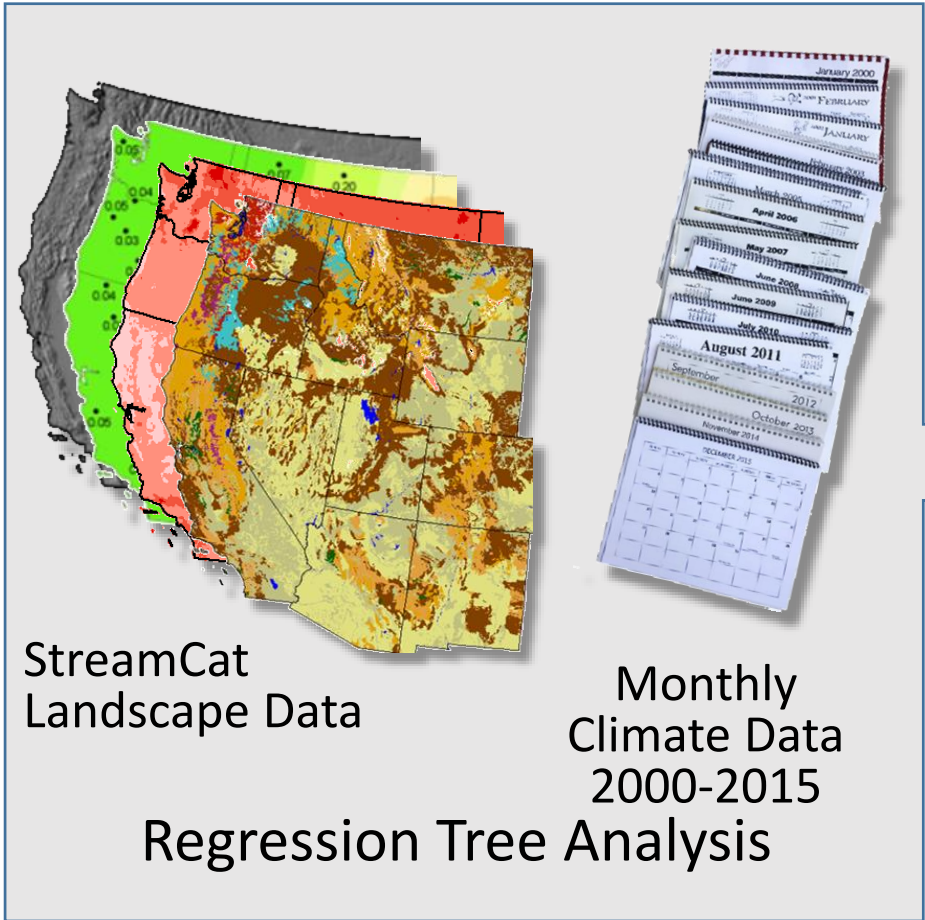
StreamCat provides hundreds of landscape metrics (e.g., % ag) for NHDPlus stream network



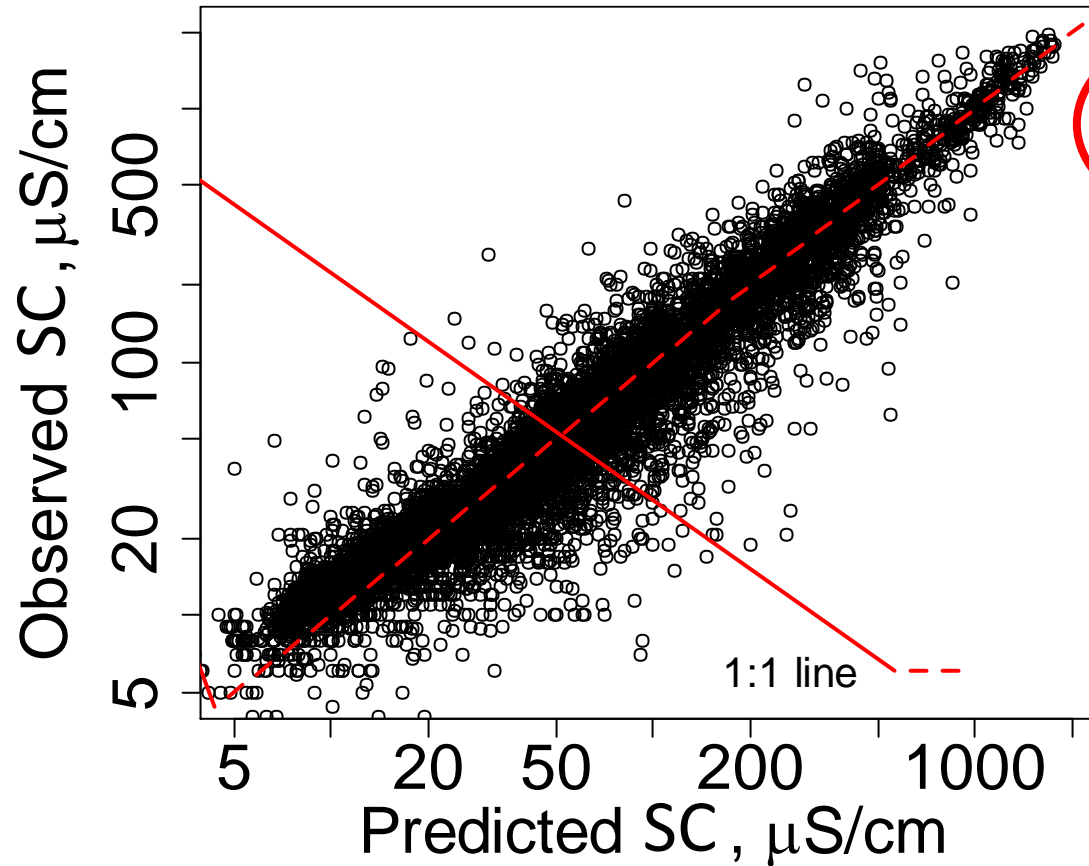
# Predictor variables used in the random forest model

Spatial

Spatial + Temporal



# Natural Background Model Performance



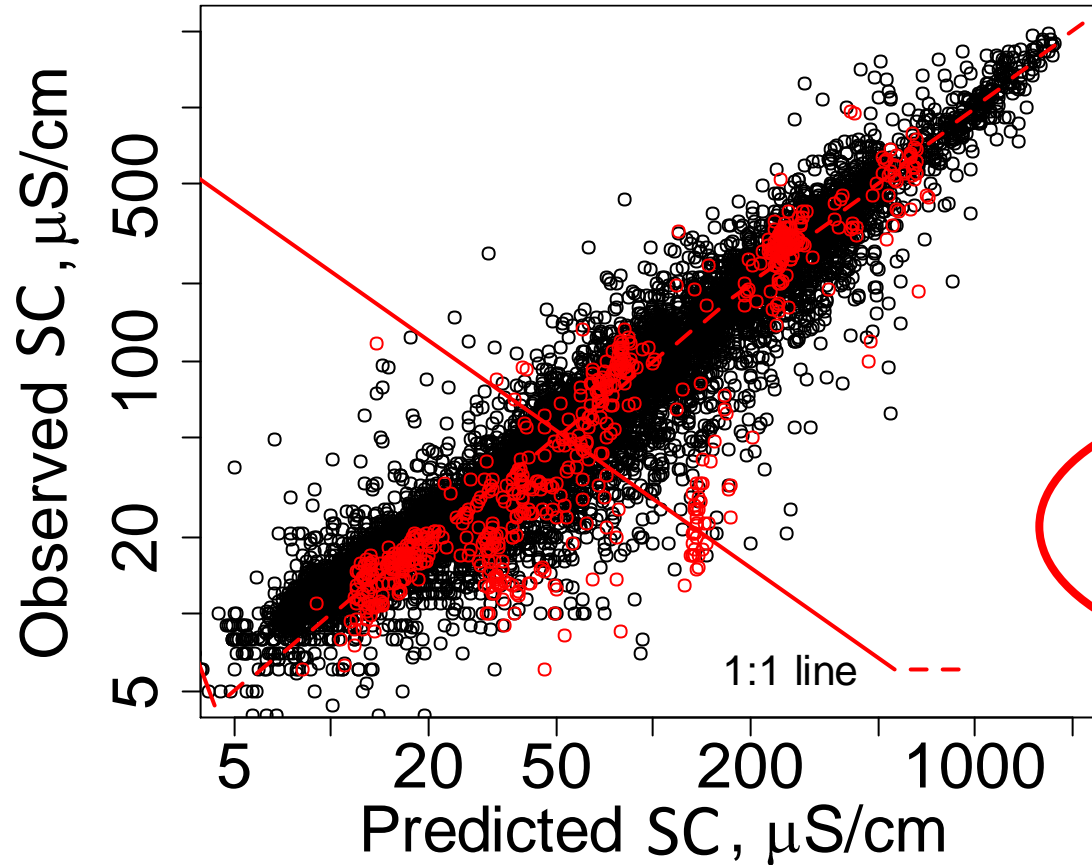
Training

$R^2 = 0.92$

RMSE\* = 55  $\mu\text{S}/\text{cm}$

\*RMSE – root mean square error

# Natural Background Model Validation

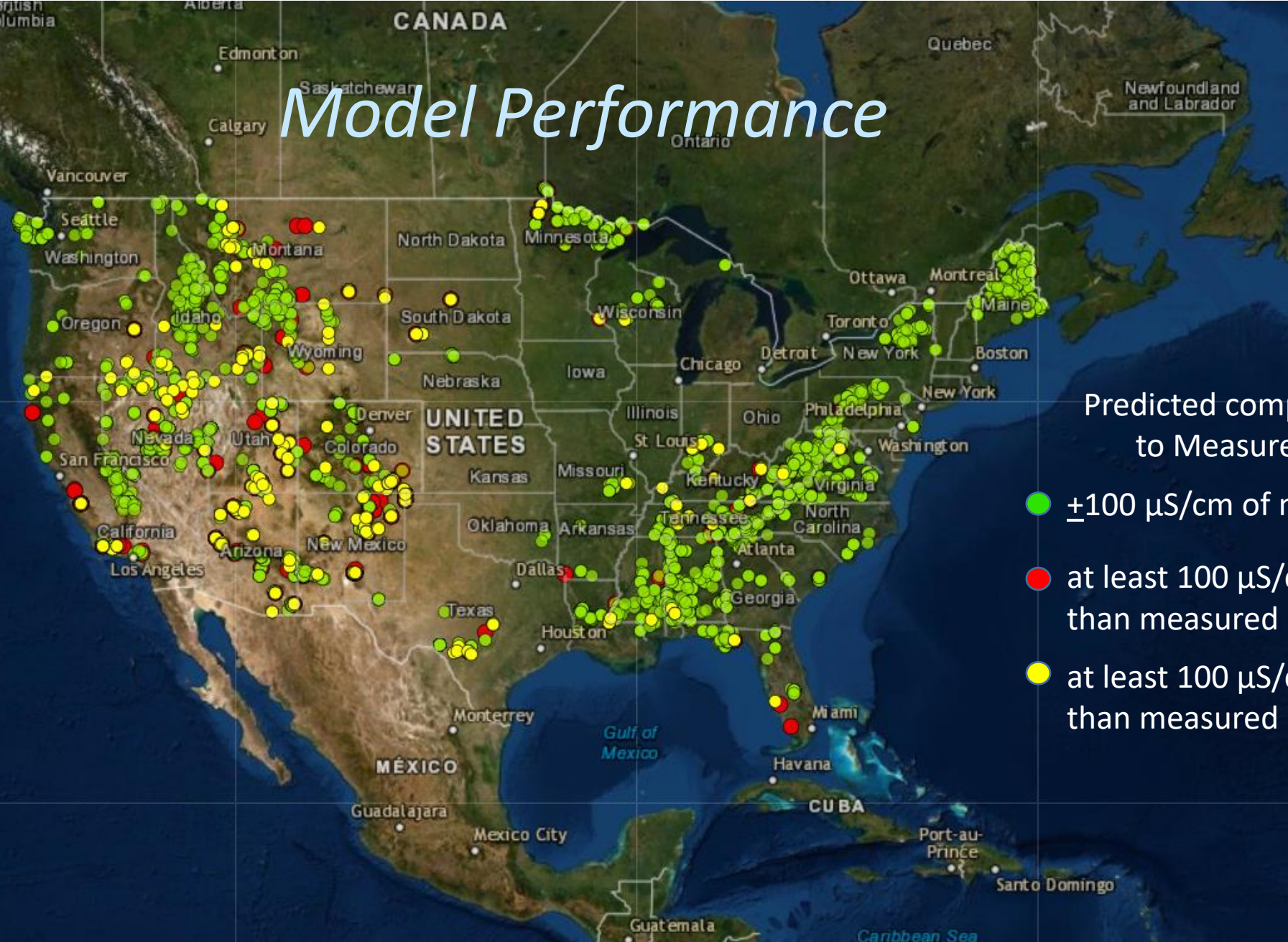


Training  
 $R^2 = 0.92$   
RMSE = 55 µS/cm

Validation  
 $R^2 = 0.83$   
RMSE = 67 µS/cm



# Model Performance

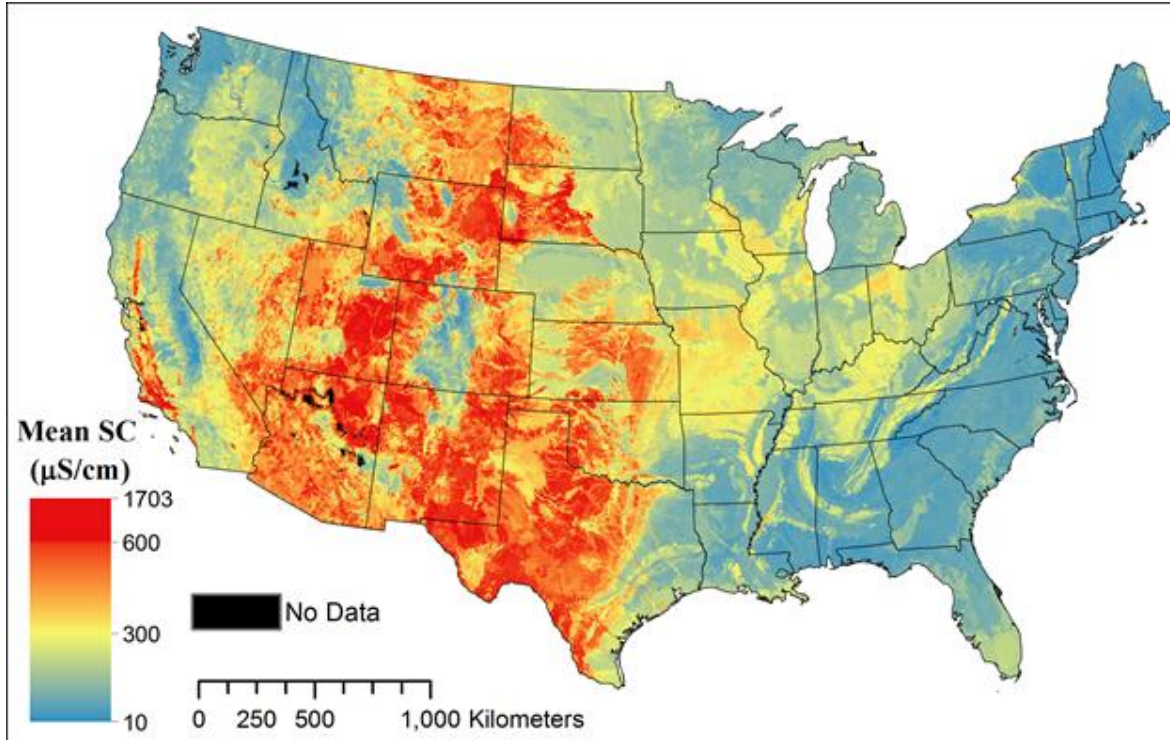


Predicted compared to Measured

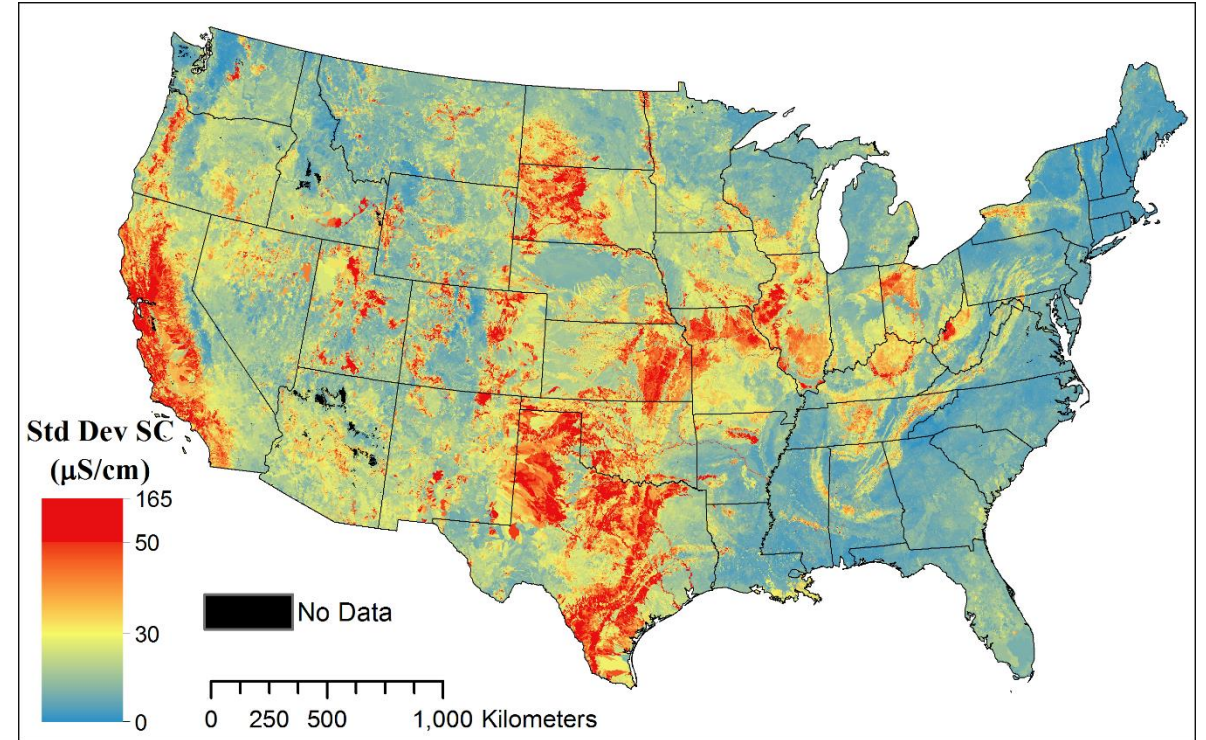
- $\pm 100 \mu\text{S}/\text{cm}$  of measured
- at least  $100 \mu\text{S}/\text{cm}$  less than measured
- at least  $100 \mu\text{S}/\text{cm}$  more than measured



# Natural Background During Drought



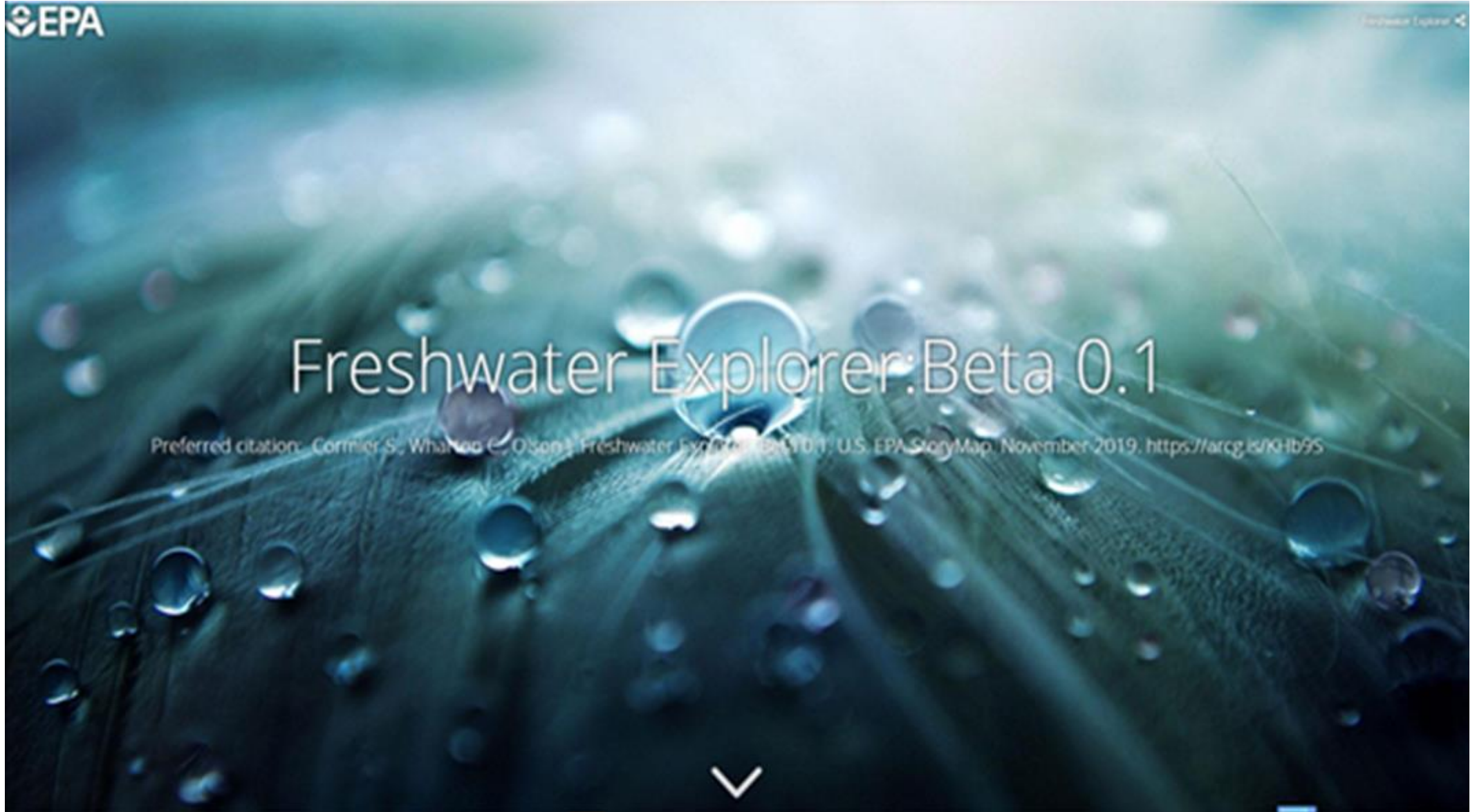
Average background  
2001-2015



Negligible change in background  
between drought and rainy years where  
other parameters are minimally  
affected  
( $<170 \mu\text{S/cm}$  nationwide)

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# Predicted background view color coded catchments

Freshwater Explorer:Beta 0.1

[Home](#) [About Conductivity](#) [Freshwater Explorer](#) [Data Access](#)

Edit × Freshwater Explorer

Predicted Background Conductivity

National Measured Conductivity - WQP

Measured Conductivity-NWIS

Model Validation

DRAFT Measured Phosphorus

### Instructions

- The Freshwater Explorer works best when launched from *Chrome*.
- To search for a place, type the name in the space near the magnifying glass icon.
- Or, use the + and - sign or use your mouse or other navigation to expand or contract the map.
- As you **zoom** in with your mouse or other navigation tool, stream basins change to individual stream segments.
- At the scale showing the stream network, point and click on a stream segment. It will become emphasized and a pop-up data box will appear.
- The specific conductivity (SC) color coding is listed in the pull-down Legend in the upper right.
- Background was not estimated for streams delineated in gray.
- Inset map on lower right shows relative location of large map.

**Predicted Background Conductivity:**  
Ventura River

COPIID	17587720
Stream Name	Ventura River
Average Predicted Background Conductivity	550.2 uS/cm
Stream Type	StreamRiver

Map shows stream network colored by predicted background conductivity. Data box shows information for a selected stream reach highlight in turquoise.

### Map Explanation

At the continental scale, the coloration

+  
🏠  
-

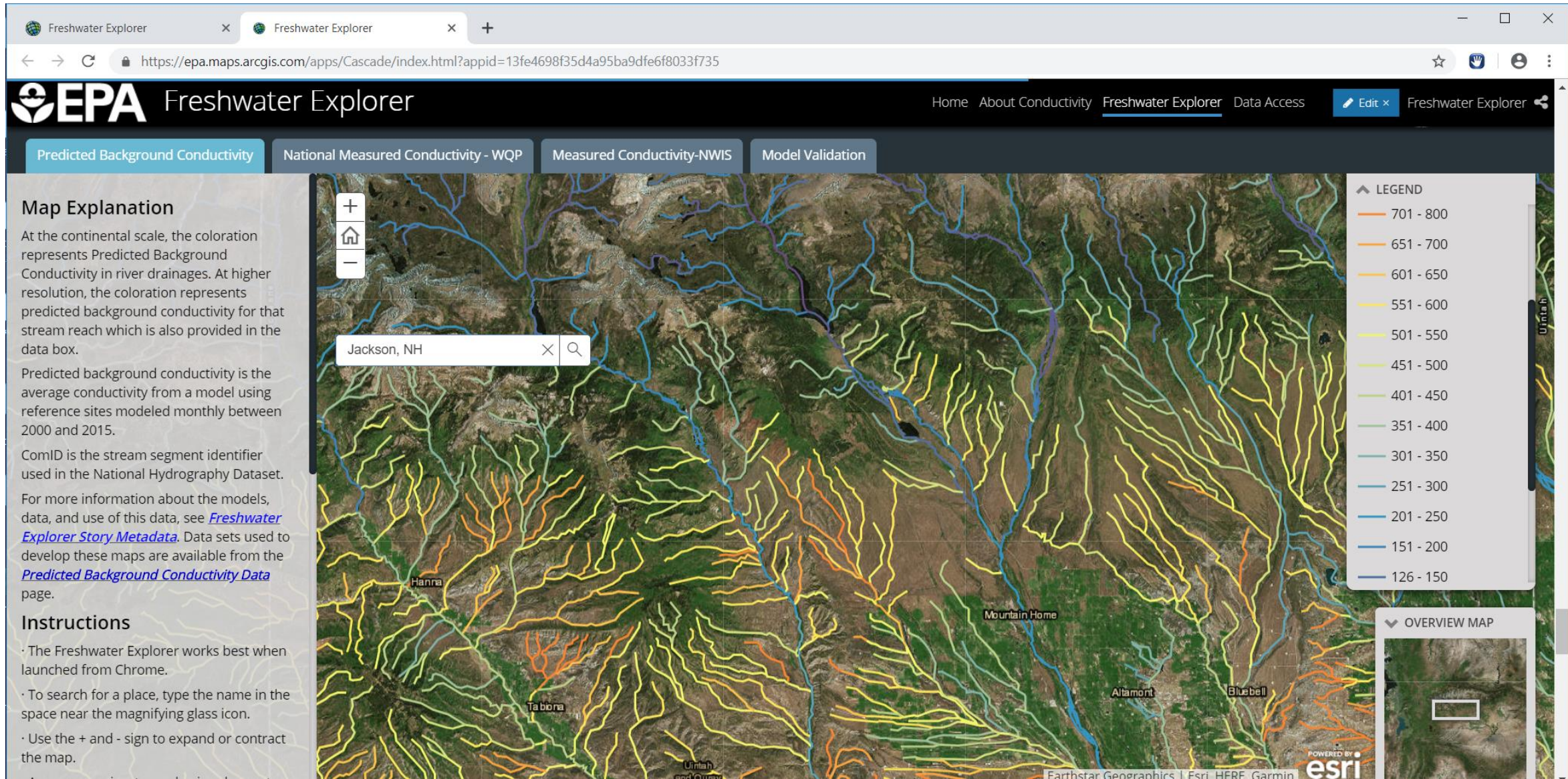
▼ LEGEND

Earthstar Geographics | Esri, HERE, Garmin

POWERED BY



# At higher resolution, watersheds change to stream network





# Select a stream segment for predicted background



Select a stream reach to obtain information

**Predicted Background Conductivity : H-Z Wash**

COMID	22441576
Stream Name	H-Z Wash
Average Predicted Background Conductivity	603.7 $\mu\text{S}/\text{cm}$
Stream Type	StreamRiver



Predicted Background Conductivity

**National Measured Conductivity - WQP**

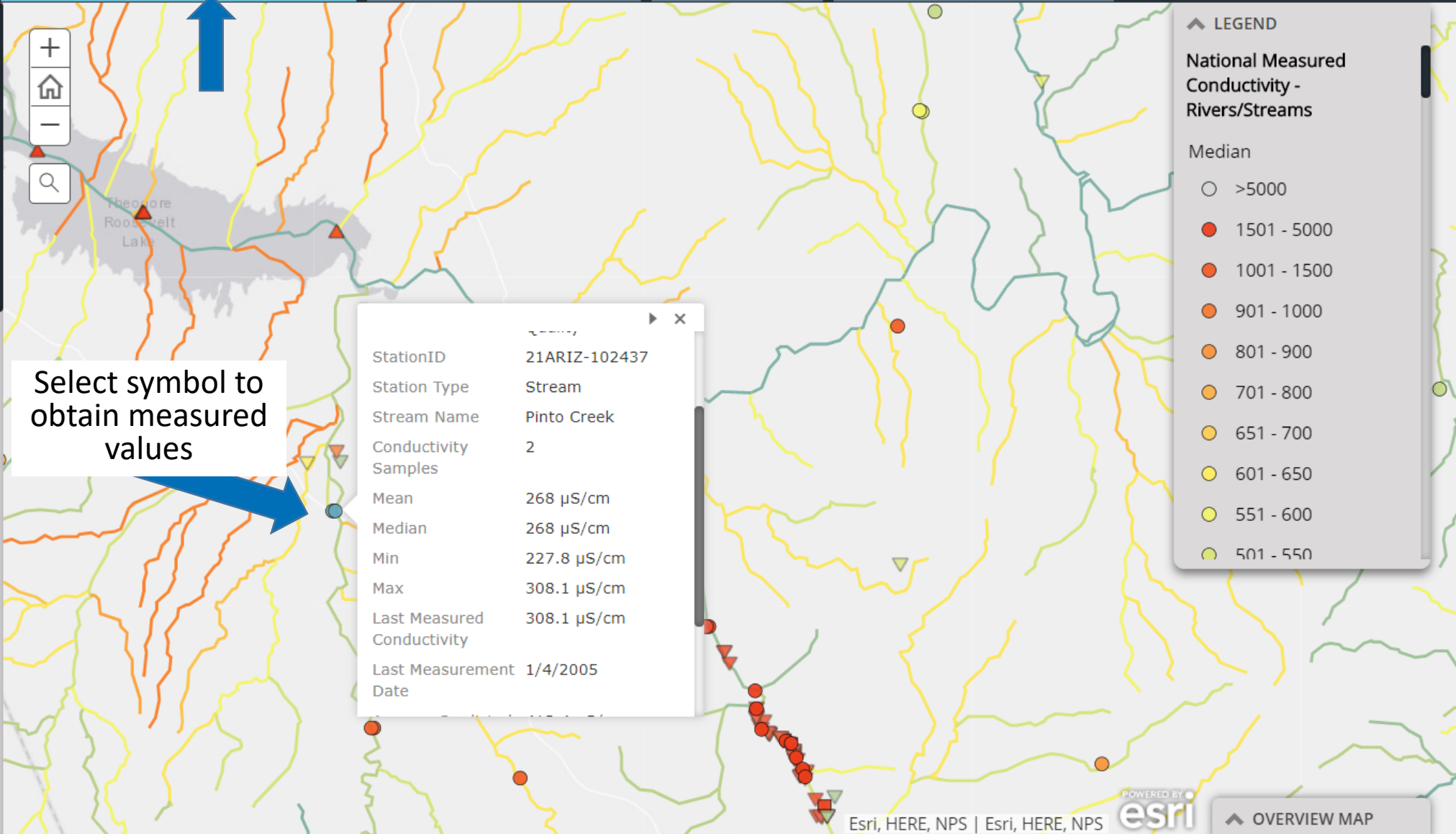
Measured Conductivity-NWIS

Model Validation

DRAFT Measured Phosphorus

### Instructions

- The Freshwater Explorer works best when launched from Chrome.
- To search for a place, type the name in the space near the magnifying glass icon.
- Or, use the + and - sign or use your mouse or other navigation to expand or contract the map.
- As you zoom in, a network of stream will appear.
- At scales showing the stream network, colored shapes will appear. Dots are streams, triangles are lakes, inverted triangles are wells, and squares are other water body types such a waste outfalls.
- The specific conductivity (SC) color coding is listed in the pull-down **Legend** in the upper right. Gray dots indicate that conductivity is not within the freshwater range or that there is uncertainty with data quality.
- Point and click on a colored shape. A data box will appear. Background was only measured for streams in the contiguous 48 states.
- **Inset Overview Map** on lower right shows relative location of the larger

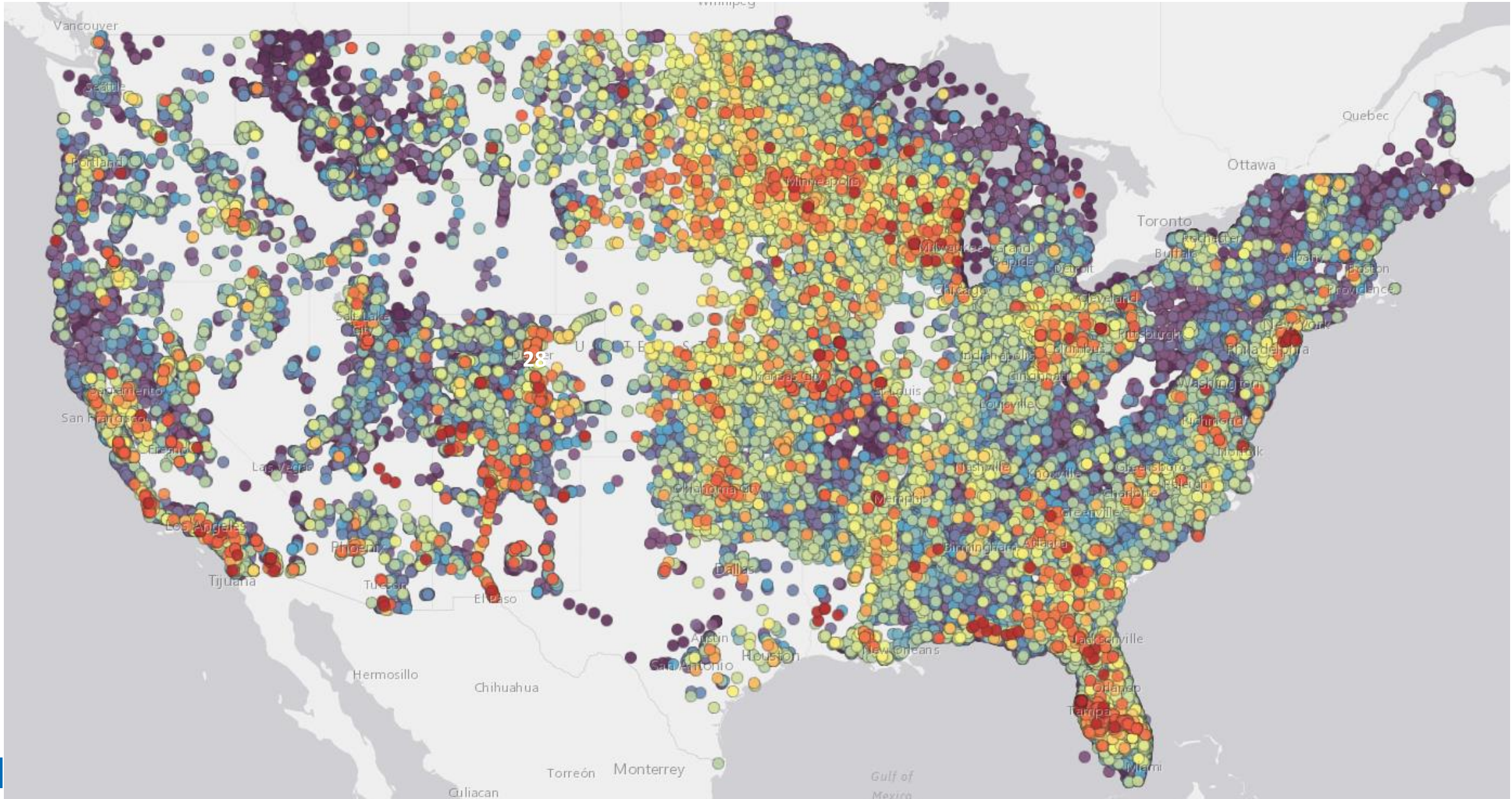


Select symbol to obtain measured values





# National Measured Total Phosphorus View



# Access the data behind the Freshwater Explorer

*Predicted Background Conductivity*

*National Measured Conductivity  
(EPA WQP)*

*National Measured Conductivity  
(NWIS)*

The predictor variables were generated for each stream line within the National Hydrography Dataset Plus version 2 (NHDPlusV2) with algorithms and code from the StreamCat Dataset (ESRI 2012, Hill et al 2016). StreamCat data can be downloaded from <https://www.epa.gov/national-aquatic-resource-surveys/streamcat>.

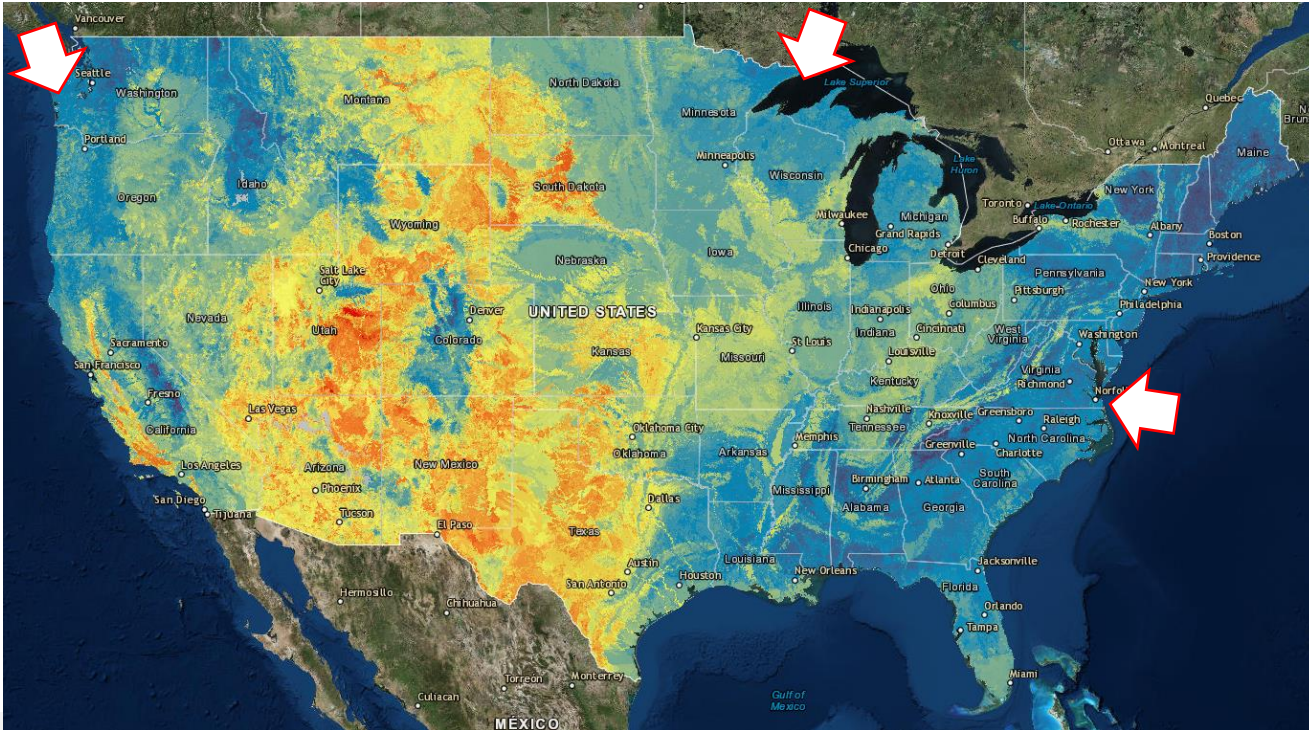
Password  
protected links

[PBC Link](#)

[EPA WQP Link](#)

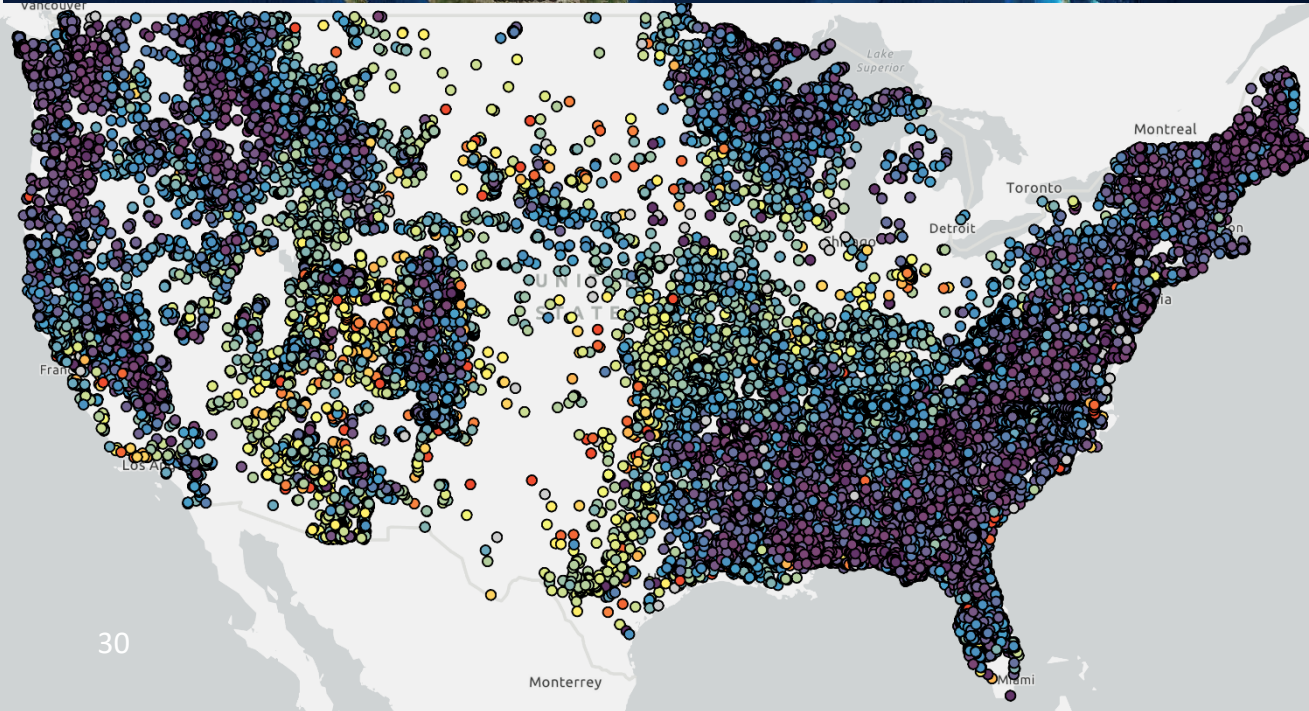
[NWIS Link](#)





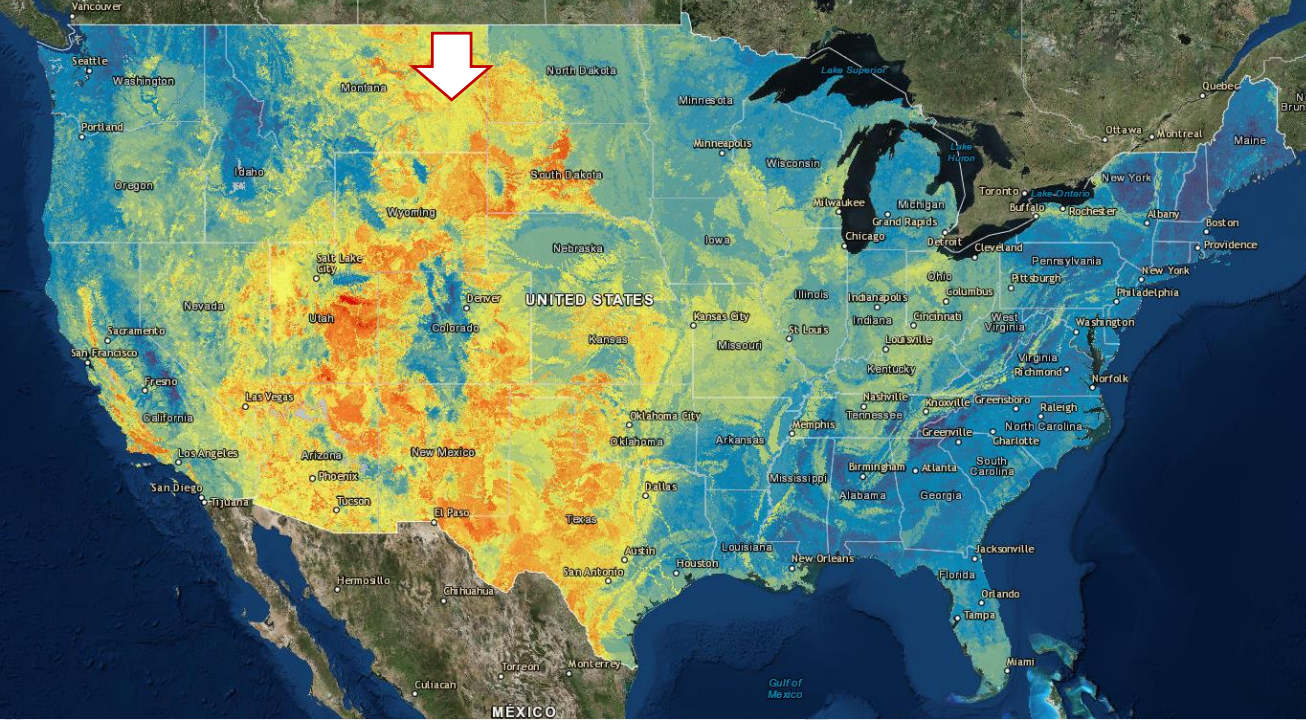
*Places with measured values within 100 microS/cm or less than calculated background*

Nationally, wetter and higher elevations have naturally fresher water, particularly in the Northwest, East and Southeast.



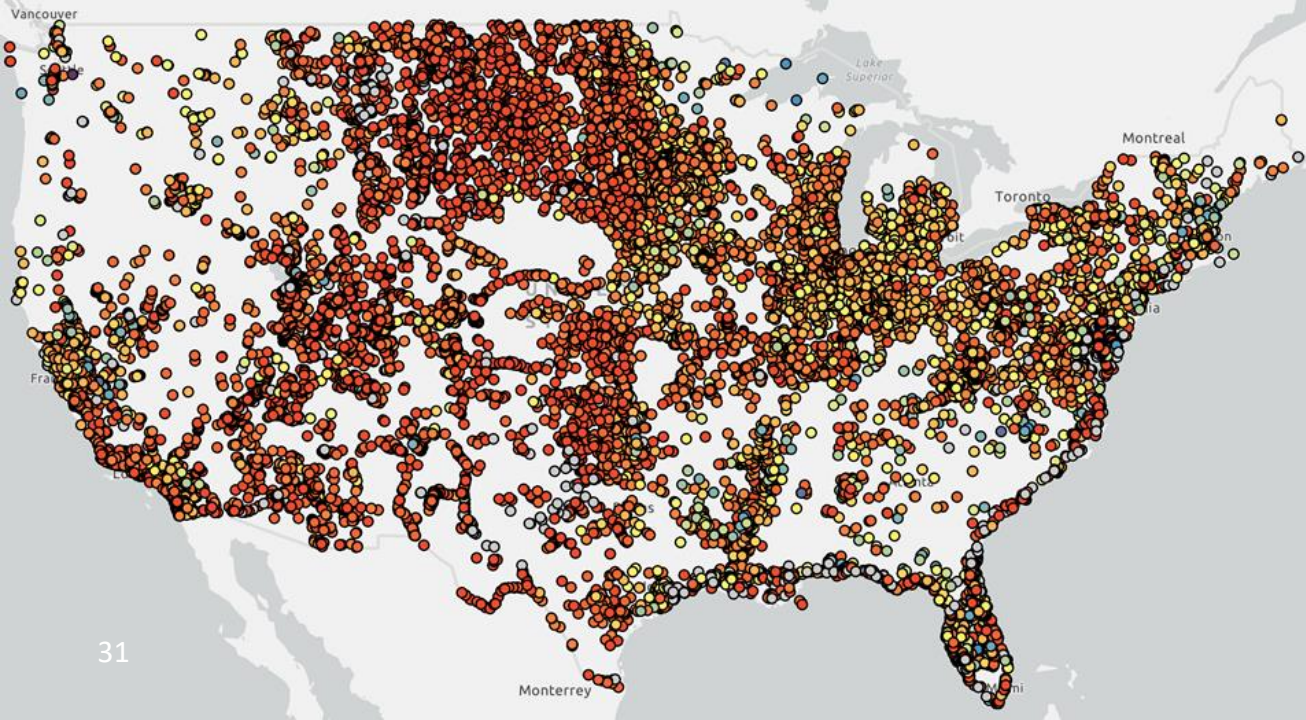
Measured conductivity in these areas are often near predicted background conductivity.





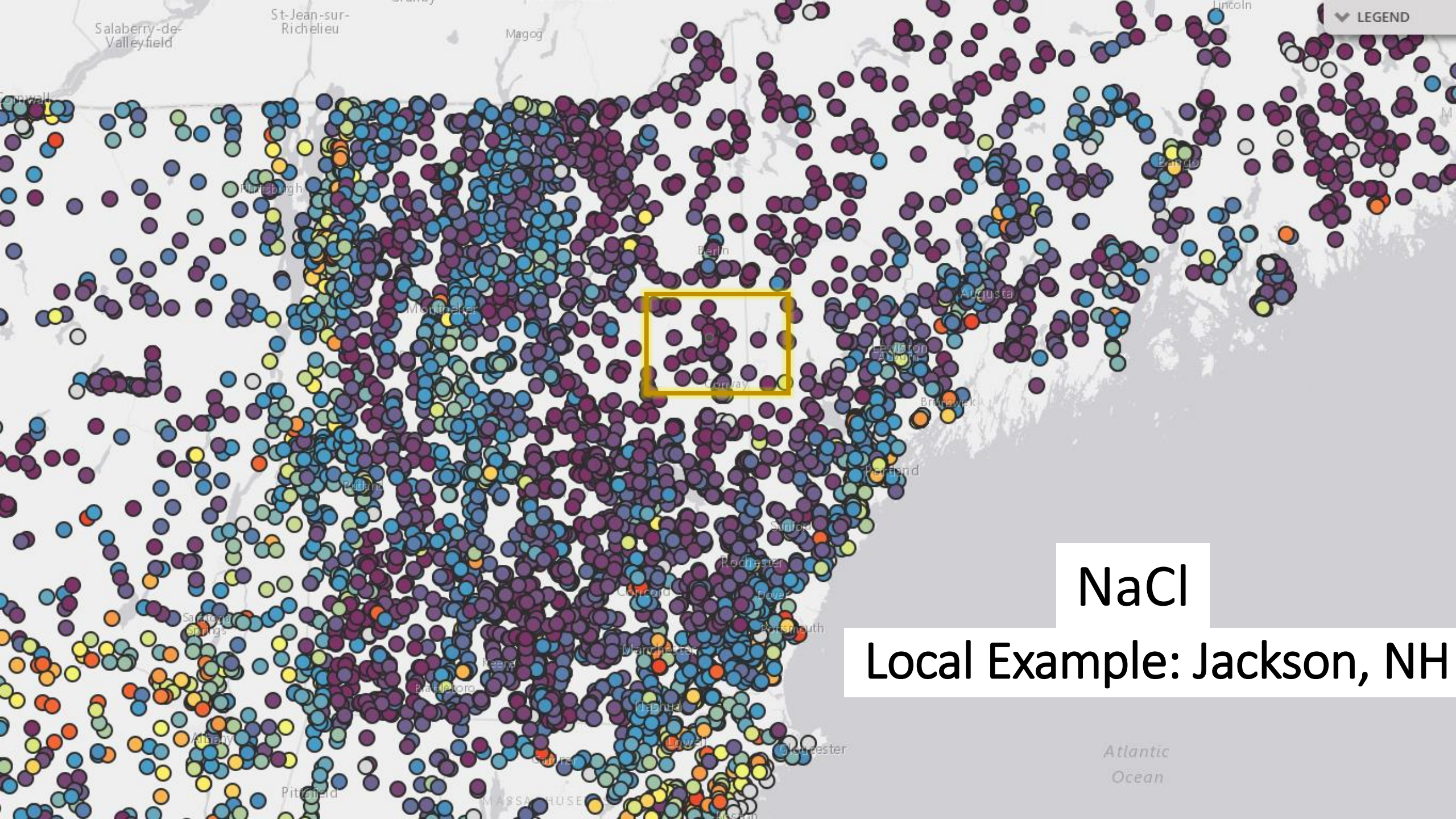
## *Places with measured at 500 microS/cm greater than calculated Background*

Predicted background conductivity is greater in the arid West and agricultural Midwest.



Measured conductivity is greater than predicted natural conditions in these locations.





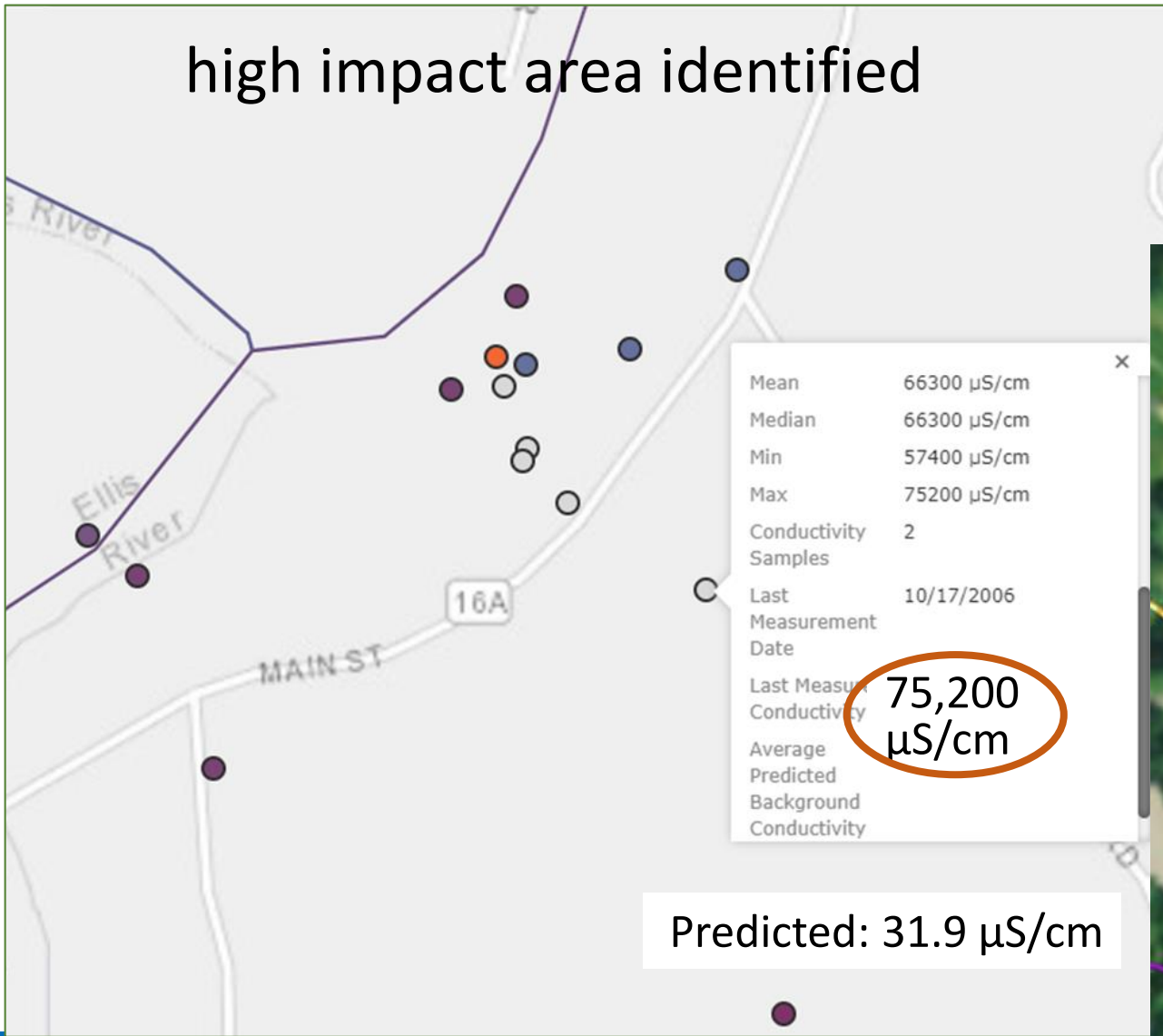
NaCl

Local Example: Jackson, NH



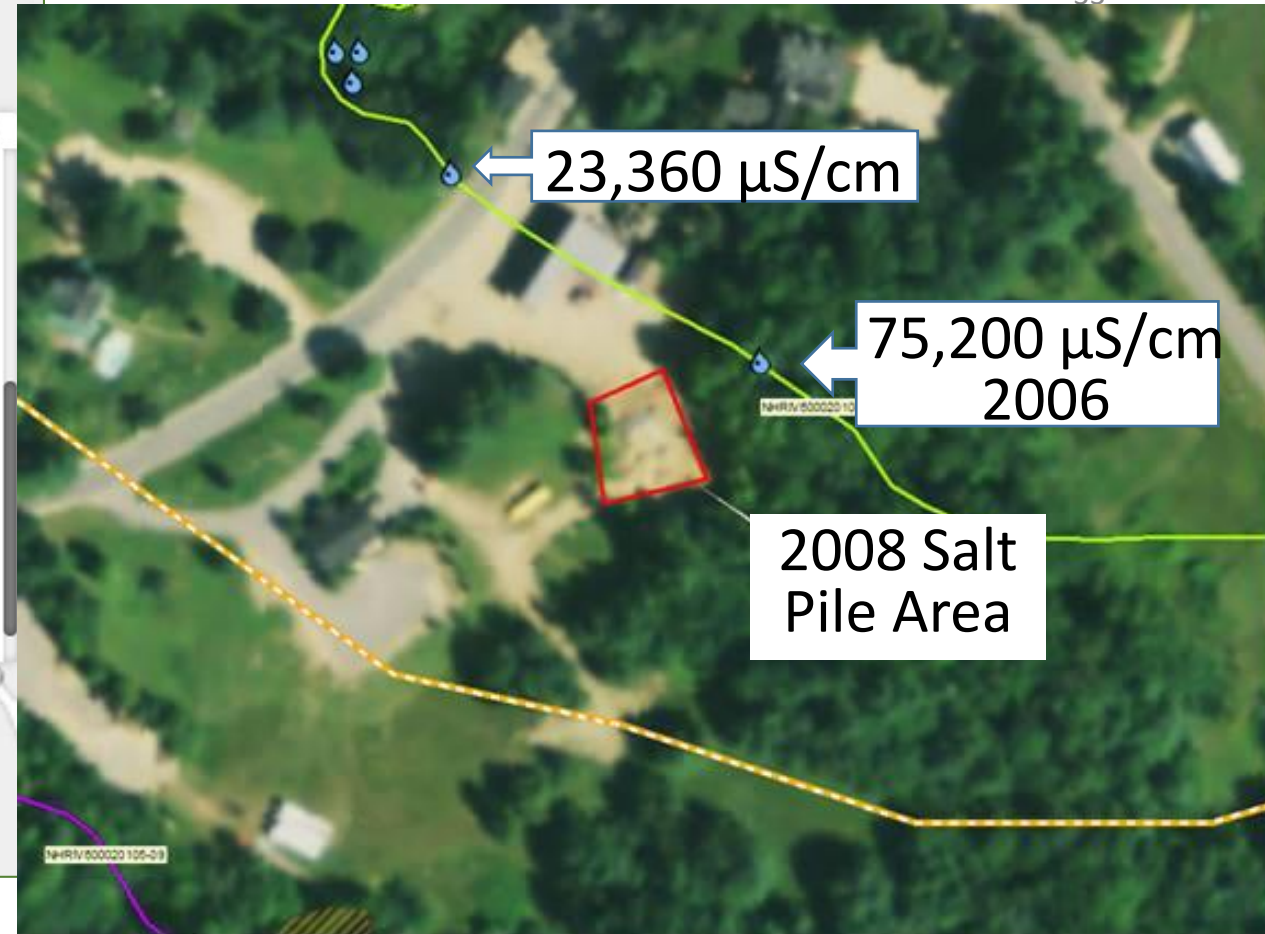
# Freshwater Explorer Case Study: NH

high impact area identified



Courtesy of: Matt Wood, Assessment Coordinator  
NH Department of Environmental Services

33





Salt pile was removed  
and covered salt  
storage was built

75,200  $\mu\text{S}/\text{cm}$   
2006

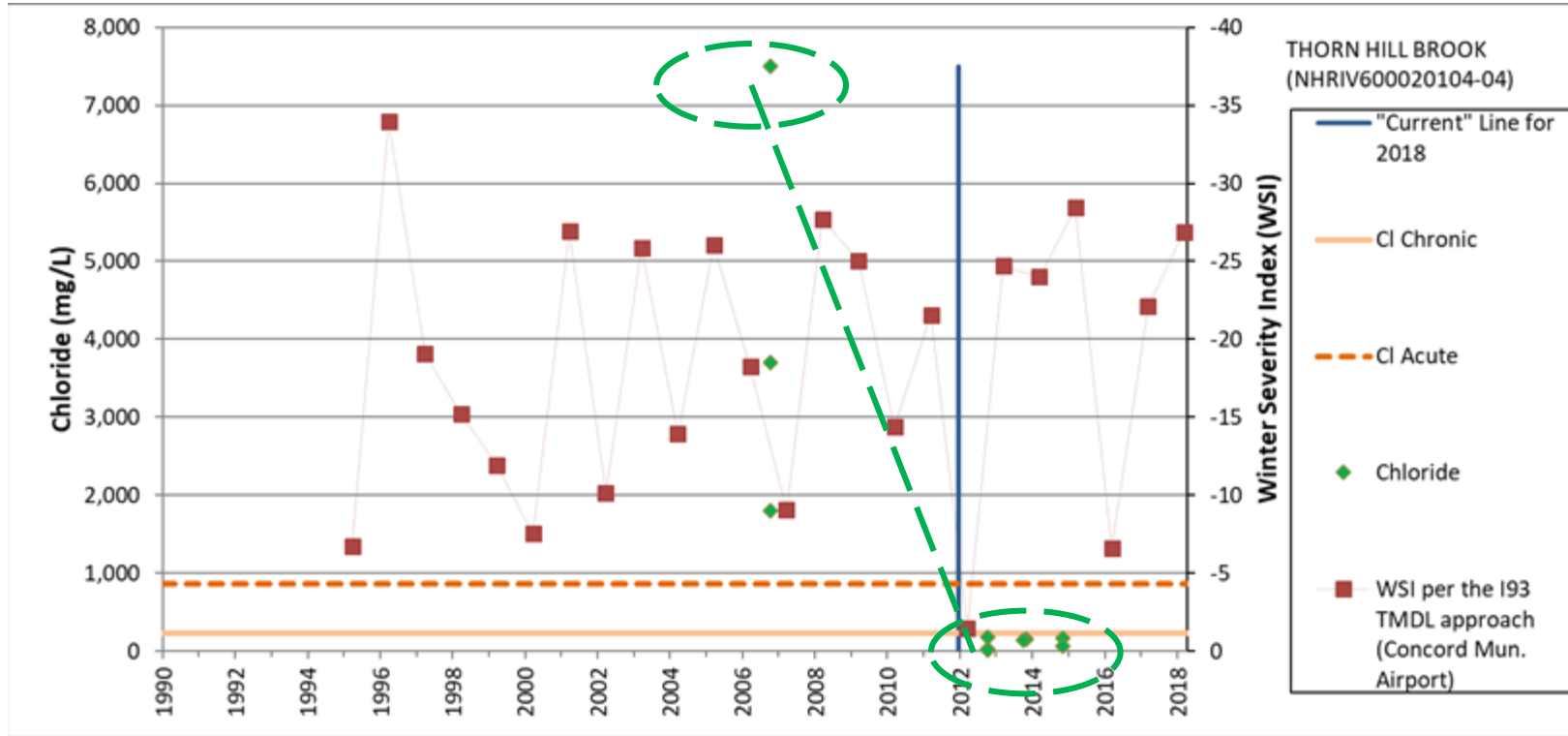
Salt Pile Area  
2006

New Storage  
Area 2018



If some spillage, split  
between streams

# Plans are to delist from 303d after a bit more monitoring



Chloride level decreased dramatically after moving pile away from stream and covering it

- Winter Severity Index
- Chloride (mg/L)

Courtesy of: Matt Wood, Assessment Coordinator  
NH Department of Environmental Services

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# Example: of Enhancing the Freshwater Explorer: Arkansas

## Arkansas Freshwater Explorer

No issues detected ×

Edit ×

A Story Map



### Overview

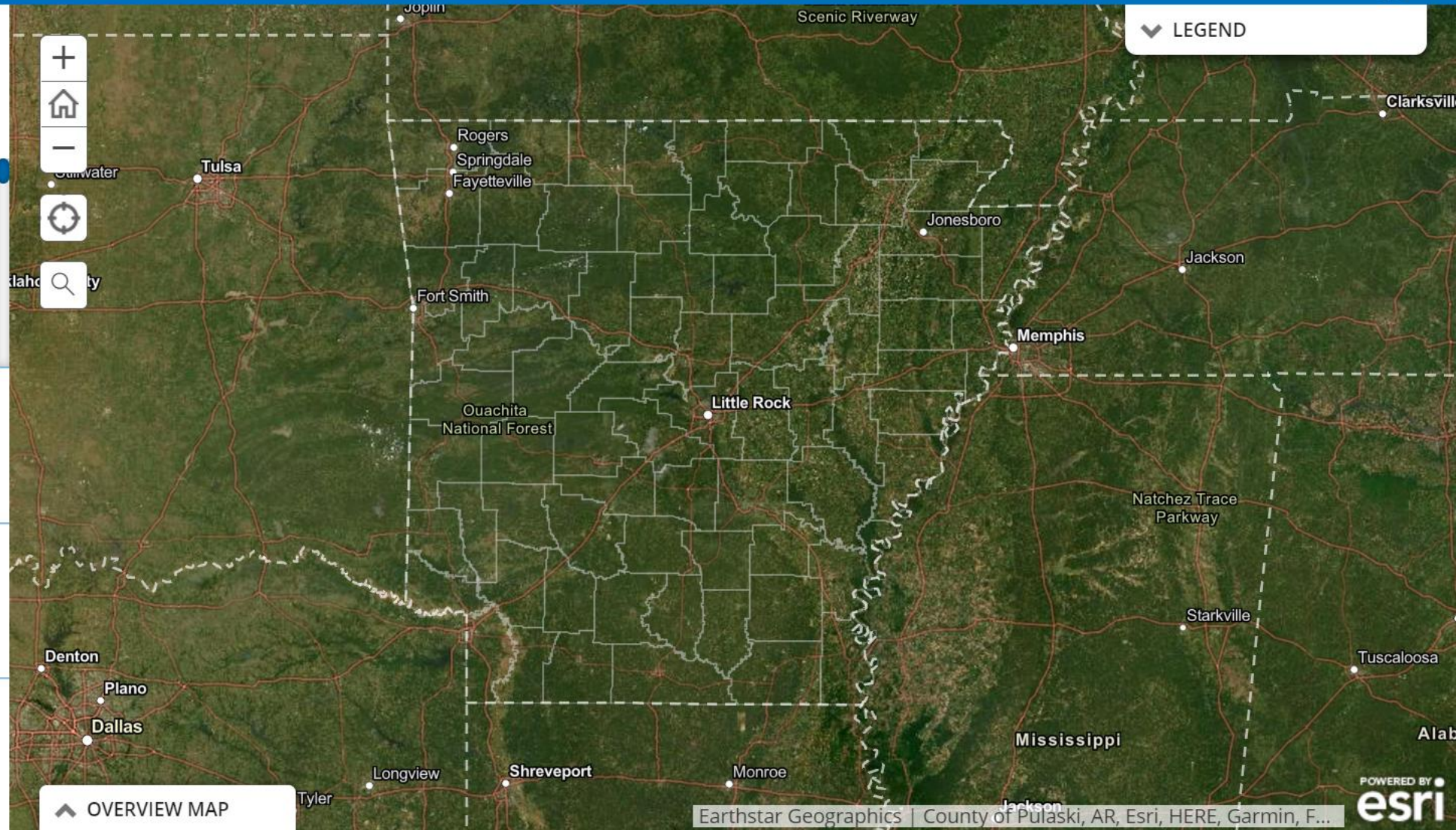
### What is the Arkansas Freshwater Explorer?

The Arkansas Freshwater Explorer is an interactive map of a network of streams in Arkansas. It allows you to see where

### Phosphorus

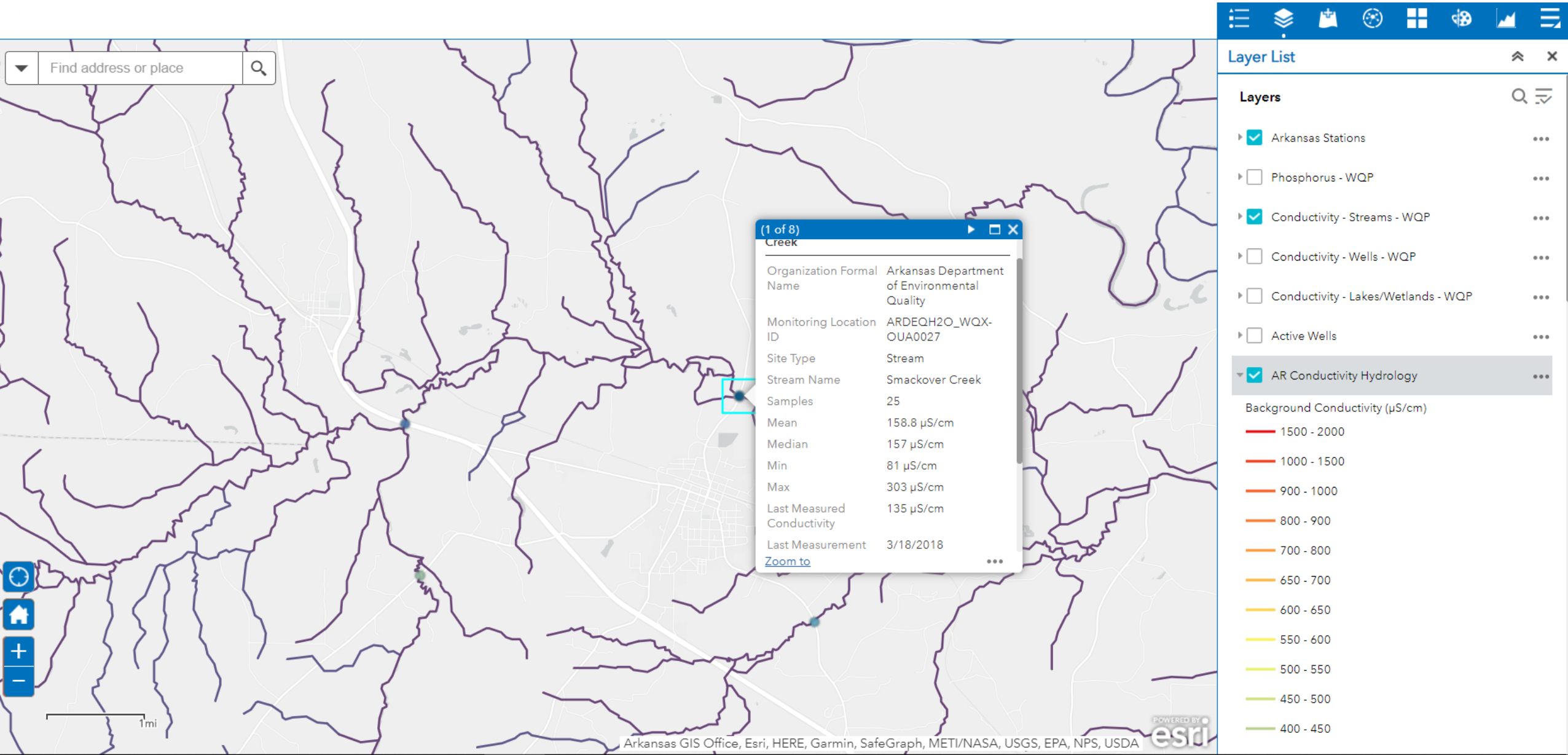
### Conductivity

### Explore Additional Data

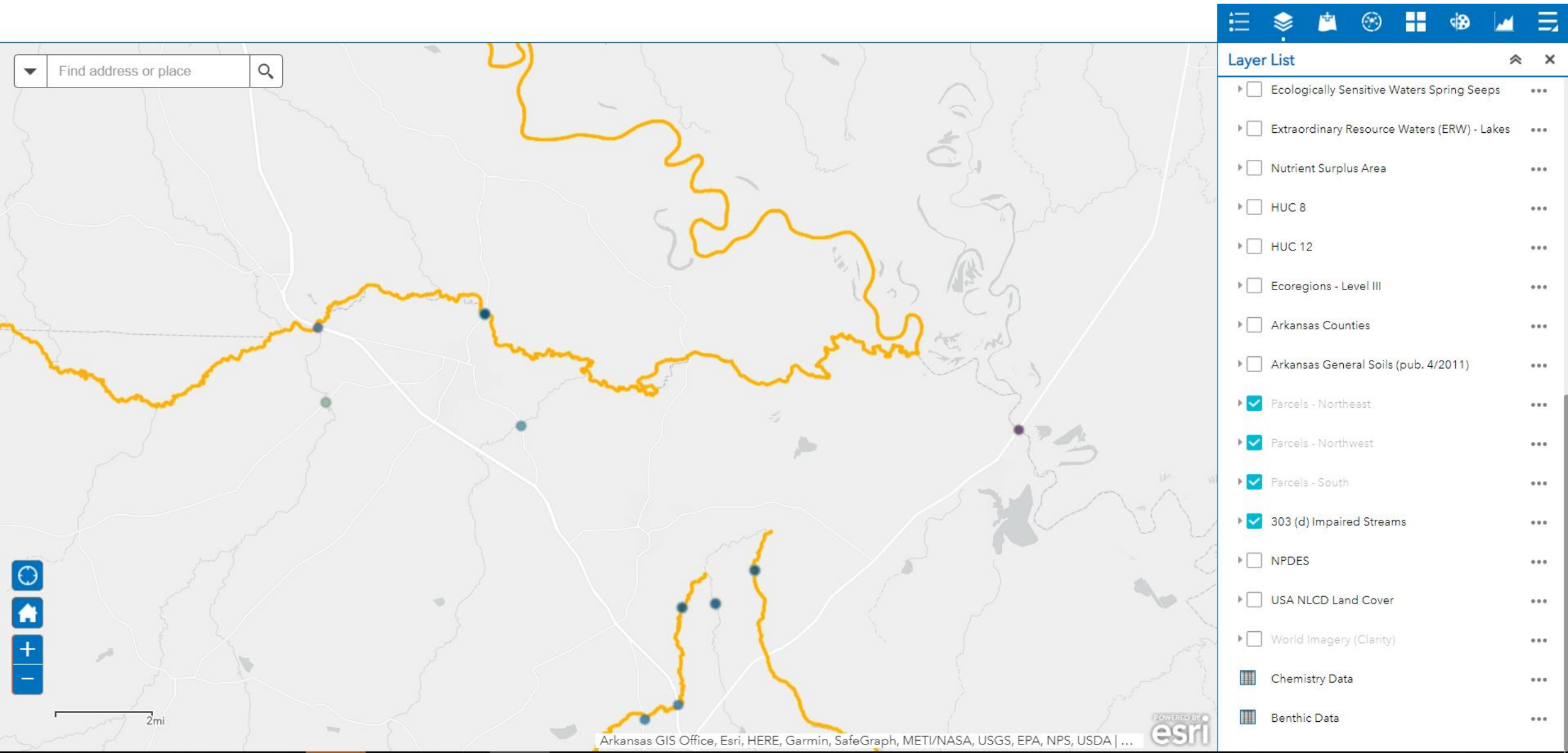




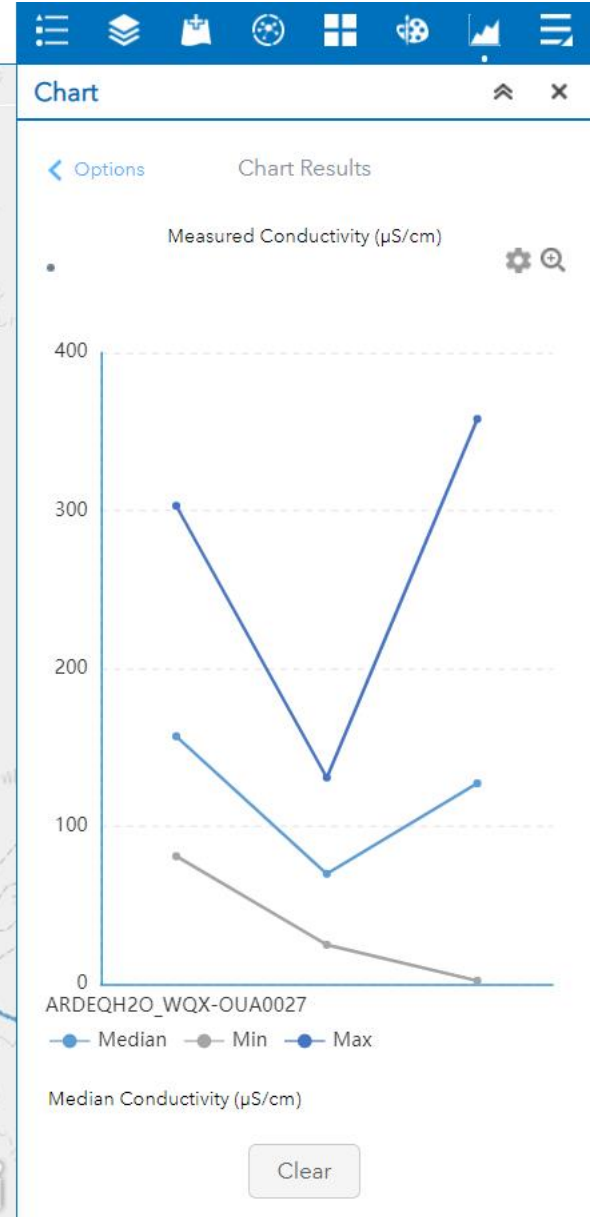
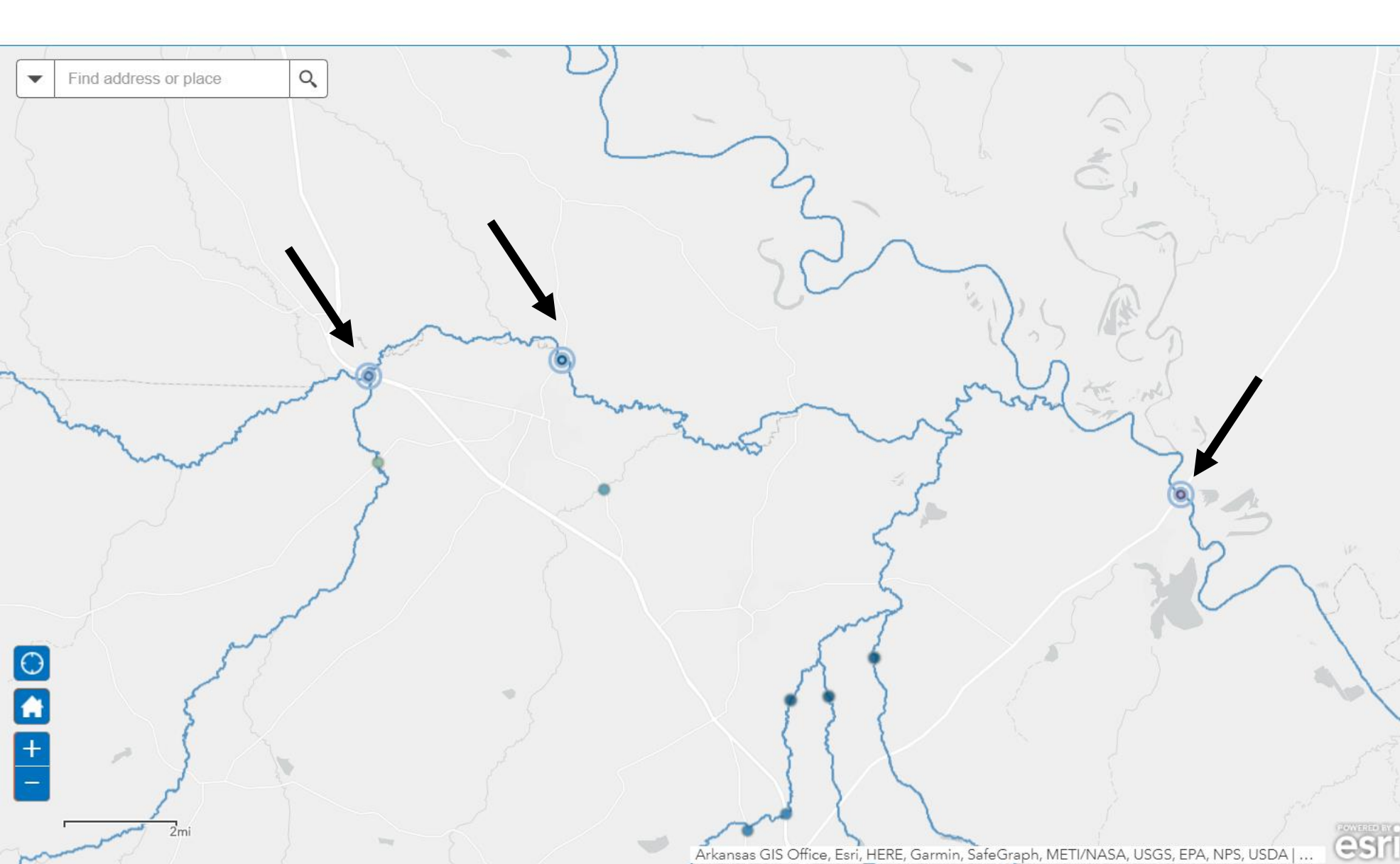
# Summary information for range of concentrations



# 303d listed area can be highlighted



# Points can be selected and graphed



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# Take Home Messages

- **EPA's Freshwater Explorer**
  - Assess areas of interest
  - Water Quality Exchange contributors can spot data integrity issues
  - Share watershed and regional stories
  - Background nutrient estimates will be added in 2021
- **We've given you a framework...**
  - Go ahead use as is or download and add other data
  - Increase analytical potential with other spatial information
  - Provide us with feedback on how to improve the tool!



# Contact

**Susan Cormier, PhD**  
Senior Scientist  
US EPA Office of Research and Development  
[cormier.susan@epa.gov](mailto:cormier.susan@epa.gov)  
513-569-7995

*Contact me to obtain access to the tool and  
set up a password!*

## **Acknowledgements:**

Christopher Wharton, TetraTech, Inc.

John Olson, California State University-Monterrey

Matt Wood, New Hampshire Department of Environmental Services

Joe Martin, Arkansas Department of Environmental Quality

Preferred citation: Cormier S., Wharton C., Olson J. Freshwater Explorer: Beta 0.1. U.S. EPA StoryMap. November 2019.  
<https://arcg.is/KHb9S>

