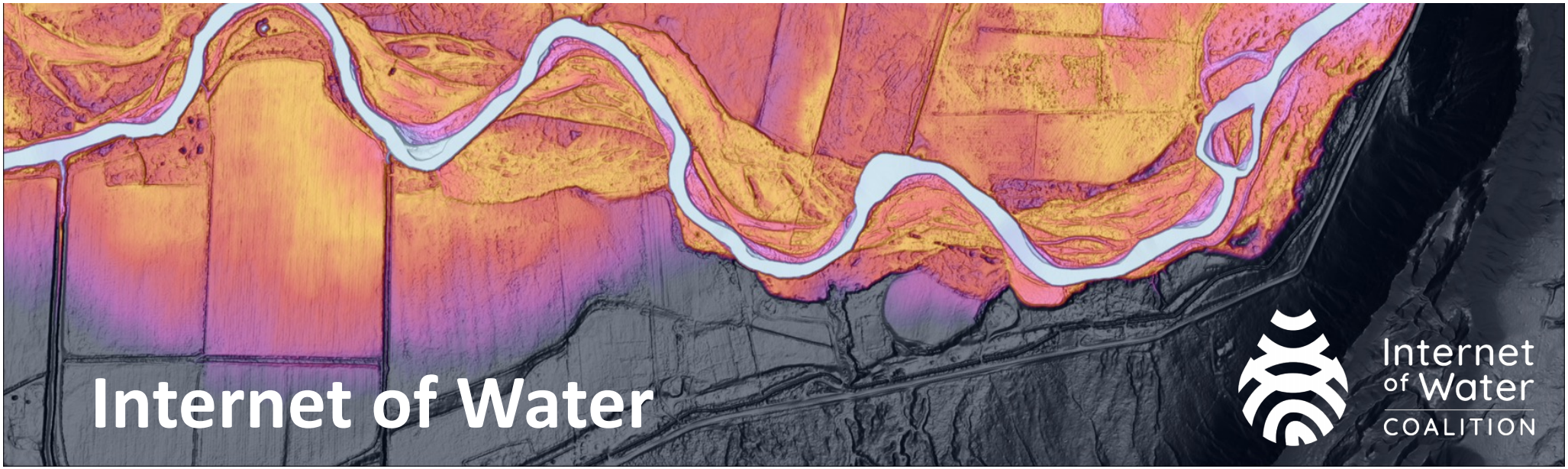

The Frontend, Backend, and Everything in Between

Kyle Onda, Director
konda@lincolninst.edu

CENTER FOR GEOSPATIAL SOLUTIONS

LINCOLN INSTITUTE OF LAND POLICY

Agenda

- Introduction to CGS
- The Water Data Discovery Challenge
- Geoconnex Explorer
- How the Internet of Water Works
- Internet of Water Services

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SOLUTIONS

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CENTER FOR GEOSPATIAL SOLUTIONS

OUR MISSION

To enable data-driven decisions for the greater good of land, water, and people.

CENTER FOR
GEOSPATIAL SOLUTIONS

Helping organizations on the frontlines of our most complex land, water, and social challenges leverage **data** and **technology** to accelerate **impact**.

2020
Founded by the Lincoln Institute of Land Policy

24
Employees across the United States

~40
Public and private collaborations to date

NATURE CONSERVANCY CANADA

U.S. Endowment for Forestry and Communities

Ecosystem Investment Partners

MAINE CONNECTIVITY AUTHORITY

NACA
NEIGHBORHOOD ASSISTANCE CORPORATION OF AMERICA

NRCS

CENTER FOR GEOSPATIAL SOLUTIONS

+

Internet of Water COALITION

CGS is the **technical engine** for the Internet of Water Coalition providing **digital infrastructure and implementation** support to help stakeholders across the water data ecosystem modernize water **data publication and management.**

BUREAU OF RECLAMATION

USGS science for a changing world

NOAA

U.S. DEPARTMENT OF ENERGY

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The Water Data Ecosystem

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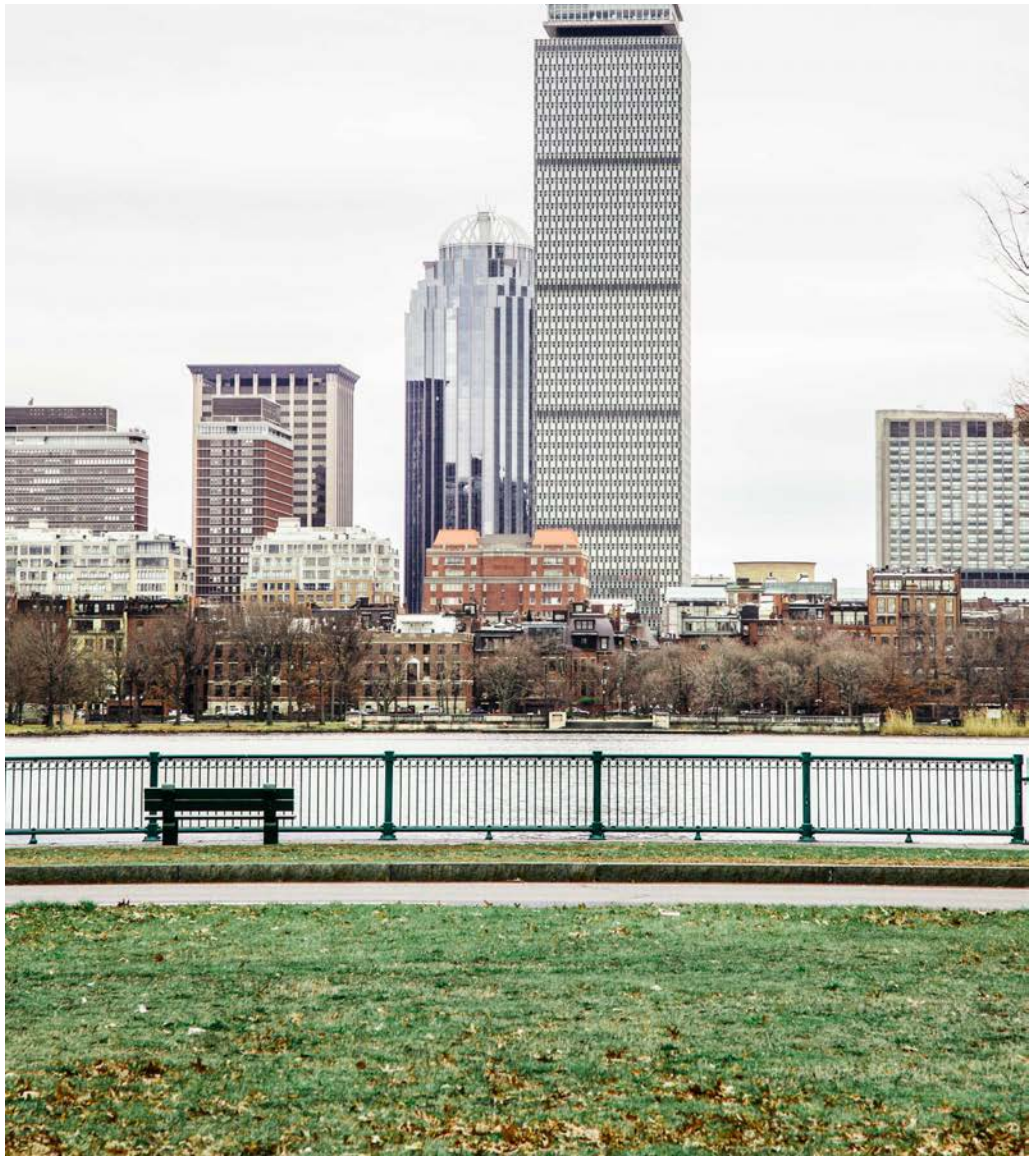
Our water future demands data-driven, real time, and accurate decision-making.

Our current water data ecosystem is **fragmented** with producers, users, and decision-makers lacking access to the information they need.

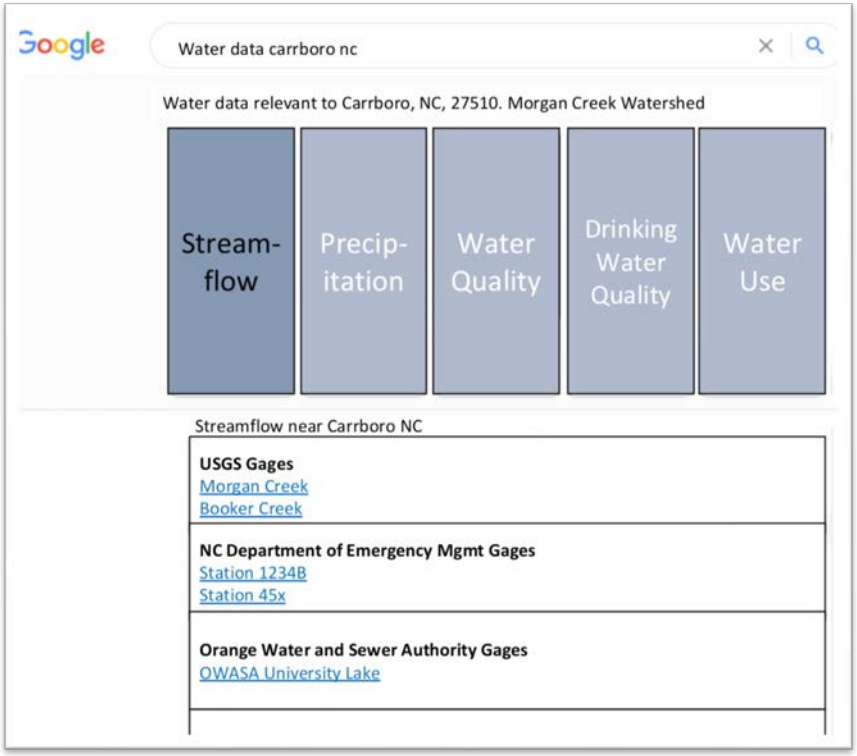


Geoconnex works by...

Helping water data producers **describe data sets** with common vocabulary

Establishing **persistent identifiers** for every water feature across the US

Unlocking the ability to **organize, link, connect, and access data** in one place



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Today, Geoconnex is comprised of…

An **open, centralized knowledge-base** serving **as an index** for all water data.

The backbone of the Internet of Water, exposing data with a knowledge graph.

High frequency time series (Surface water, Groundwater, hydrological forecasting)

Water Quality Samples

Water Administration

Water Infrastructure

Drinking Water Quality

Reservoir Operations

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Exploring Geoconnex Today

Curious User

Interested in what data is available upstream or downstream of their water source

No technical skills required

↓

Geoconnex Explorer

Savvy User

GIS user or programmer looking to visualize, analyze, and manipulate data

QGIS, or ArcGIS suite familiarity

↓

REST Endpoints
OGC API

Super User

Data scientist/engineer, hydrologist, or developer

Python, SPARQL, R programming experience

↓

Geoconnex Graph
HyRiver

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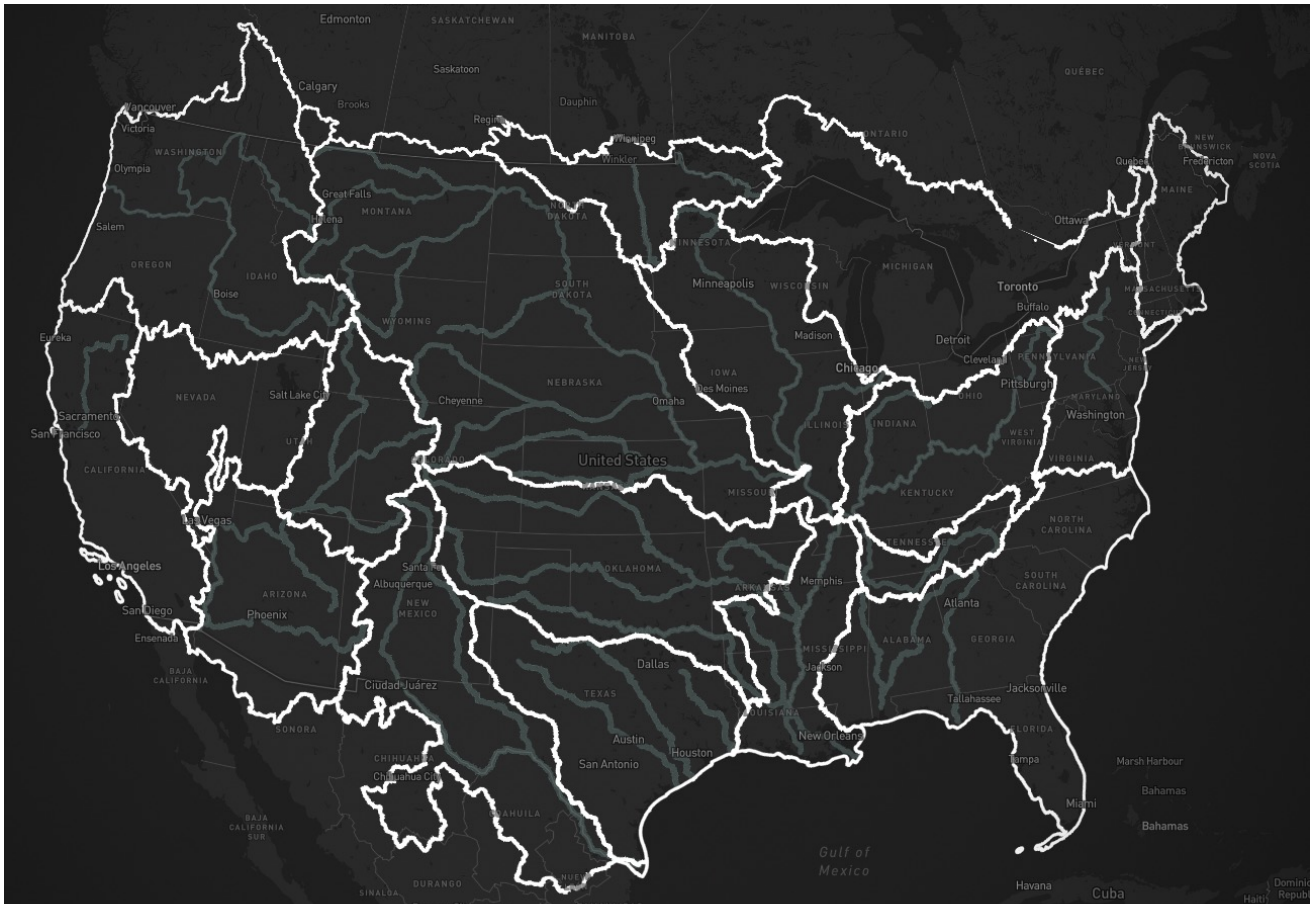
Geoconnex Explorer



https://explorer.geoconnex.us

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Geoconnex Explorer

https://explorer.geoconnex.us

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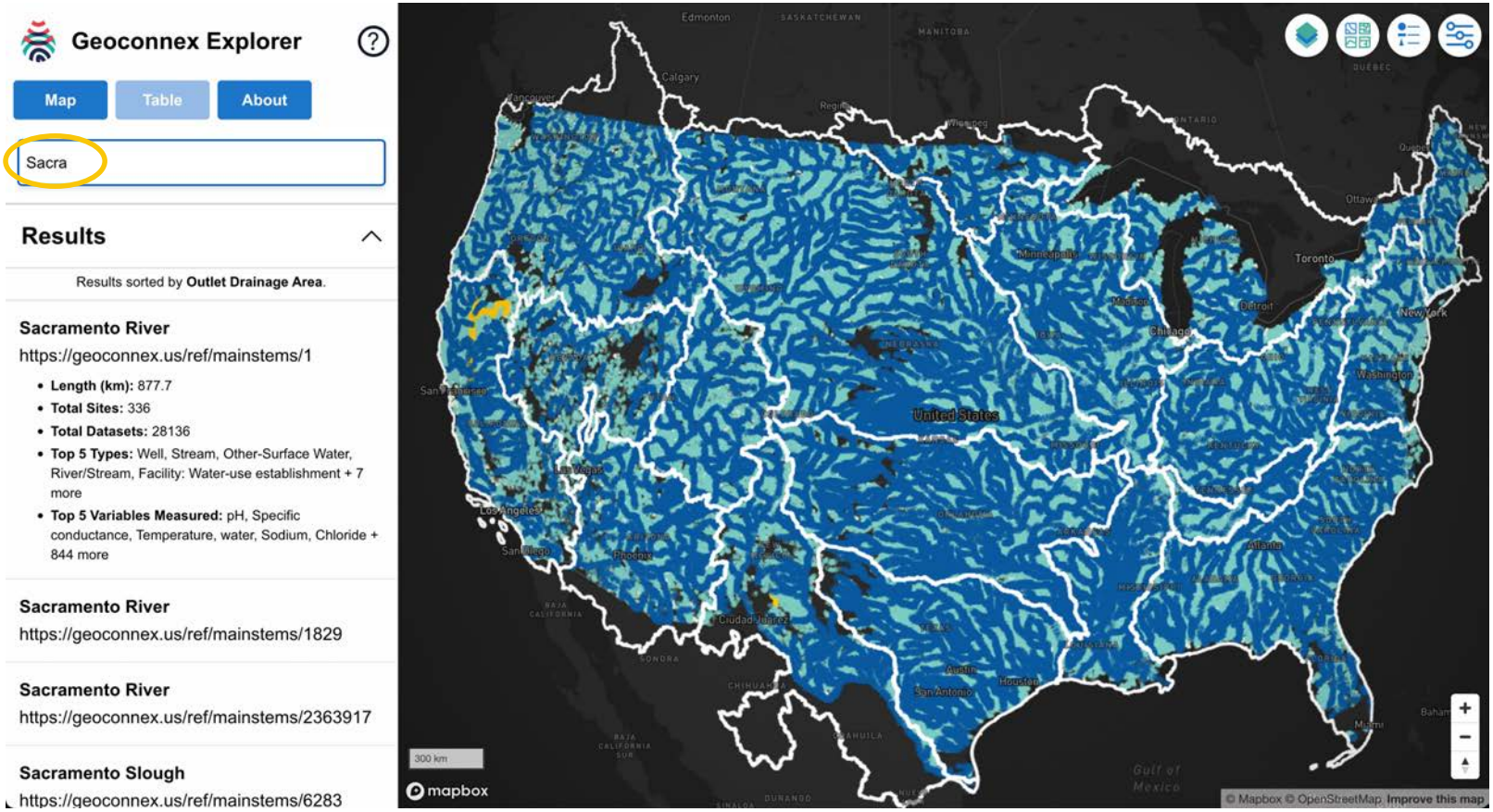
Geoconnex Explorer



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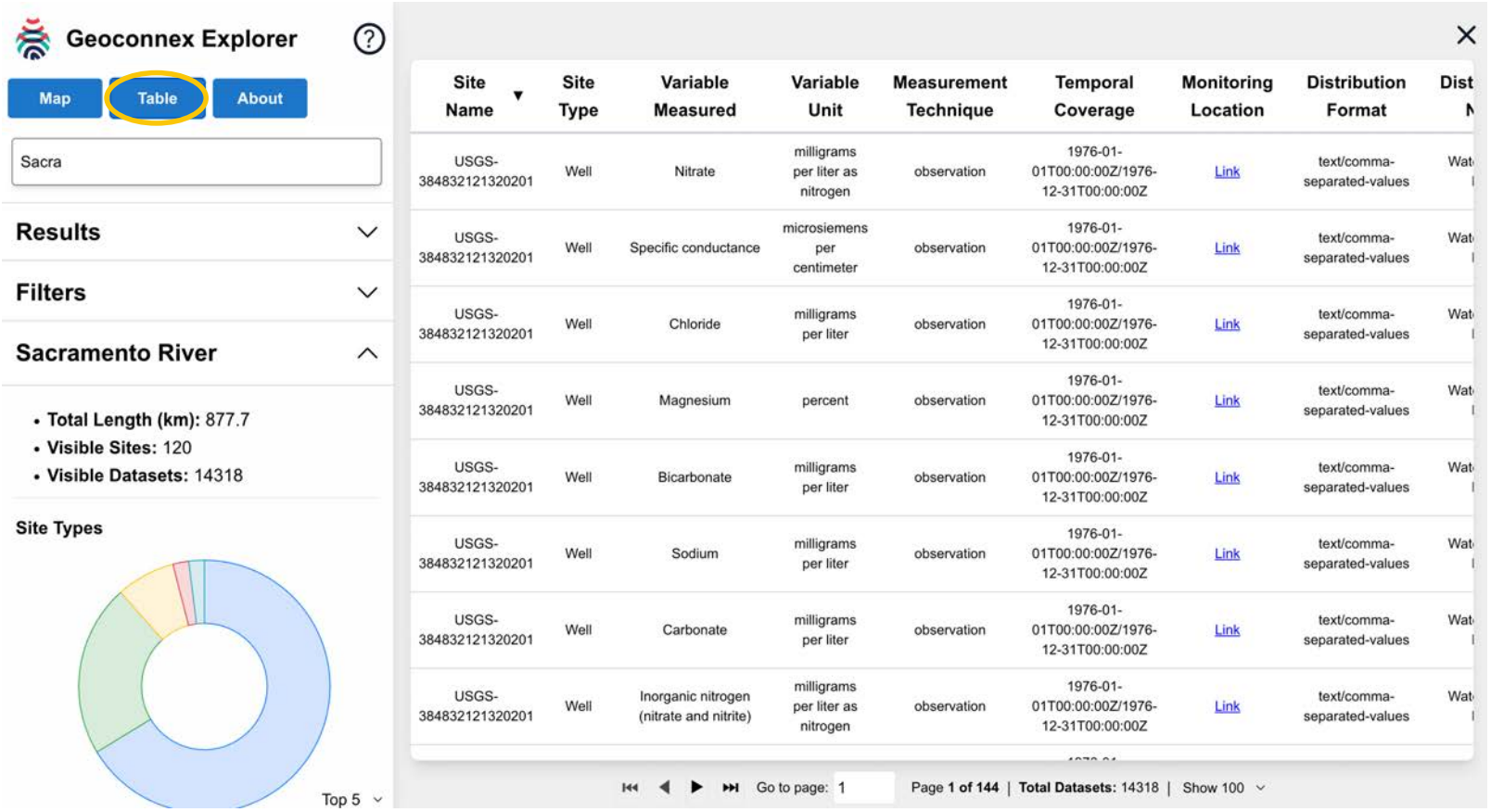
Geoconnex Explorer



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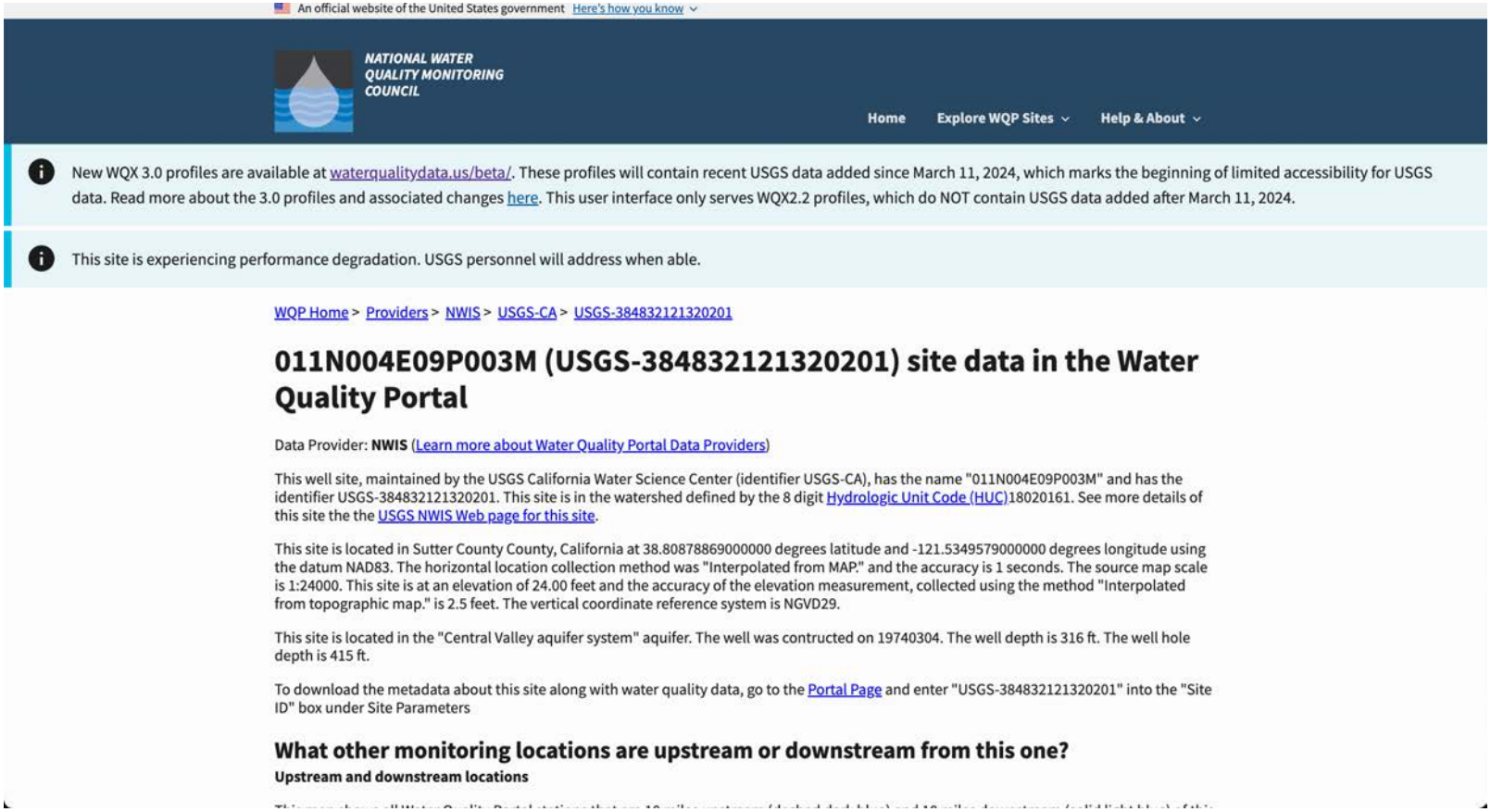
Geoconnex Explorer



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OGC API

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Python, SPARQL, R programming experience

↓

Geoconnex Graph
HyRiver

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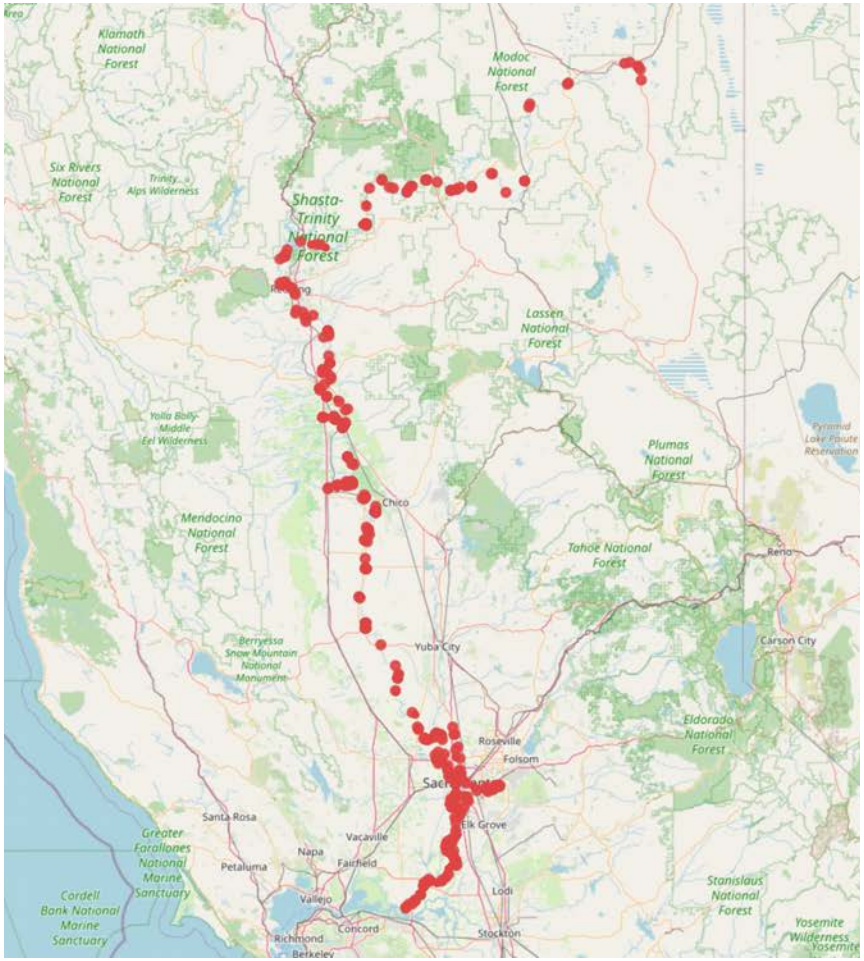
Geoconnex Explorer

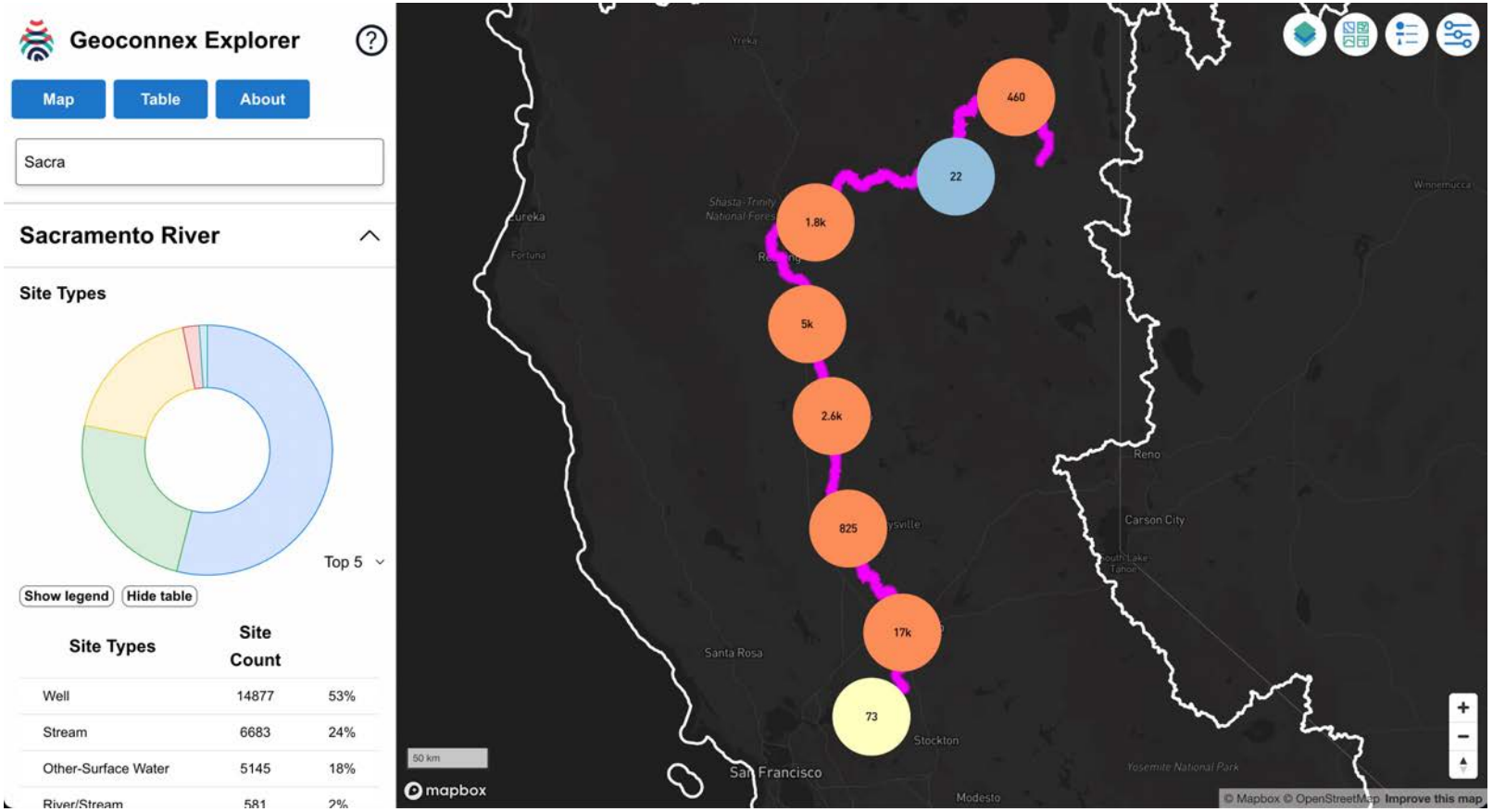
What's going on under the hood?

```
PREFIX hyf: <https://www.opengis.net/def/schema/hy_features/hyf/>
PREFIX gsp: <http://www.opengis.net/ont/geosparql#>

SELECT DISTINCT ?location ?wkt
WHERE {
  VALUES ?mainstem { <https://geoconnex.us/ref/mainstems/1> }
  ?location hyf:referencedPosition/hyf:HY_IndirectPosition/hyf:linearElement ?mainstem ;
            gsp:hasGeometry/gsp:asWKT ?wkt .
}
```



Geoconnex Explorer



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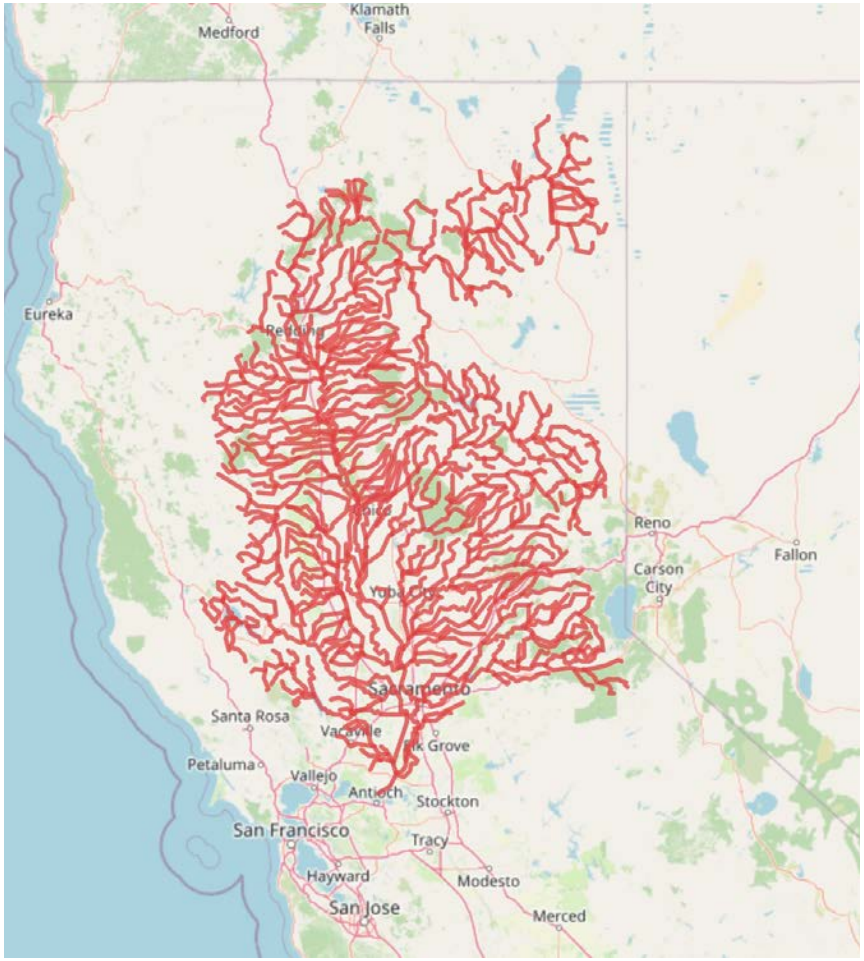
How can we change this query?

> Show upstream mainstems

```
PREFIX hyf: <https://www.opengis.net/def/schema/hy_features/hyf/>
PREFIX gsp: <http://www.opengis.net/ont/geosparql#>

SELECT DISTINCT ?mainstems ?wkt
WHERE {
  VALUES ?mainstem { <https://geoconnex.us/ref/mainstems/1> }
  ?mainstems hyf:downstreamWaterbody+ ?mainstem ;
             gsp:hasGeometry/gsp:asWKT ?wkt .
}
```

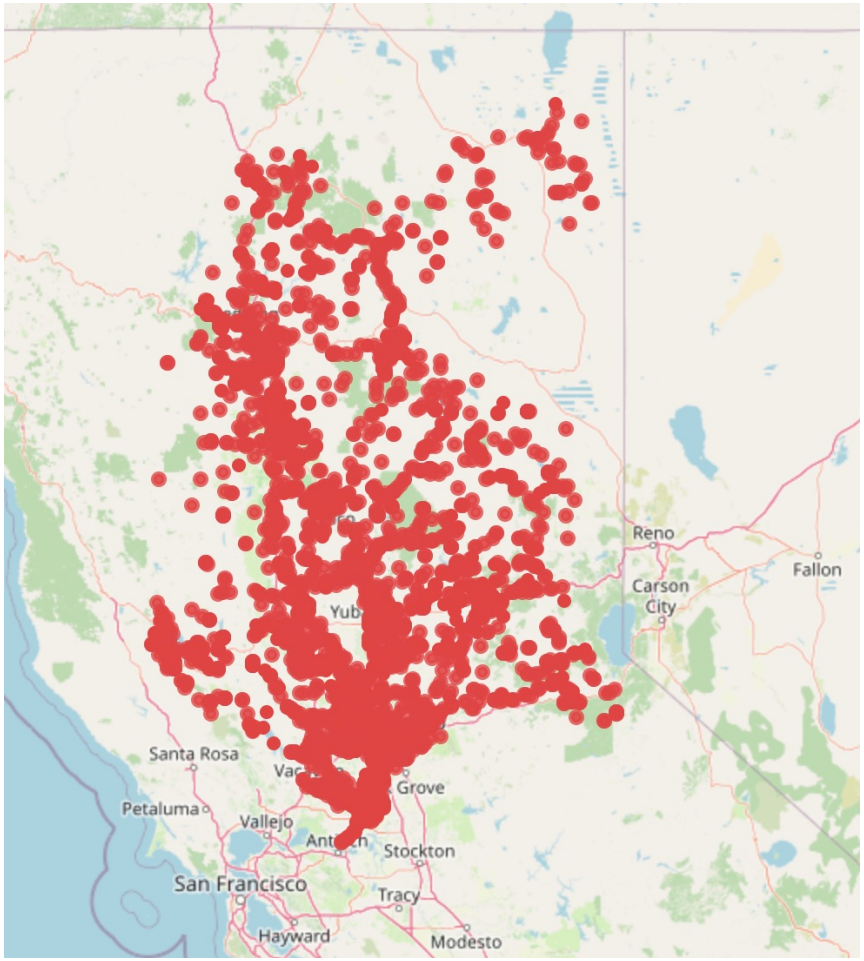


How can we change this query?

> Show upstream monitoring locations

```
PREFIX hyf: <https://www.opengis.net/def/schema/hy_features/hyf/>
PREFIX gsp: <http://www.opengis.net/ont/geosparql#>

SELECT DISTINCT ?location ?wkt
WHERE {
  VALUES ?mainstem { <https://geoconnex.us/ref/mainstems/1> }
  ?mainstems hyf:downstreamWaterbody* ?mainstem .
  ?location hyf:referencedPosition/hyf:HY_IndirectPosition/hyf:linearElement ?mainstems;
            gsp:hasGeometry/gsp:asWKT ?wkt .
}
```

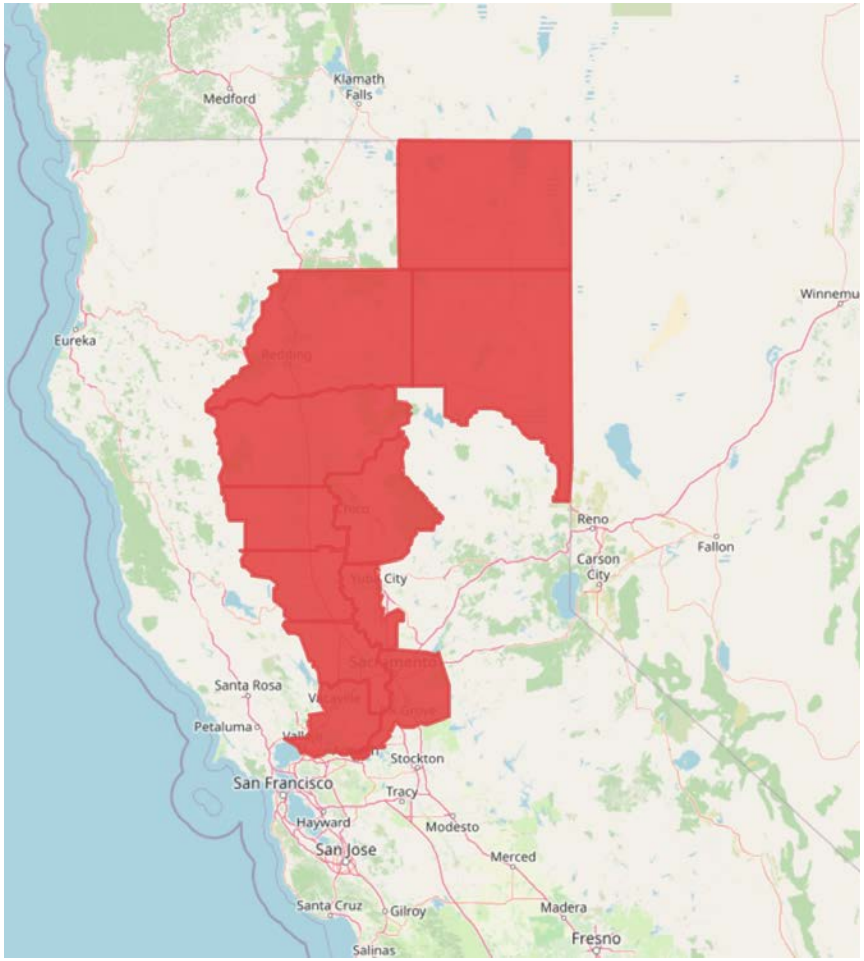


How can we change this query?

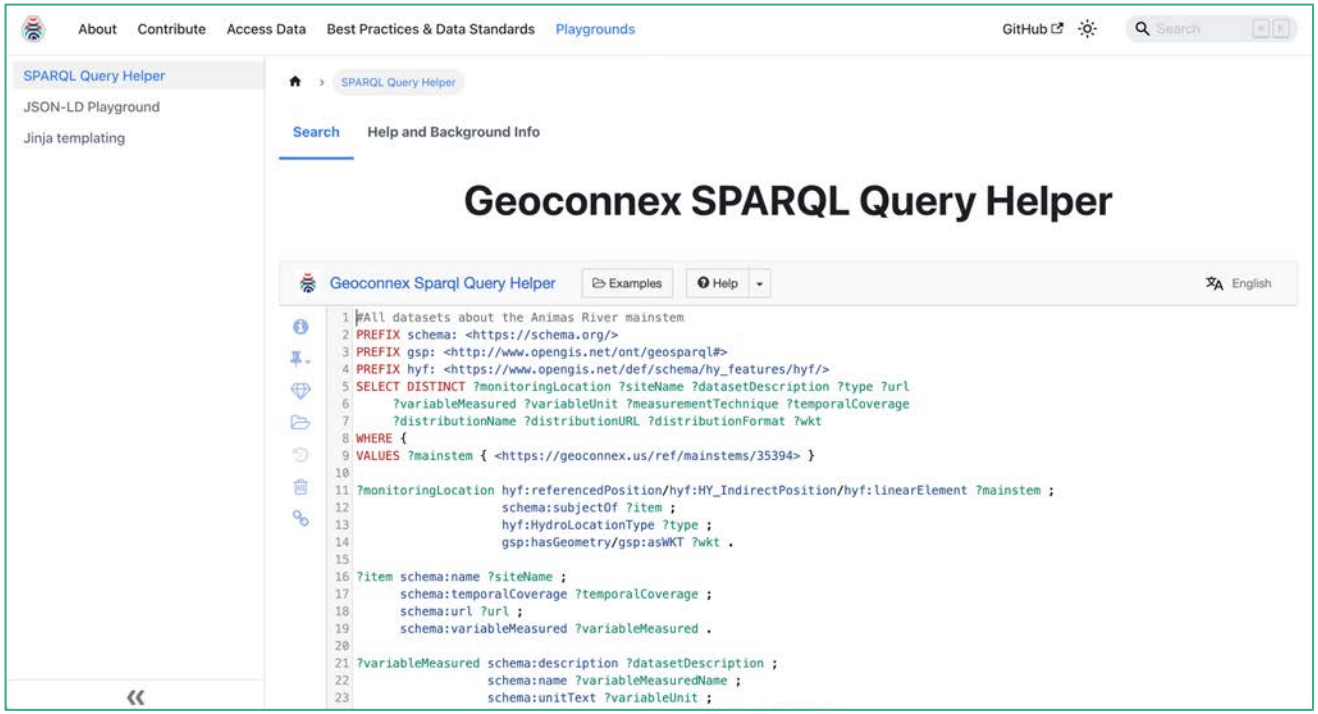
> Show relevant counties

```
PREFIX hyf: <https://www.opengis.net/def/schema/hy_features/hyf/>
PREFIX gsp: <http://www.opengis.net/ont/geosparql#>
PREFIX geof: <http://www.opengis.net/def/function/geosparql/>

SELECT DISTINCT ?feature ?featureWKT
WHERE {
  VALUES ?mainstem { <https://geoconnex.us/ref/mainstems/1> }
  ?mainstem gsp:hasGeometry/gsp:asWKT ?wkt .
  ?feature gsp:hasGeometry/gsp:asWKT ?featureWKT .
  FILTER(geof:sfIntersects(?featureWKT, ?wkt))
  FILTER(STRSTARTS(STR(?feature), "https://geoconnex.us/ref/counties"))
}
```



… and so much more



https://docs.geoconnex.us/playground/sparql

Agenda

- Introduction to CGS
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- **How the Internet of Water Works**
- Internet of Water Services

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Internet of Water Principles

- Commonly accepted data, metadata, and exchange standards should be adopted by water data producers to promote interoperability, efficiency, sharing, equity, and secondary uses of data
- Federated, distributed systems of interoperable public water data generally provide scalability and flexibility to meet the diverse needs of data producers and users.

https://internetofwater.org/internet-of-water-principles/

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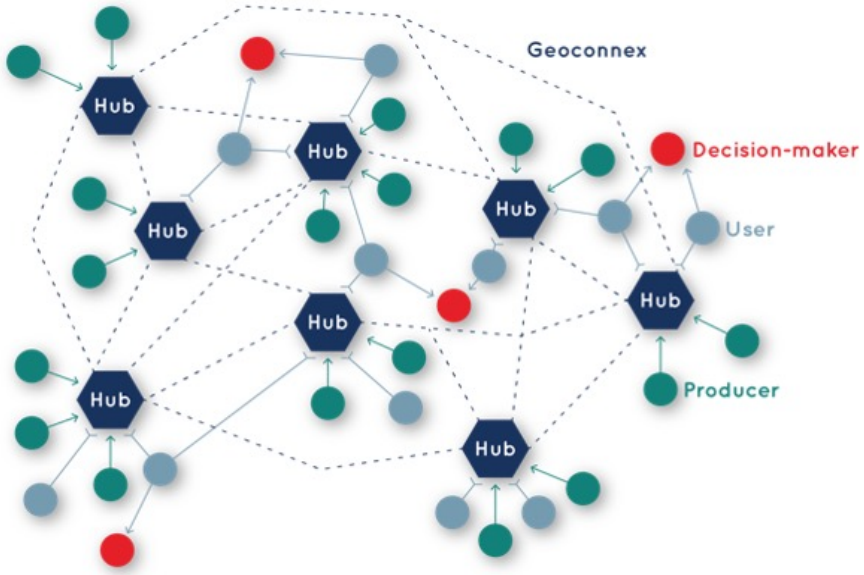
How the Internet of Water Works:

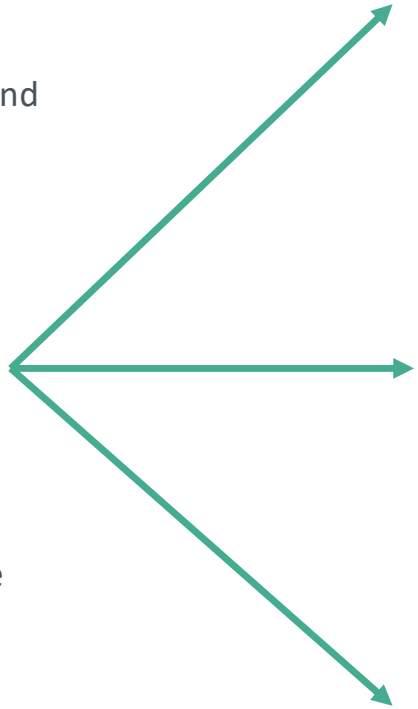
A decentralized community of data sharing practice



- **Producers** collect and QA/QC data
- **Hubs** aggregate and publish **FAIR** data, and ensure they are published on the web using **best practices** and **standards** compatible with **Geoconnex**
- **Geoconnex** links data across hubs
- **Users** discover, access, and integrate data from multiple Hubs, leveraging Geoconnex
- **Decision-makers** leverage tools and analyses built by **Users**

FAIR Principles:

- **Findable** – We know where the data are located and can utilize it
- **Accessible** – Data is downloadable
- **Interoperable** – Data with standards or metadata that allow the data to be used and connected to other data correctly
- **Reusable** – Many users over time can create value from the same data

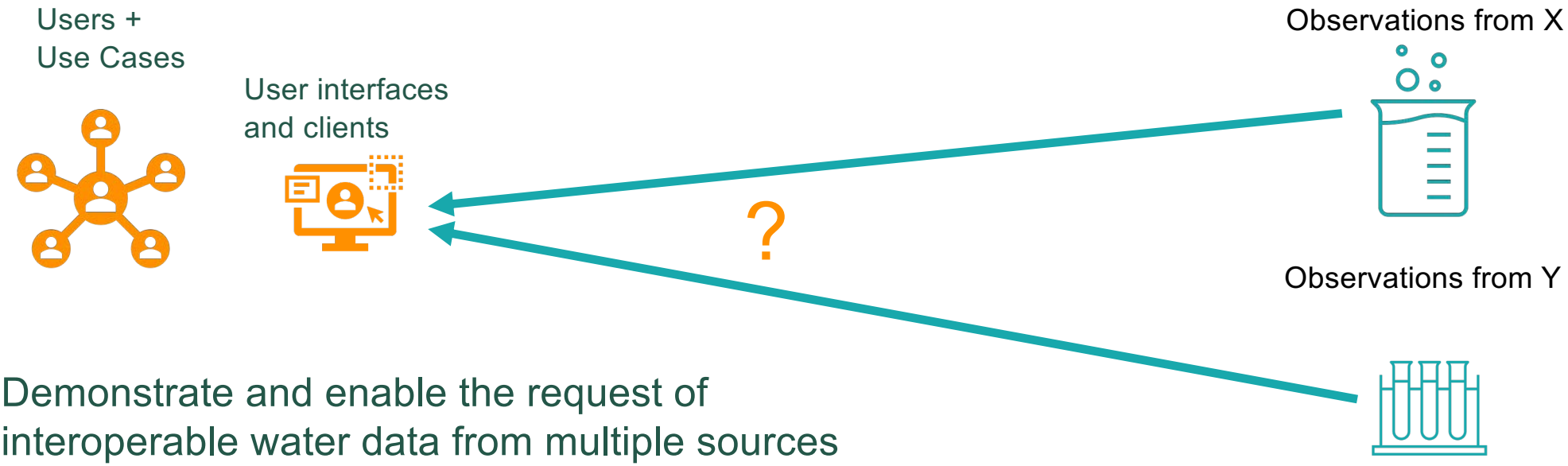


Technical: Can a given computer program open datasets from multiple sources?

Semantic: To the data fields within multiple datasets make sense to be used together? (e.g. “discharge”, “streamflow” “Q”, “flow”)

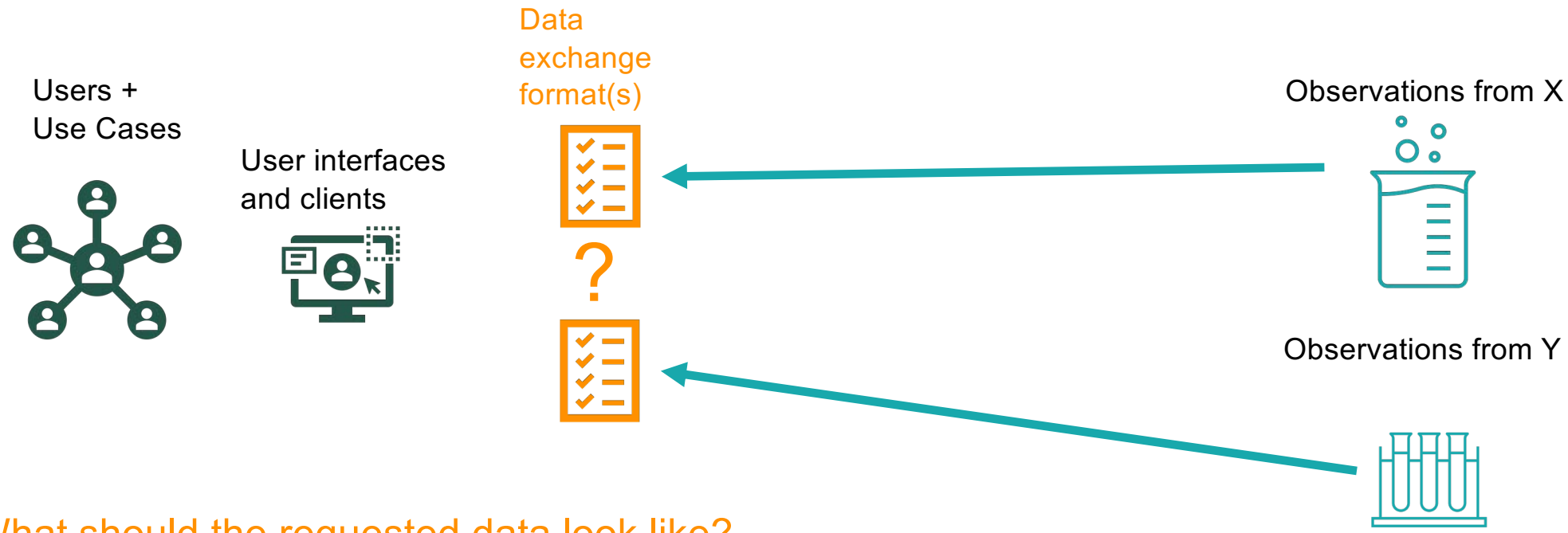
Hydrologic: Are multiple datasets about the same real-world things or related things? (e.g. river, watershed, well, aquifer)

Facets of interoperability: Technical



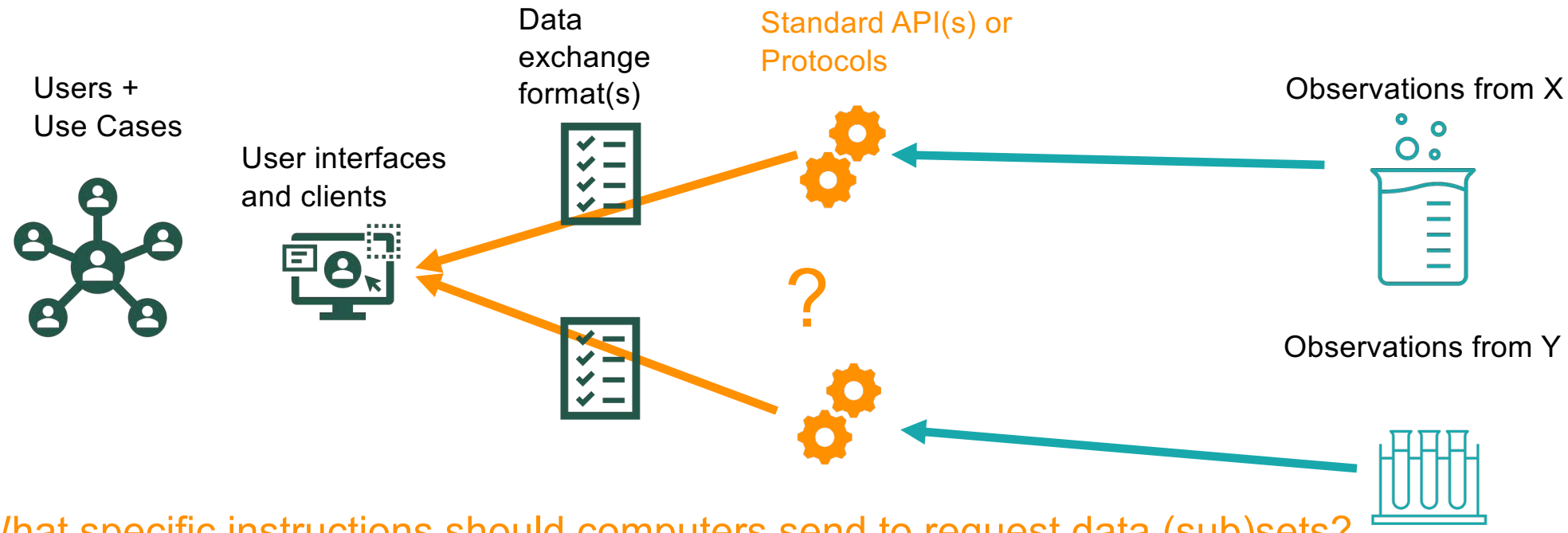
Demonstrate and enable the request of interoperable water data from multiple sources to meet use cases

Facets of interoperability: Technical



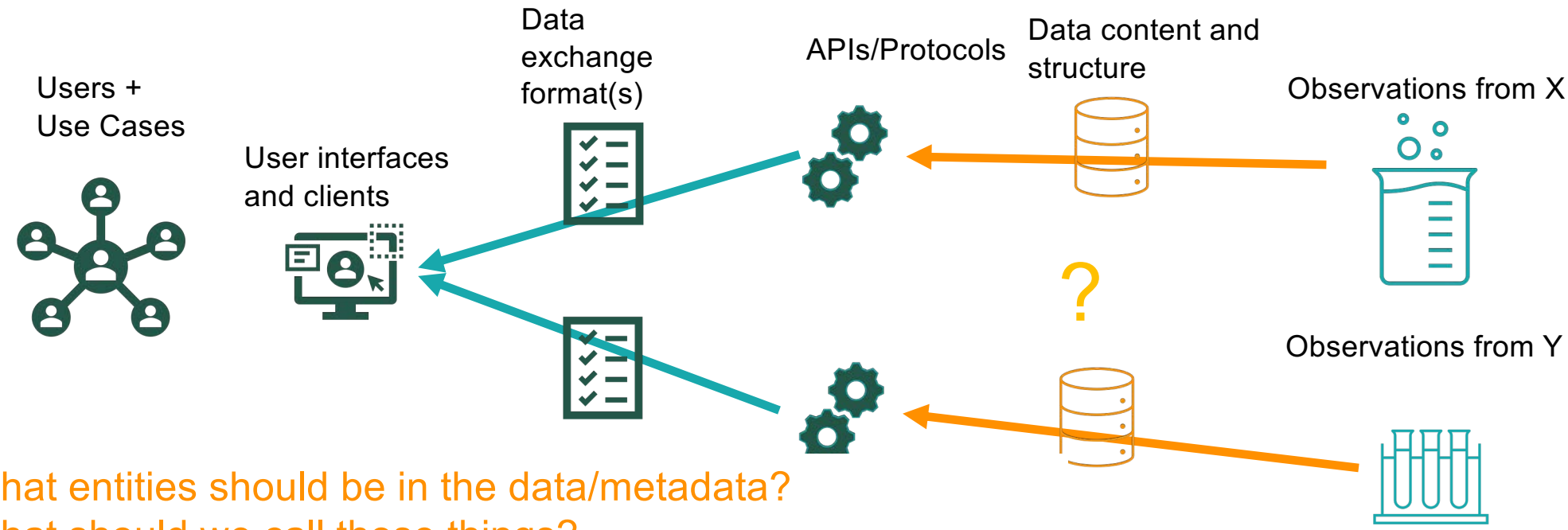
What should the requested data look like?

Facets of interoperability: Technical



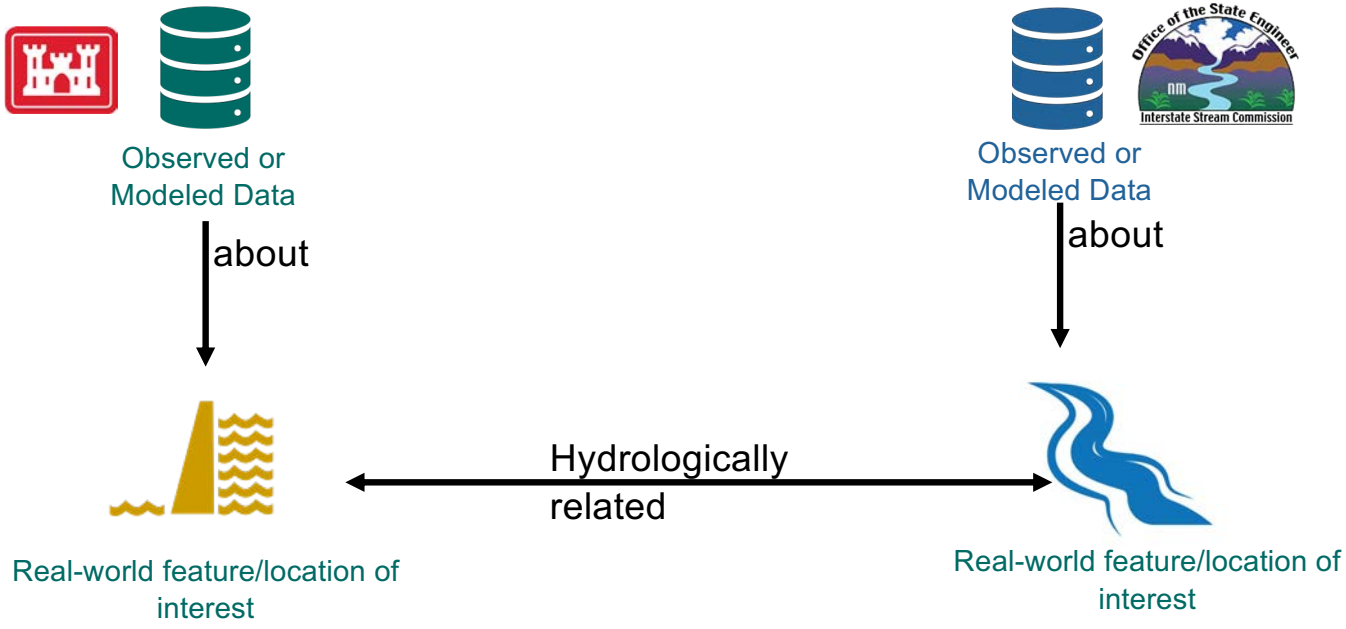
What specific instructions should computers send to request data (sub)sets?
What requests should be possible?

Facets of interoperability: Semantic

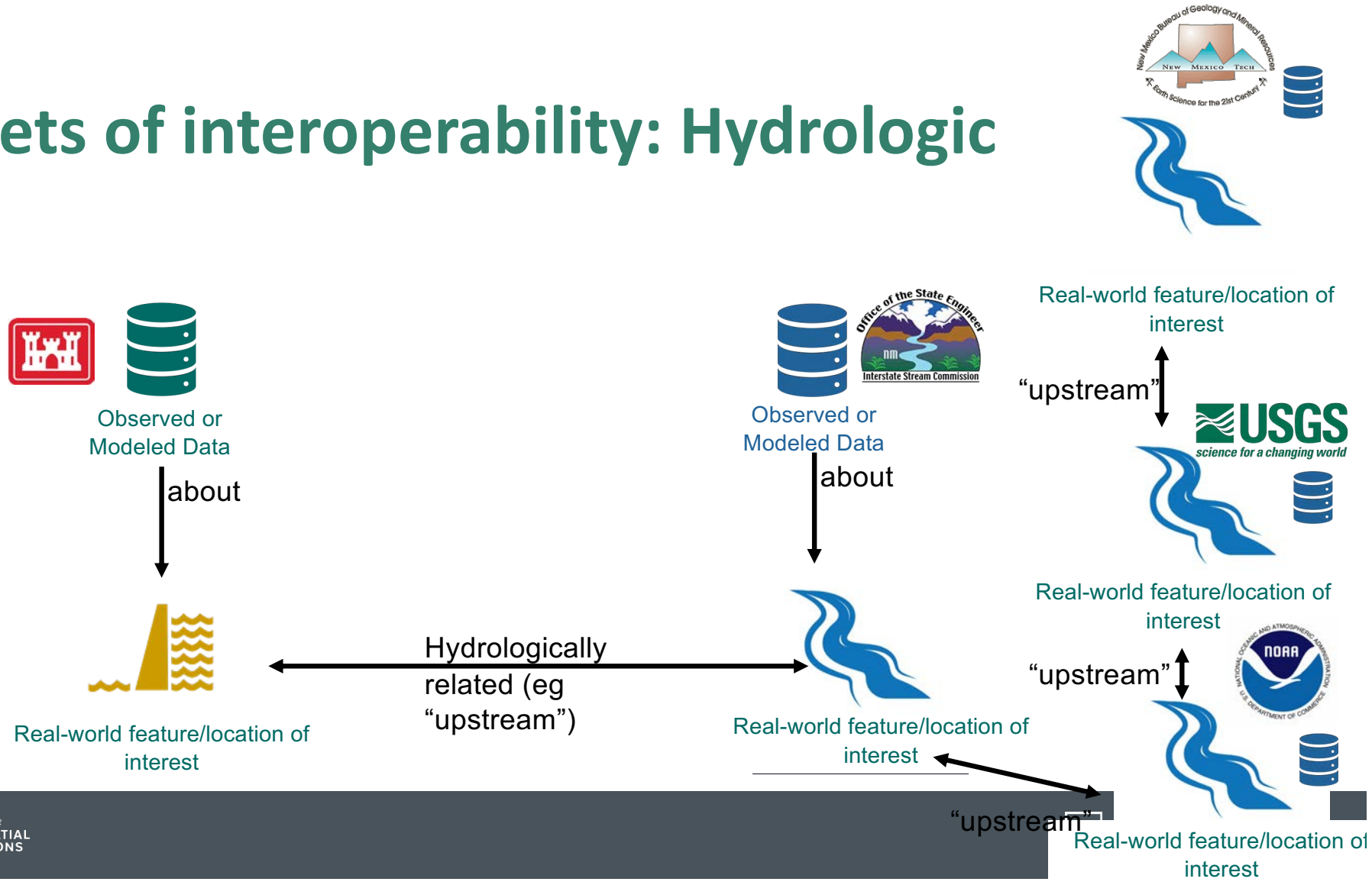


What entities should be in the data/metadata?
What should we call those things?
What standard lists of terms exist that we can use?
What lists of terms should exist?
How can we use different terms that mean the same thing?

Facets of interoperability: Hydrologic



Facets of interoperability: Hydrologic



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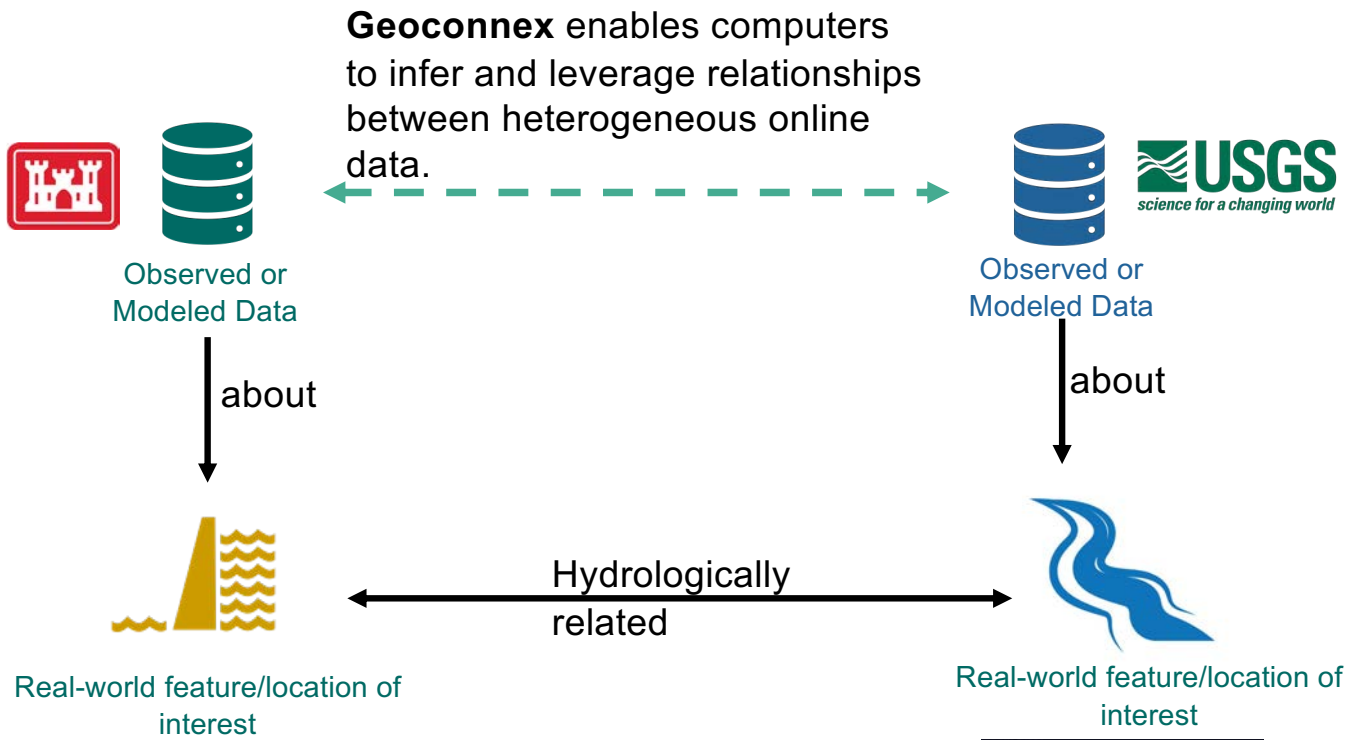
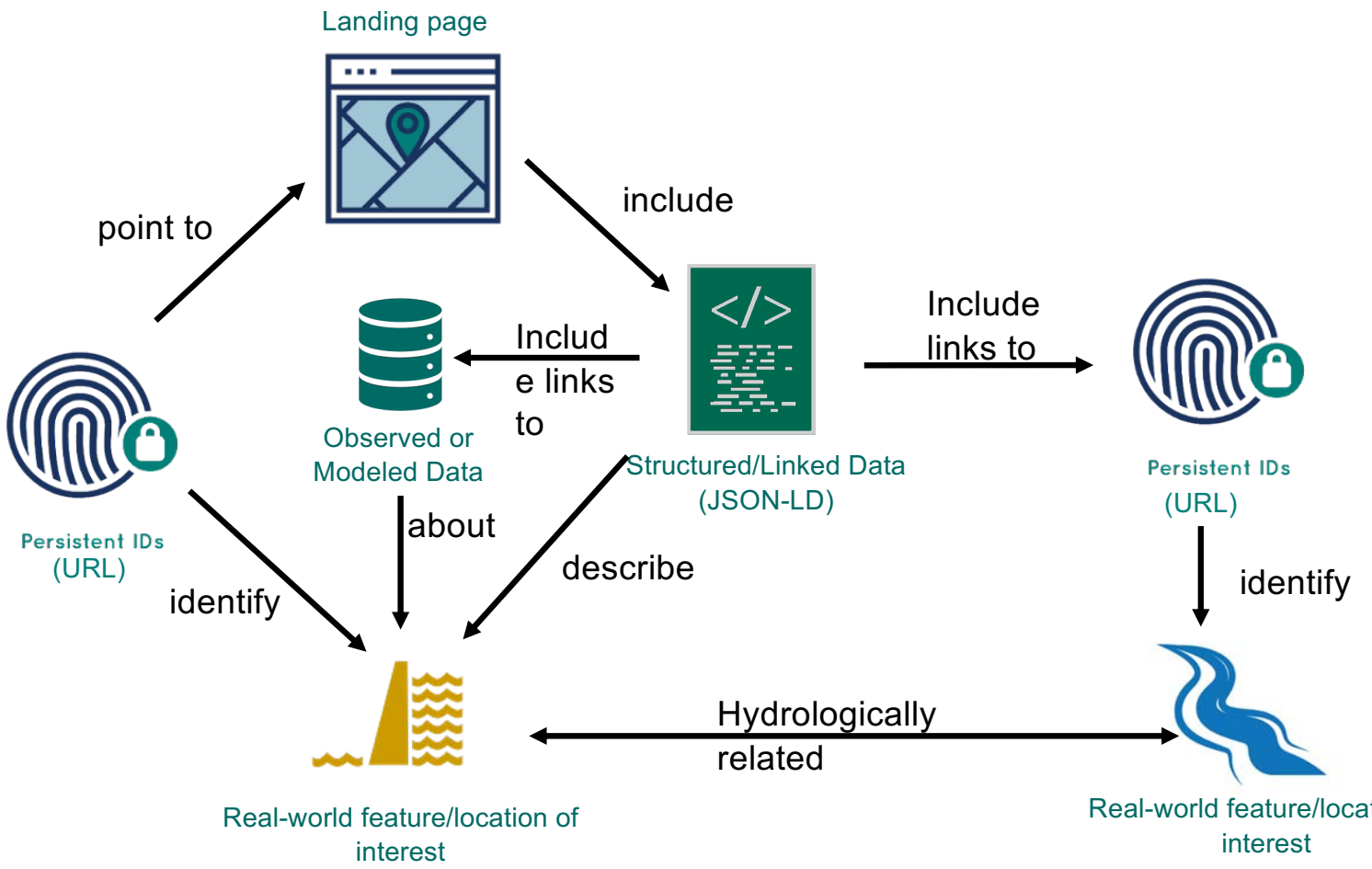
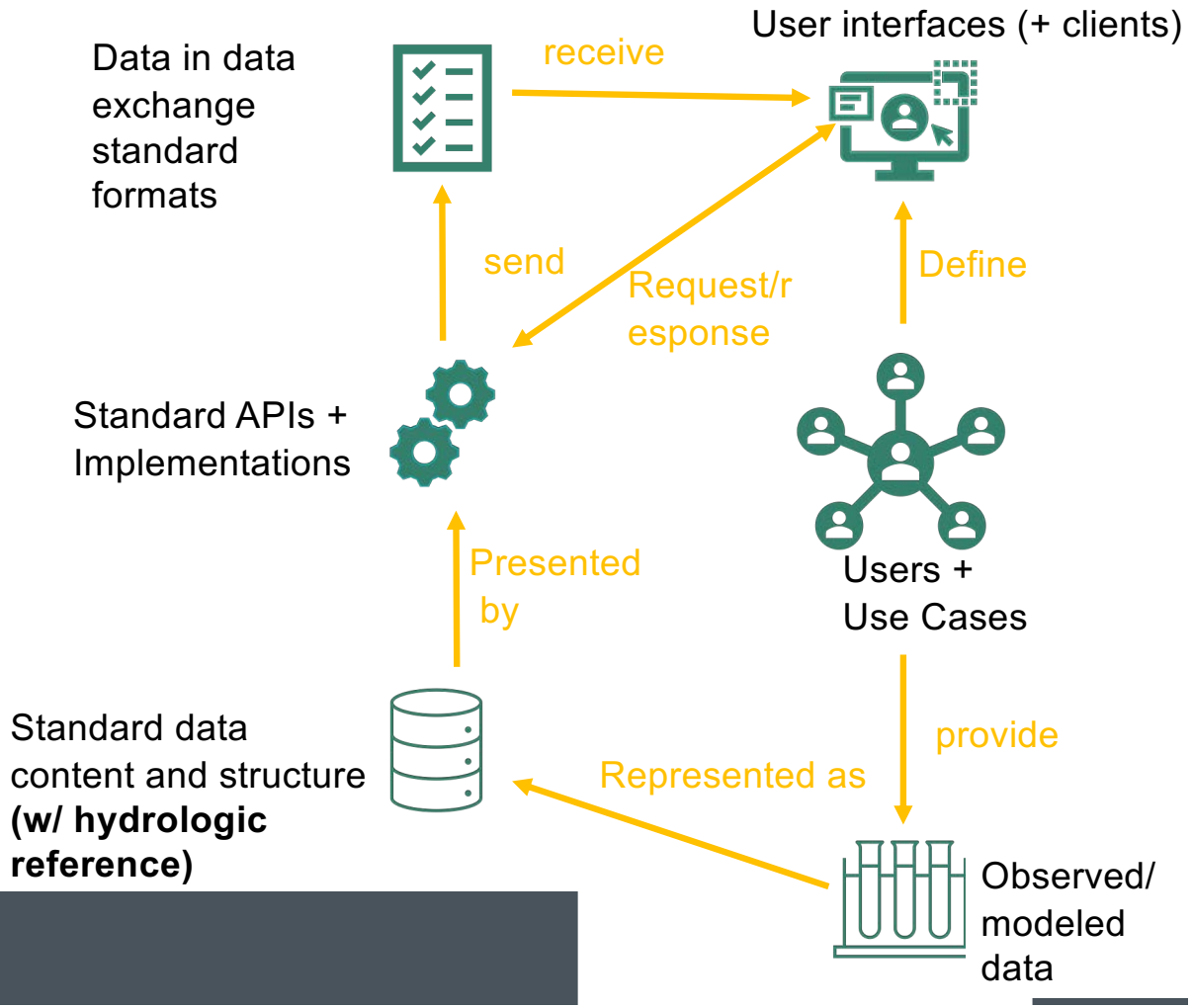


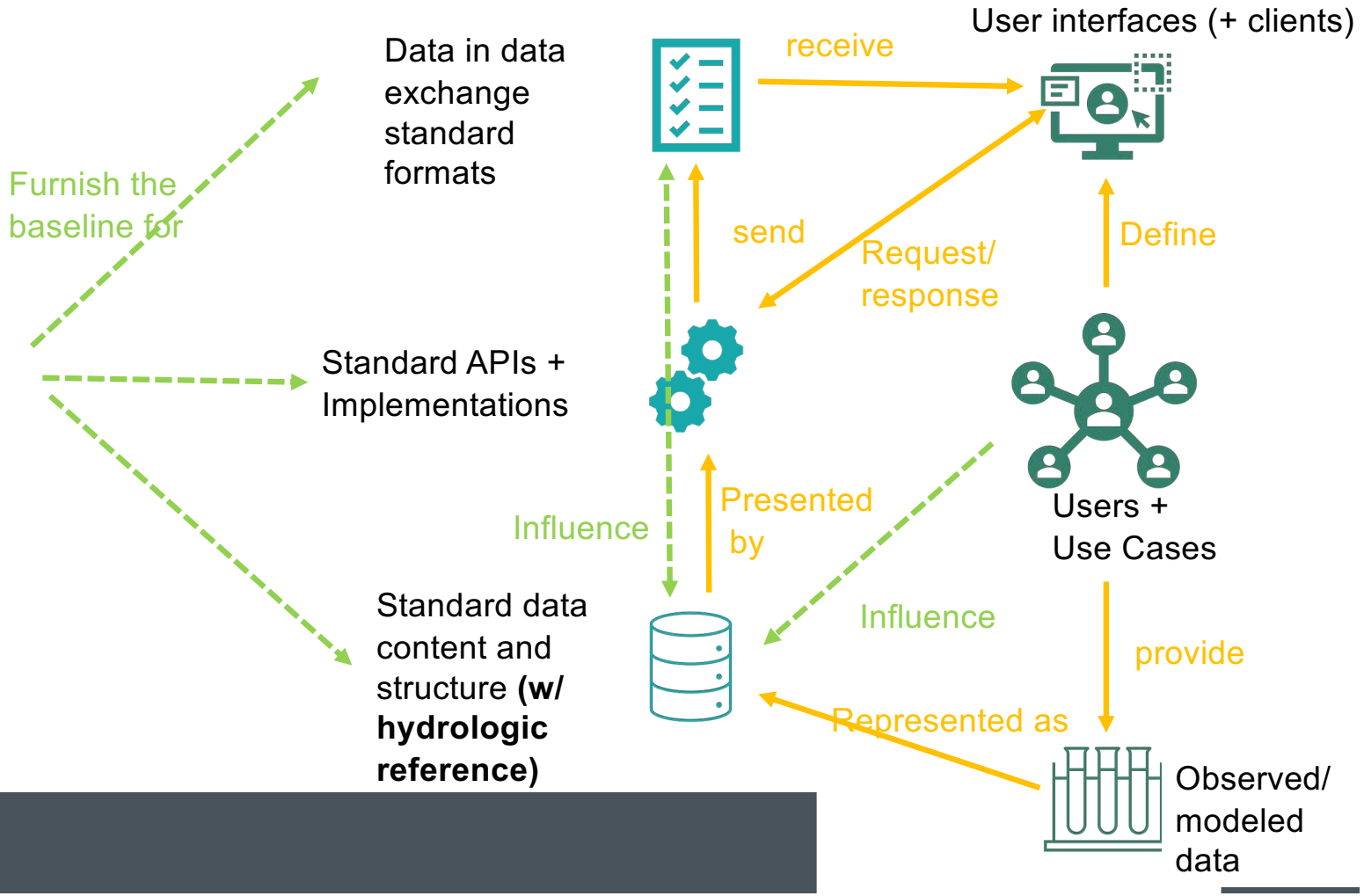

Landing page
point to
include
Includ
e links
to
Include
links to
Observed or
Modeled Data
Structured/Linked Data
(JSON-LD)
Persistent IDs
(URL)
Persistent IDs
(URL)
about
describe
identify
identify
Hydrologically
related
Real-world feature/location of
interest
Real-world feature/location of
interest


Data in data exchange standard formats
receive
User interfaces (+ clients)
send
Request/response
Define
Standard APIs + Implementations
Users + Use Cases
Presented by
provide
Standard data content and structure **(w/ hydrologic reference)**
Represented as
Observed/ modeled data

Geoconnex

Open Geospatial Consortium

W3C®



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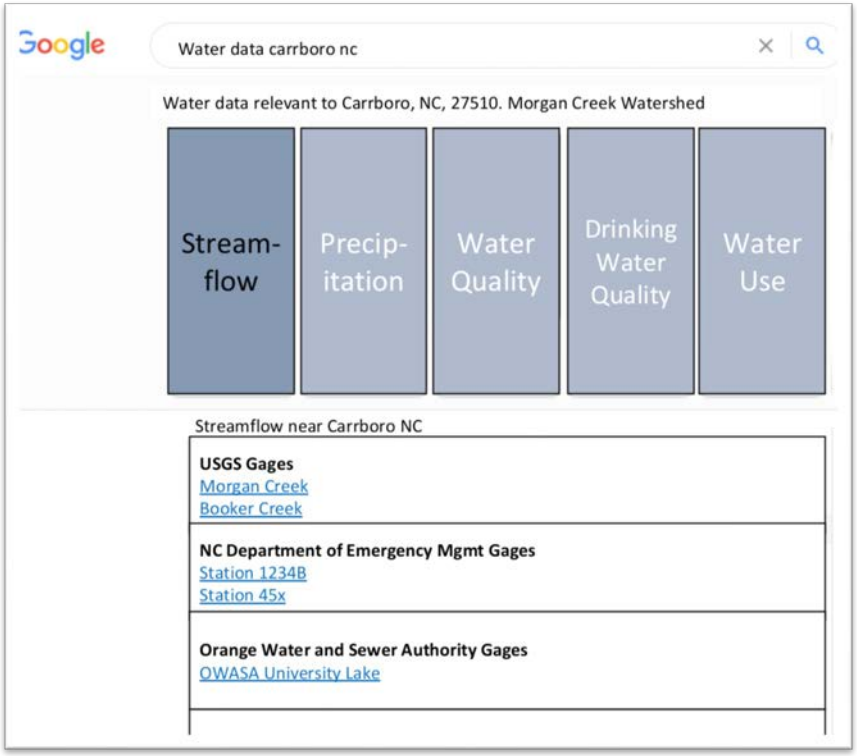

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An **open, centralized knowledge-base** for all index data.

The backbone of the Internet of Water, exposing data with a knowledge graph.

A **suite of software** to equip organizations with modern data infrastructure.

Powered by open-source development, and designed to be adaptable, transparent, and community-driven.

A **documentation center** to provide developers with the technical details of the system.

A detailed guide to implementation, this is the how-to resource.

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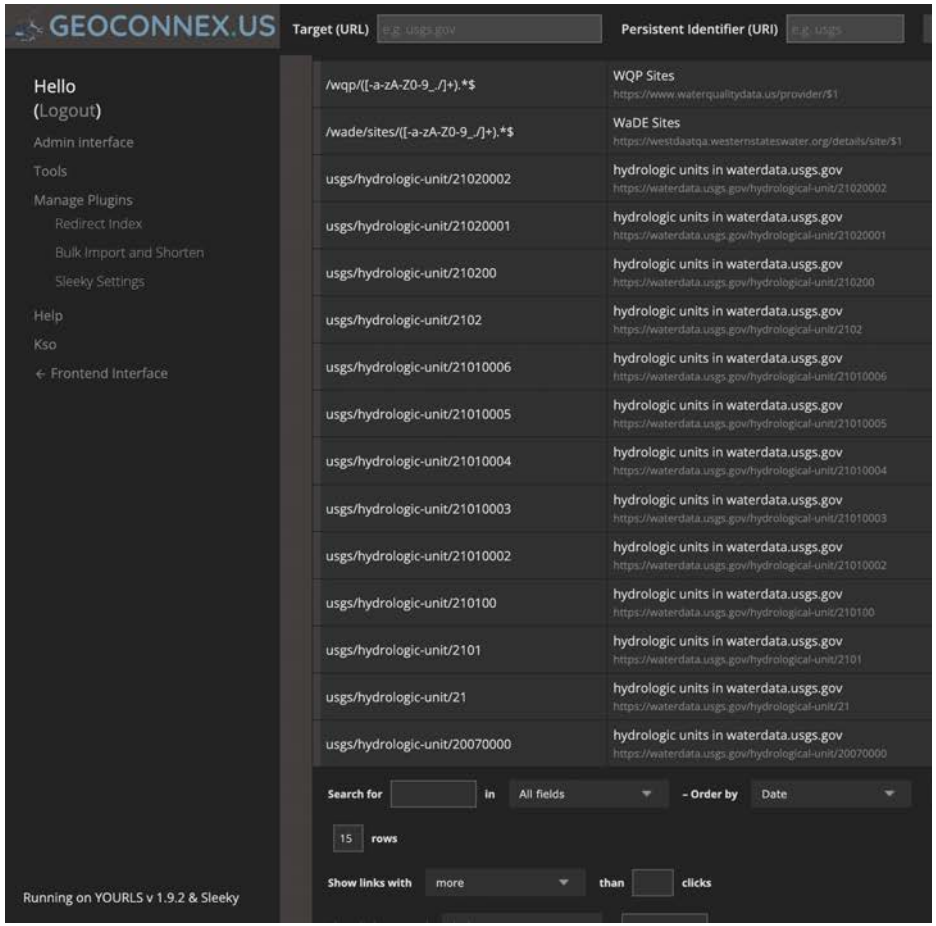
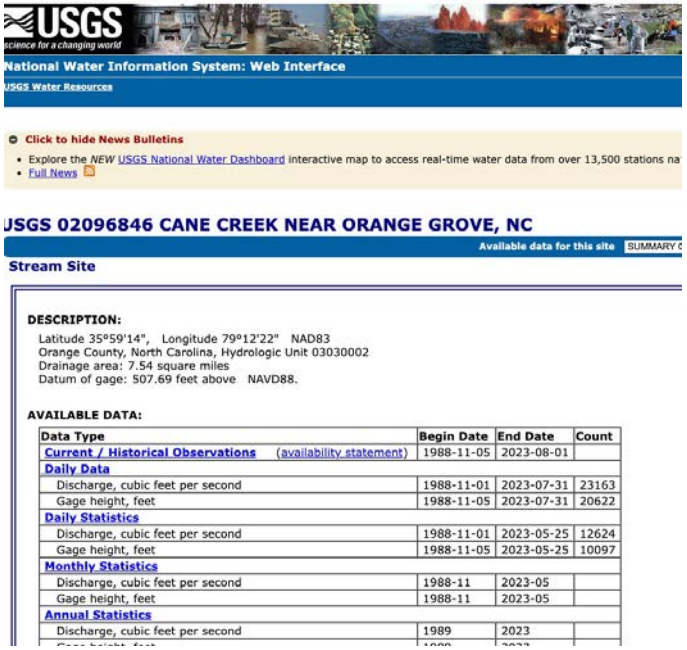
Software: Persistent Identifier Service



https://geoconnex.us/usgs/monitoring-locations/02096846

https://waterdata.usgs.gov/nwis/inventory/?site_no=02096846



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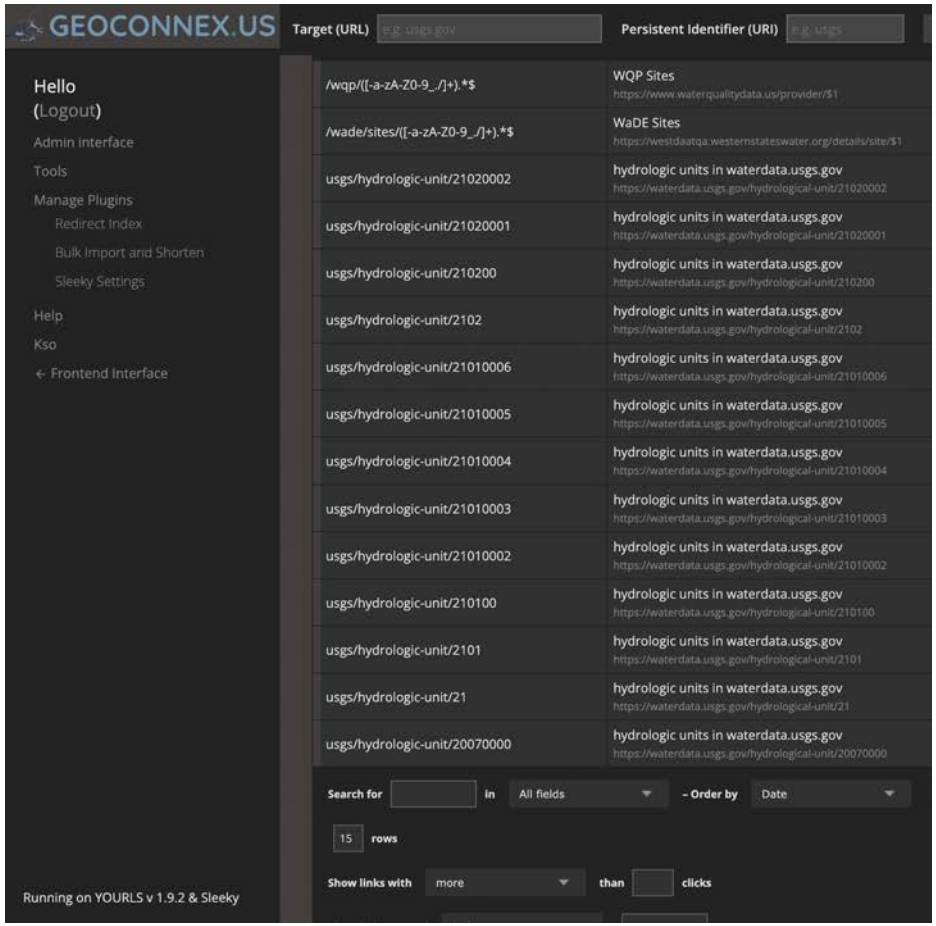

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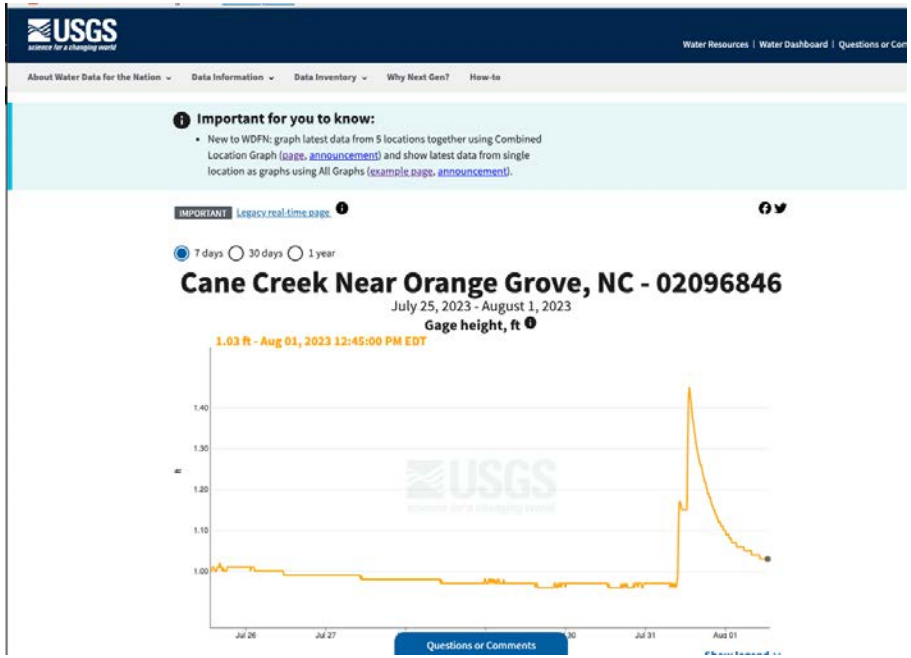
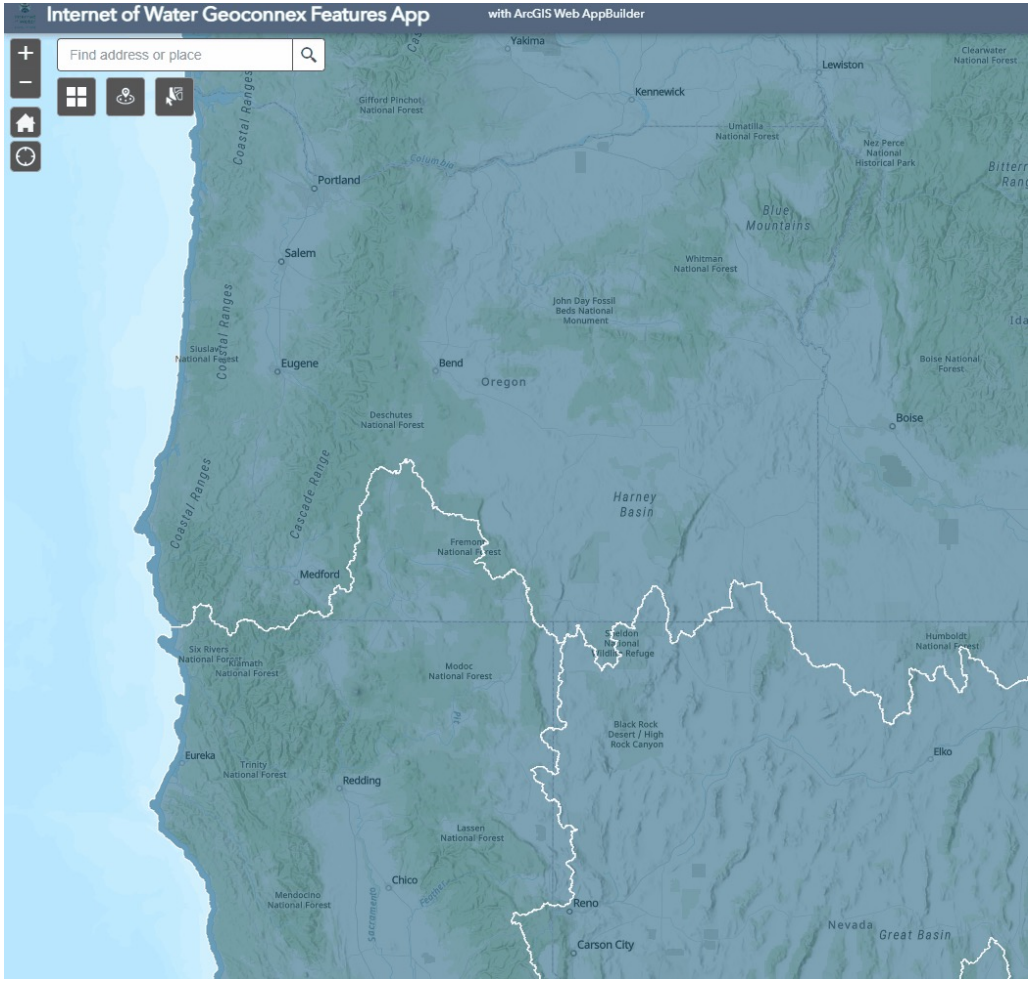


Software Reference Features

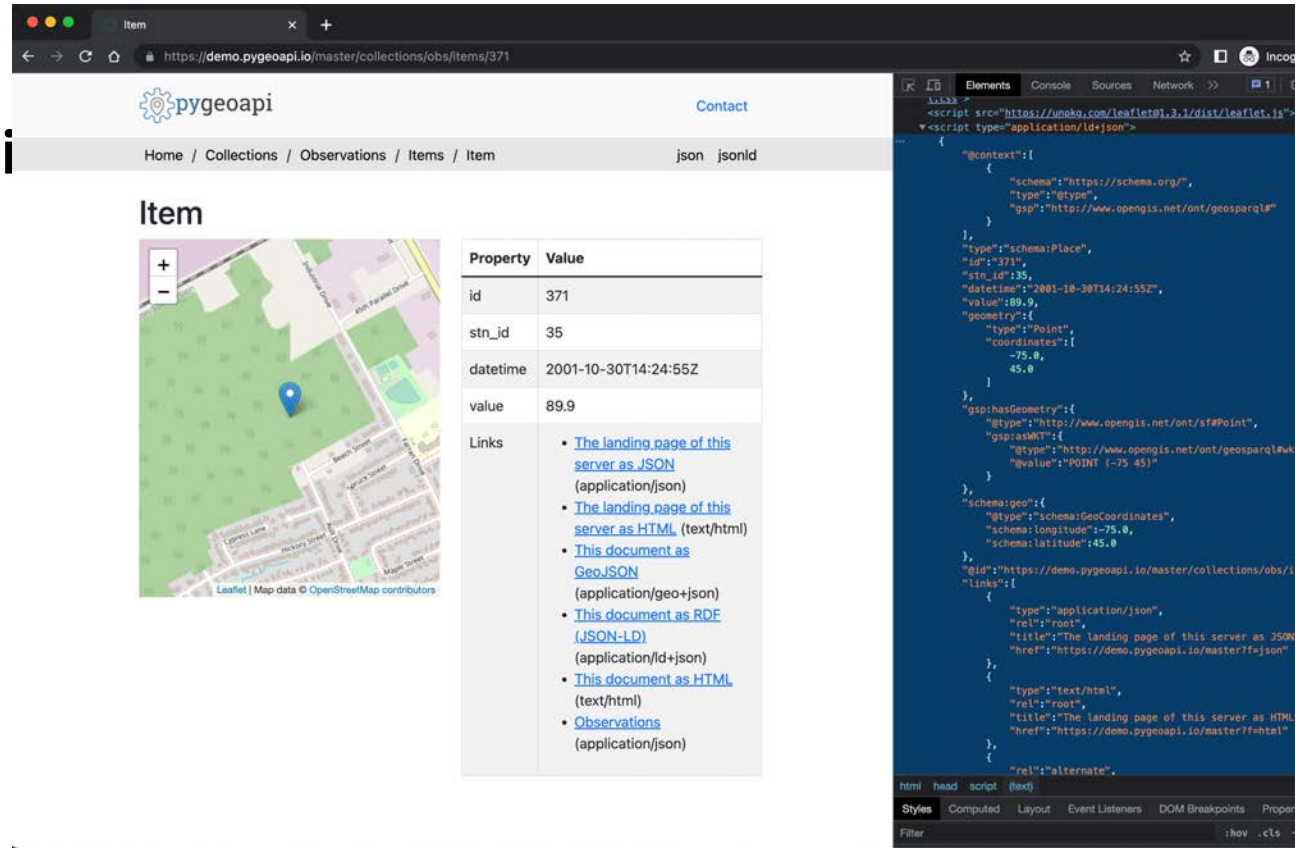
Real-world locations and areas across the United States, including common hydrologic and administrative boundaries.

- ✓ Hydrologic Regions; HUCS 2, 4, 6, 8, & 10
- ✓ Hydrogeologic system features; Principle and Secondary aquifers, Secondary hydrogeologic regions
- ✓ Stream gages
- ✓ Streams (mainstems)
- ✓ States
- ✓ Counties and jurisdictions
- ✓ Native American Lands; American Indian, Alaskan Native, and Hawaiian Home Lands (AIANHH)
- ✓ Census data; Core based statistical areas (CBAS), Urban areas, and Places
- ✓ Public water systems
- ✓ Dams
- ❑ PLSS
- ❑ Congressional Districts
- ❑ Atmospheric Deposition Stations



Software: pygeoapi

Out of the box, pygeoapi supports publishing structured data on a feature level – everything needed to publish structured data in the geoconnex.us ecosystem

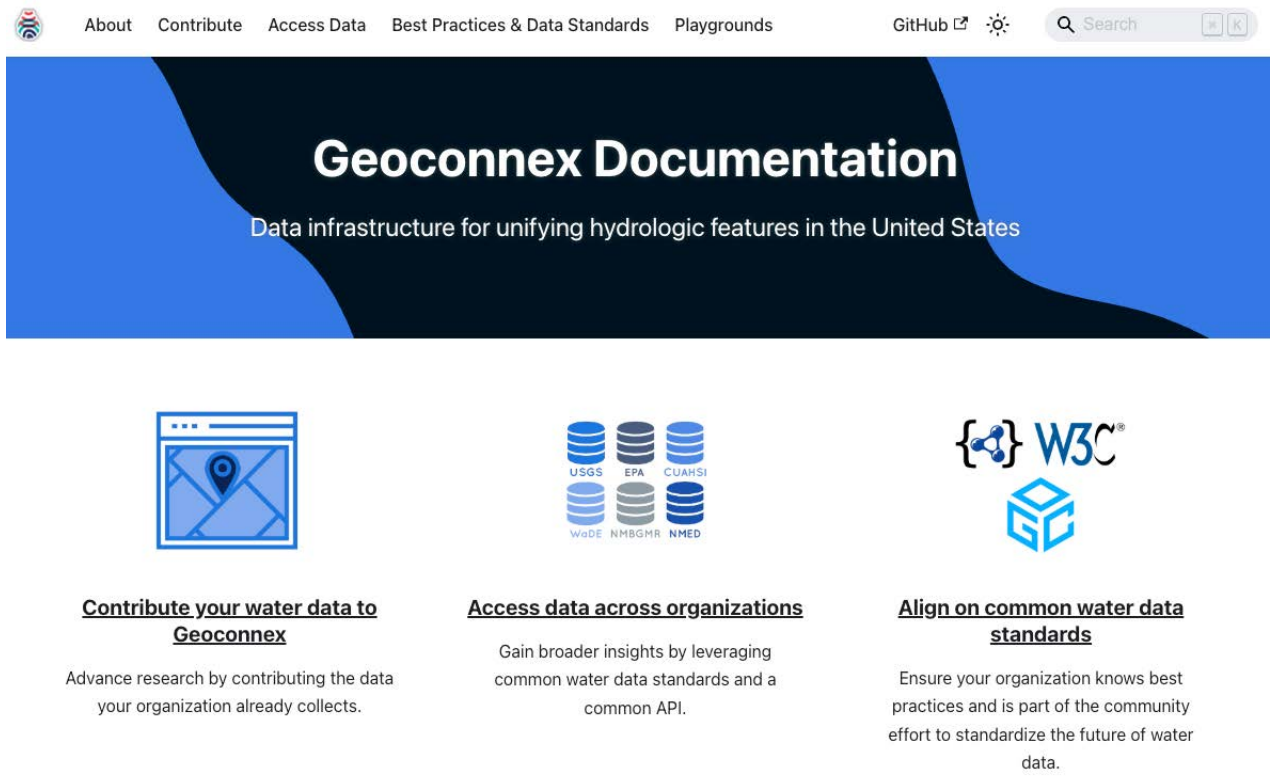


Documentation: https://docs.geoconnex.us

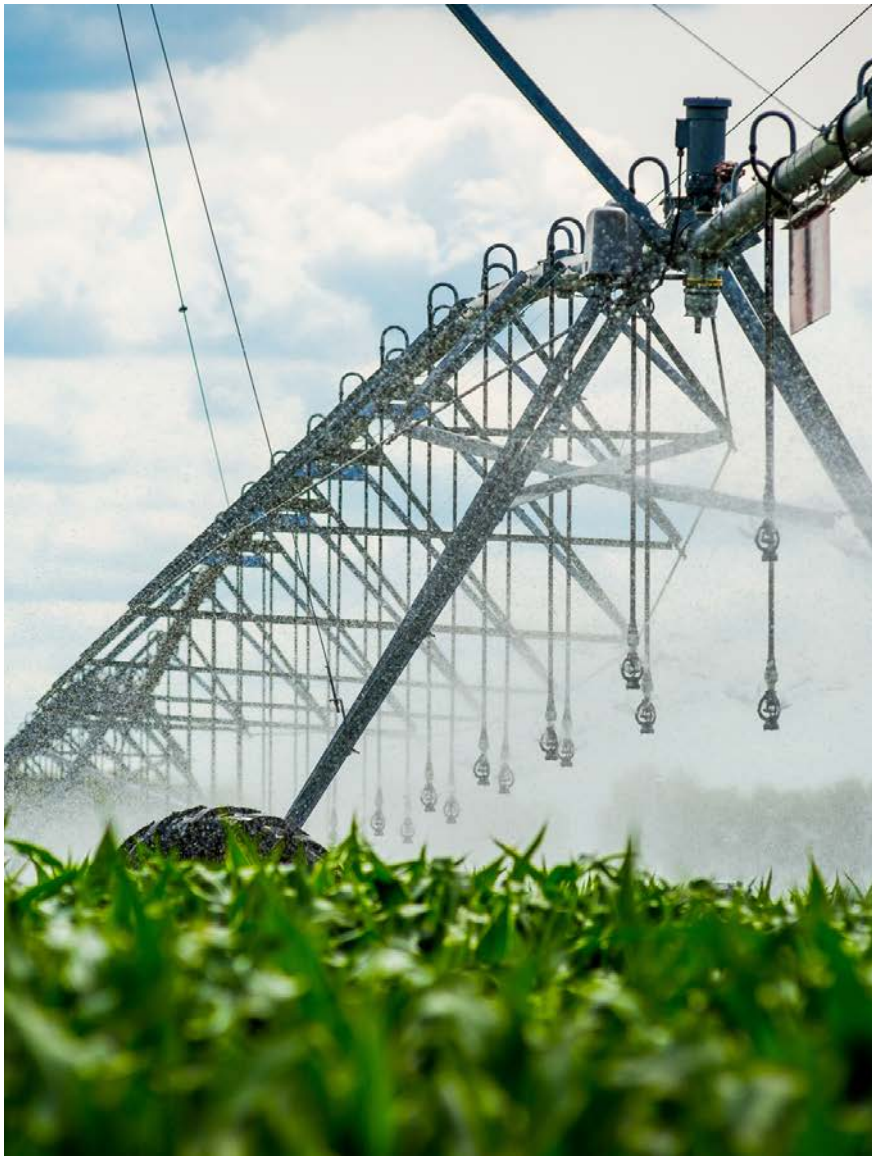
Best Practices

Tutorials for data publication

Tutorials for data access



Building an Internet of Water: Water Data Services

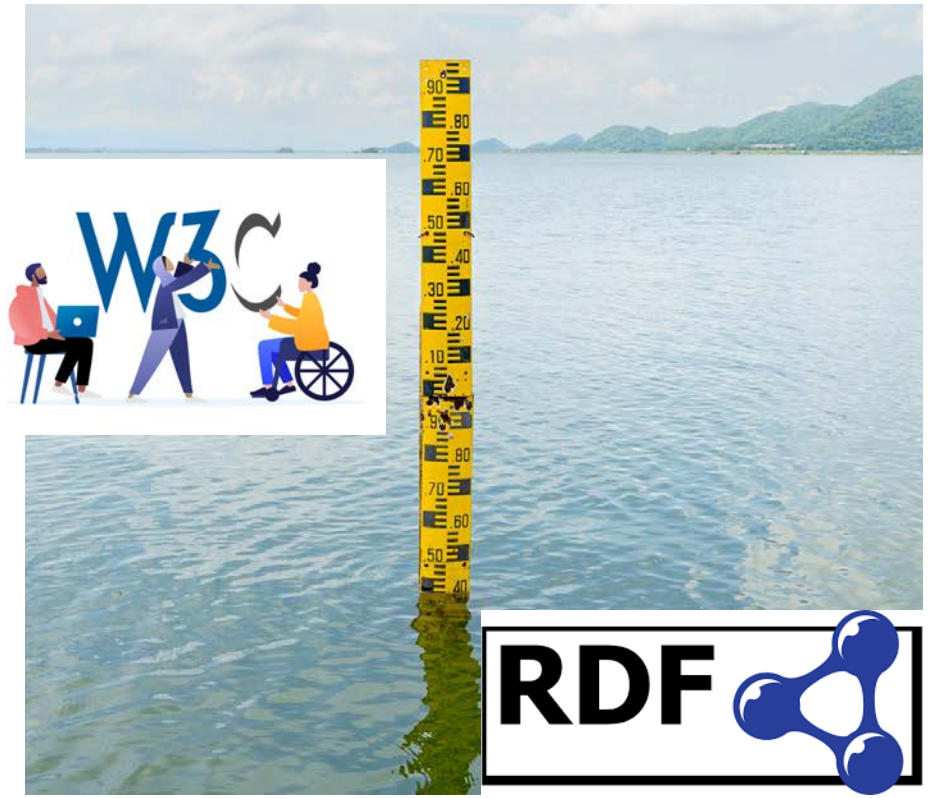


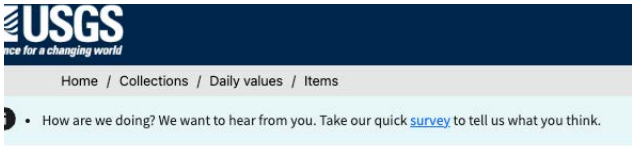
Engagement Services

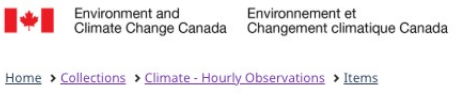
- Stakeholder Engagement
- Human-Centered Design
- Communications and Data Governance

Technical Services

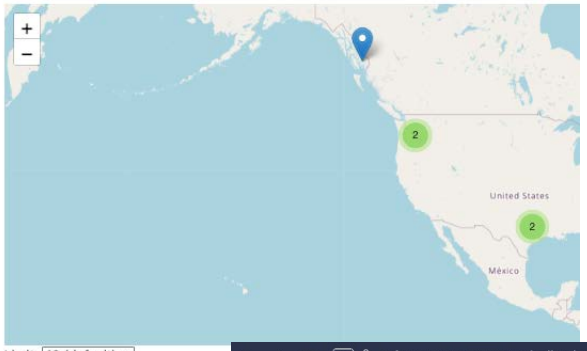
- Data Inventory, Assessment, and Recommendations
- Technical Advisory Services
- Geoconnex and Water Data Standards Implementation







Daily values



Limit: 10 (default)

id	time	unit_of_m
0000000a-...	2020-10-24	ft^3/s
0000000c-...	1949-11-03	ft^3/s

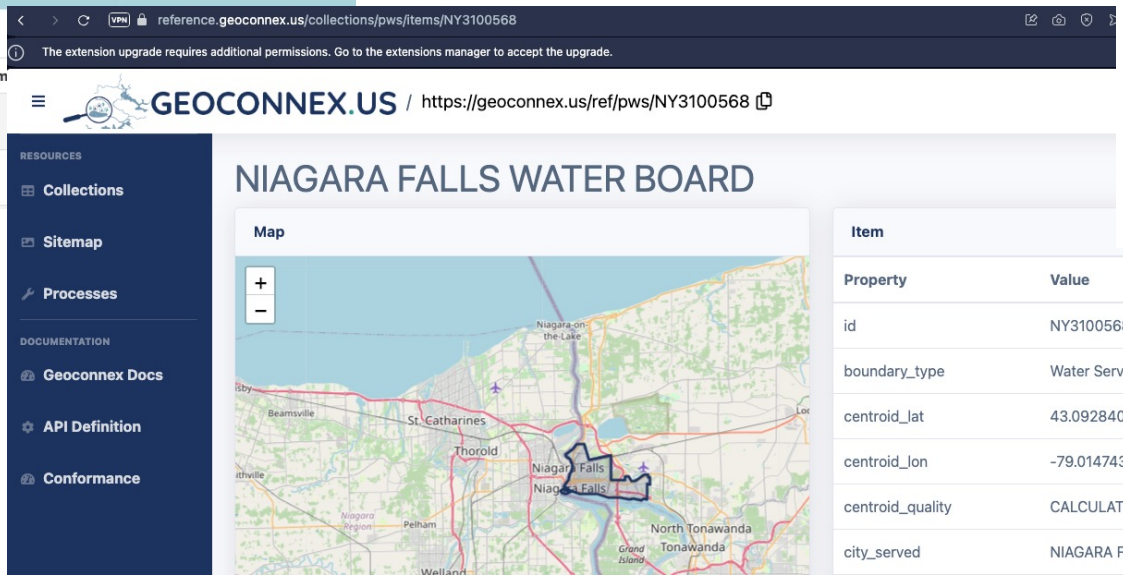
Climate - Hourly Observations

Items in this collection.

Only show items by map view

Filter table content

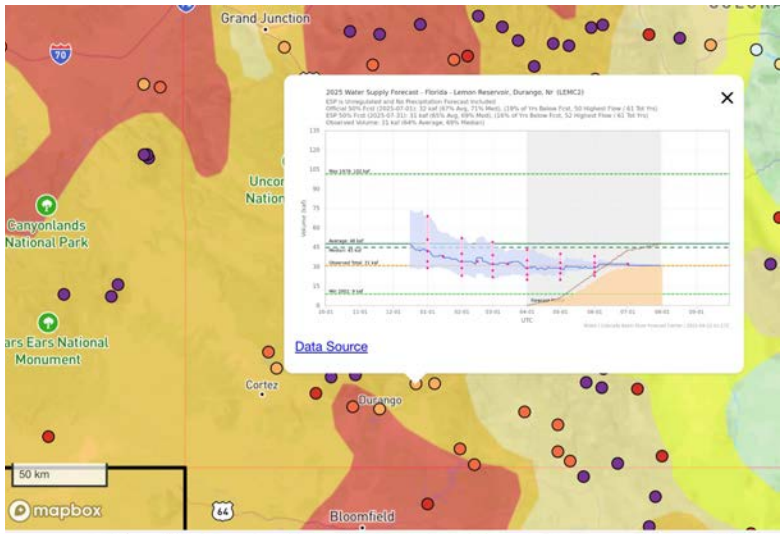
id	STATION_NAME	CLIMATE_IDENTIF...	LOCAL_DATE
	Keyword	Keyword	Keyword
1017101.2024.9.14.19	"SATURNA ISLAND CS"	"1017101"	"2024-09-14 19:00:00"
1017101.2024.9.14.20	"SATURNA ISLAND CS"	"1017101"	"2024-09-14 20:00:00"



Property	Value
id	NY3100568
boundary_type	Water Service Area - as specified in sou
centroid_lat	43.0928407
centroid_lon	-79.0147434
centroid_quality	CALCULATED FROM GEOMETRY
city_served	NIAGARA FALLS

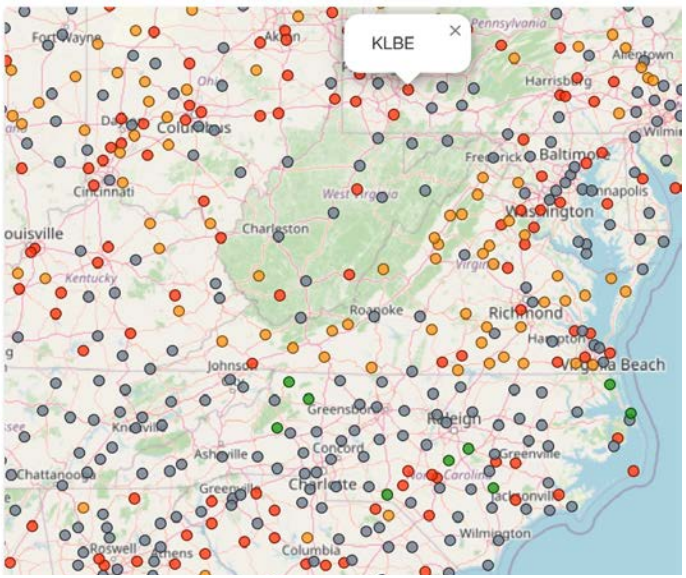
Technical Services

- Data Hub and Dashboard Development
- Use Case-Based Tools and Applications
- Data Transfer Services



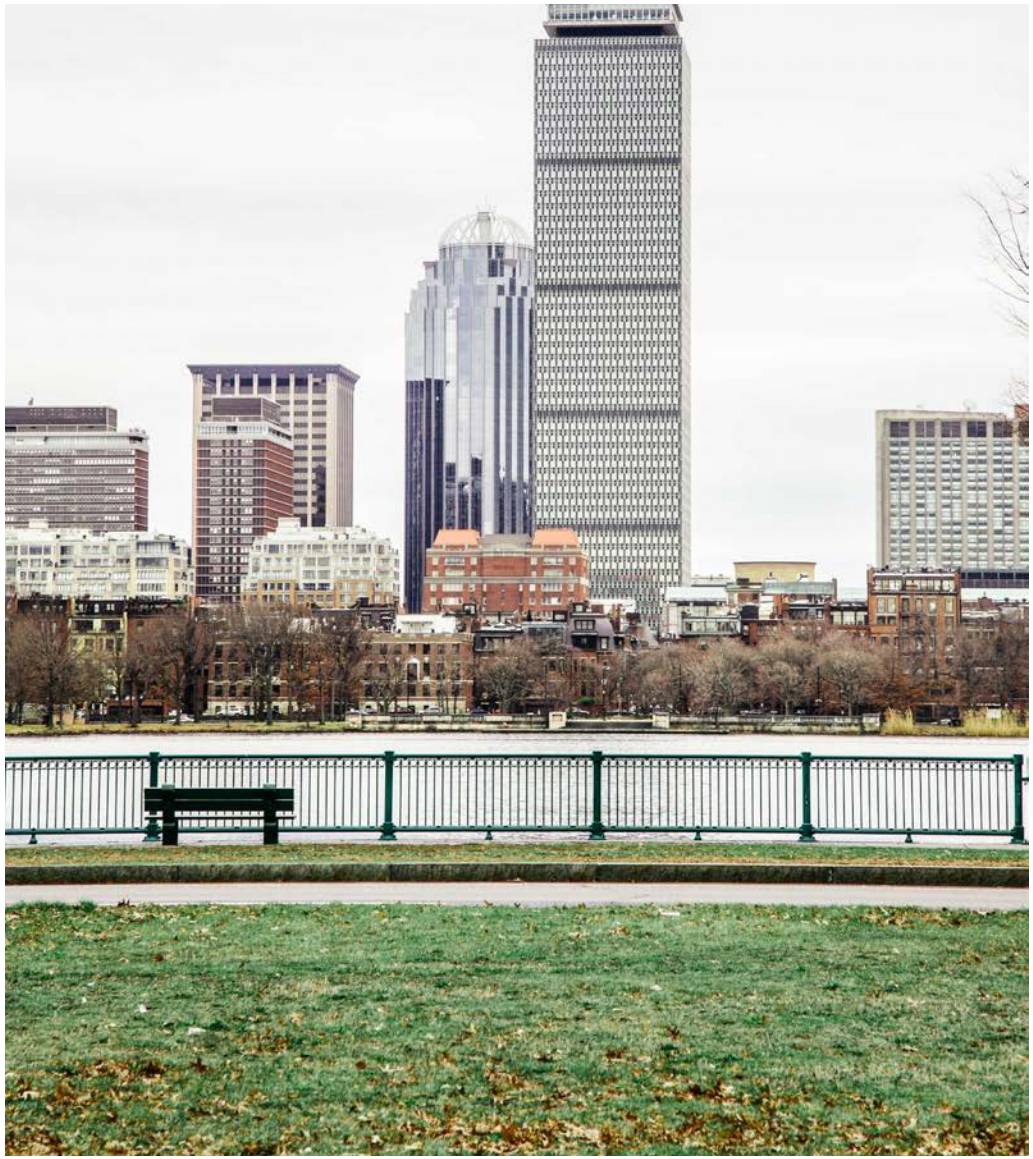
KLBE DATA

LATEST VALUES	HISTORY
from 2025-09-22T23:47:00Z	
Non coordinate pressure	972.3 hPa
Pressure reduced to mean sea level	1014 hPa
Air temperature	23 Celsius
Dewpoint temperature	17.99 Celsius
Relative humidity	74 %
Wind direction (2 min)	310 deg
Wind speed (2 min)	7.7 m/s



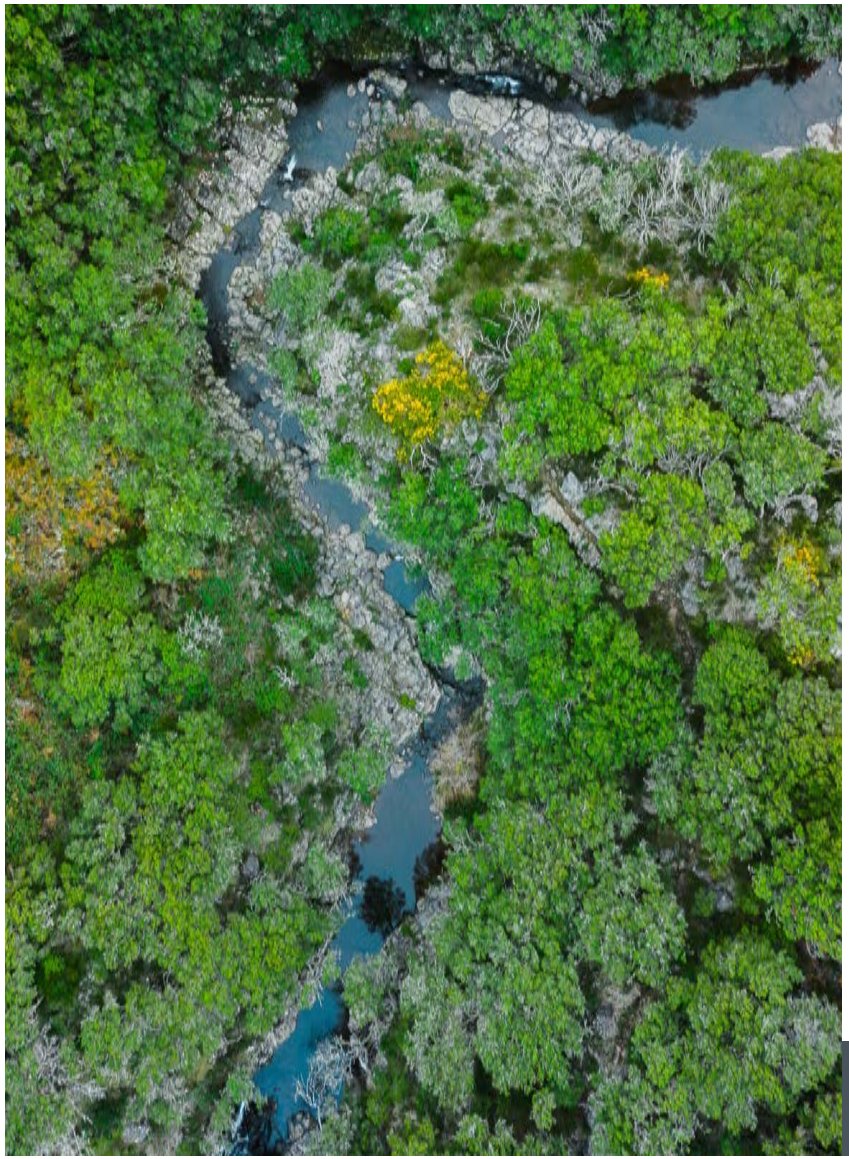
Use Cases

- Water rights shepharding
- Water quantity/quality modeling
- Facility siting
- Land use planning



Growing A Community of Practice

The **IoW Coalition** connects and mobilizes people and organizations passionate about water data and improving water data management through a variety of engagement channels.



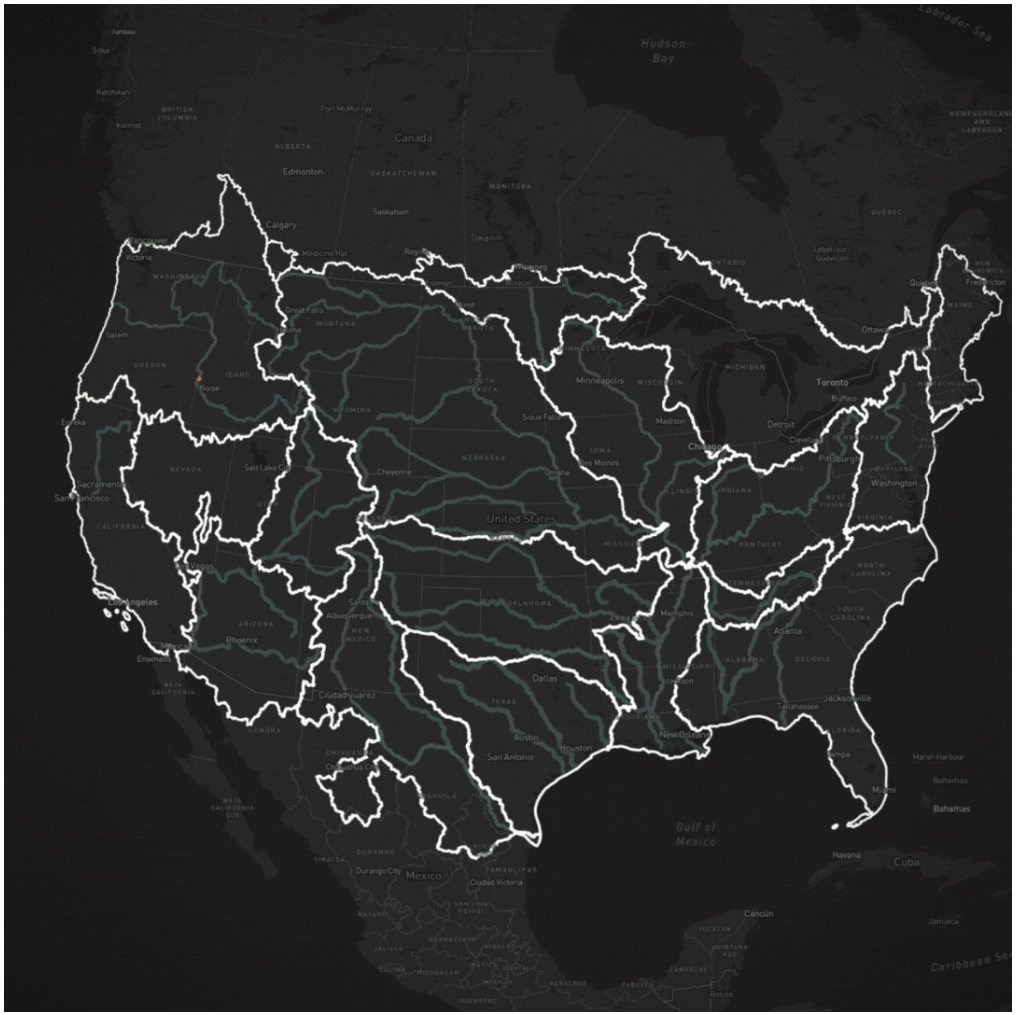
IoW Coalition Sub-Groups

- **Advisory Group** – A group of organizations that work with CGS to identify data challenges that the Service Center can facilitate and provide feedback to the IoW Working Groups
- **Working Groups** – IoW Coalition-based groups that address a specific water data challenge or audience
- **IoW Network** – Individuals that engage with IoW Coalition content

Questions?

Geoconnex.us docs [WIP]: https://docs.geoconnex.us

Internet Of Water History & Principles:
https://geoconnex.us/iow/principles



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