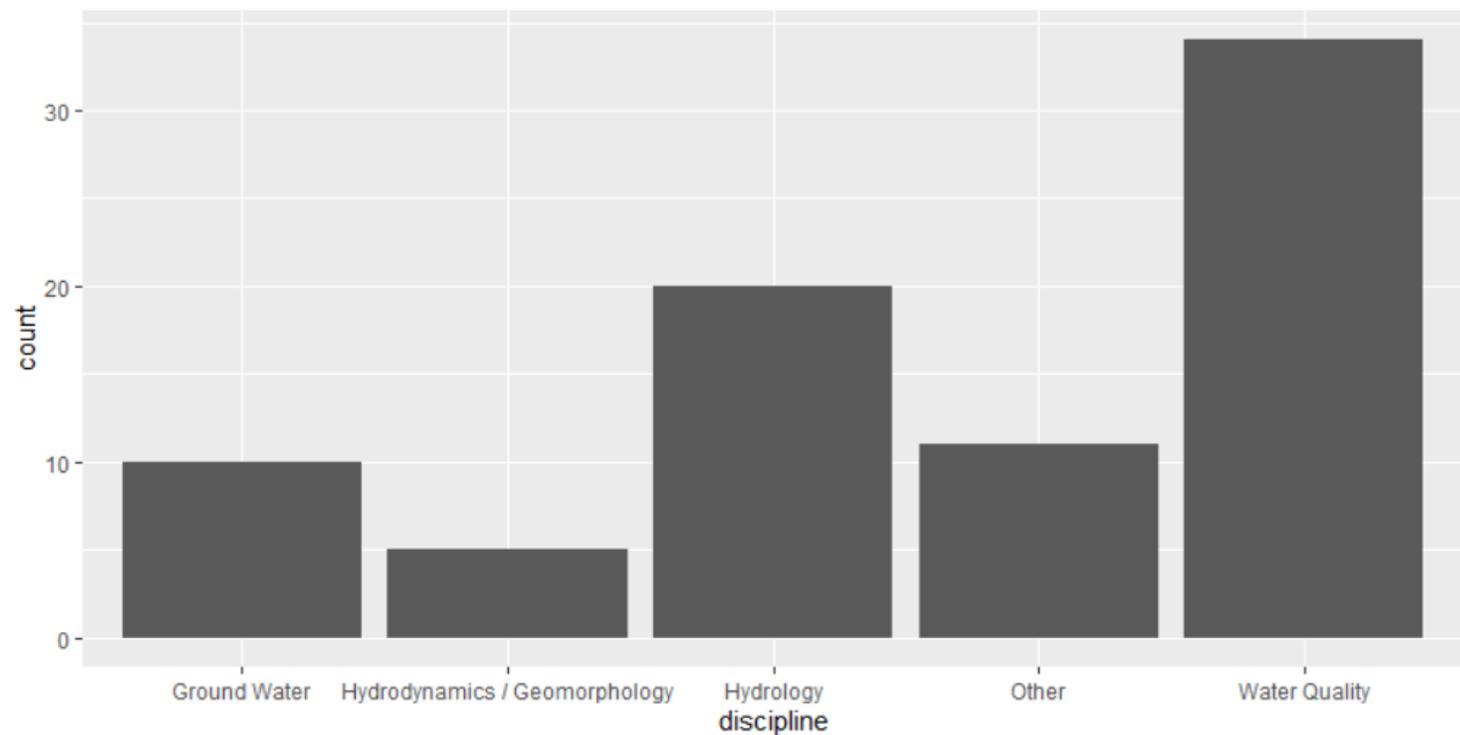
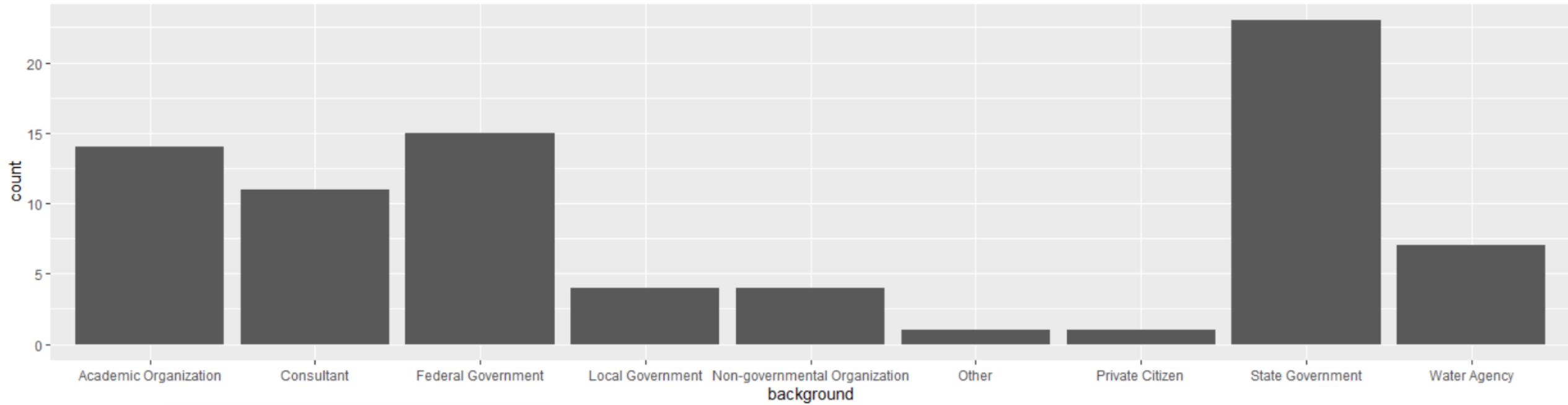




Linking Data to the Hydrographic Network

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state
web
software
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nhd
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working
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Beyond machine learning

- “As valuable as machine learning solutions are proving to be, they are going after the relatively low-hanging fruit. It is far from clear that this correlation-based approach is sufficient for a broader range of problems and a different paradigm is likely to be required.”
- Daly 2018 (https://aibusiness.com/document.asp?doc_id=760596&site=aibusiness)
- USGS FAIR workshop held September 2019; report aimed for release October 2020 (critical aspects of FAIR require semantics)

Slide Credit: Ken Bagstedt

<https://www.usgs.gov/staff-profiles/kenneth-j-bagstad>

AI for science (beyond ML)

Gil et al. 2019. Intelligent systems for geosciences: An essential research agenda. Comm. ACM 62:76-84.

Knowledge Maps

(Semantics)

- Representing scientific data and metadata
- Capturing scientific processes, hypotheses, and theories
- Interoperation of diverse types of scientific knowledge
- Automated extraction of scientific knowledge

(Robotics & sensing) Model-Driven Sensing

- Self-guided platforms for extreme environments
- Optimizing data collection based on modeling needs
- Adaptive sampling and automated detection of interesting events
- Crowdsourcing data collection for costly observations

(Information integration) Trusted Information Threads

- Integrating data from many individual investigators
- Threading data with models, workflows, software, papers
- Automated data analysis and scientific discovery
- Tracking provenance and assessing trust
- Integrating data from the literature

(Machine learning + process modeling) Theory-Guided Learning

- Geoscience knowledge incorporated into machine learning algorithms
- Combining machine learning with simulation
- Modeling extreme events
- Causal discovery/inference
- Interpretive models

(Intelligent user interaction) Integrative Workspaces

- Interactive exploration of data, models, and context
- Automated generation of targeted visualizations

Sensing in Remote Inhospitable Locations



From Local to Regional to Global



High-Dimensional Multi-Scale Data

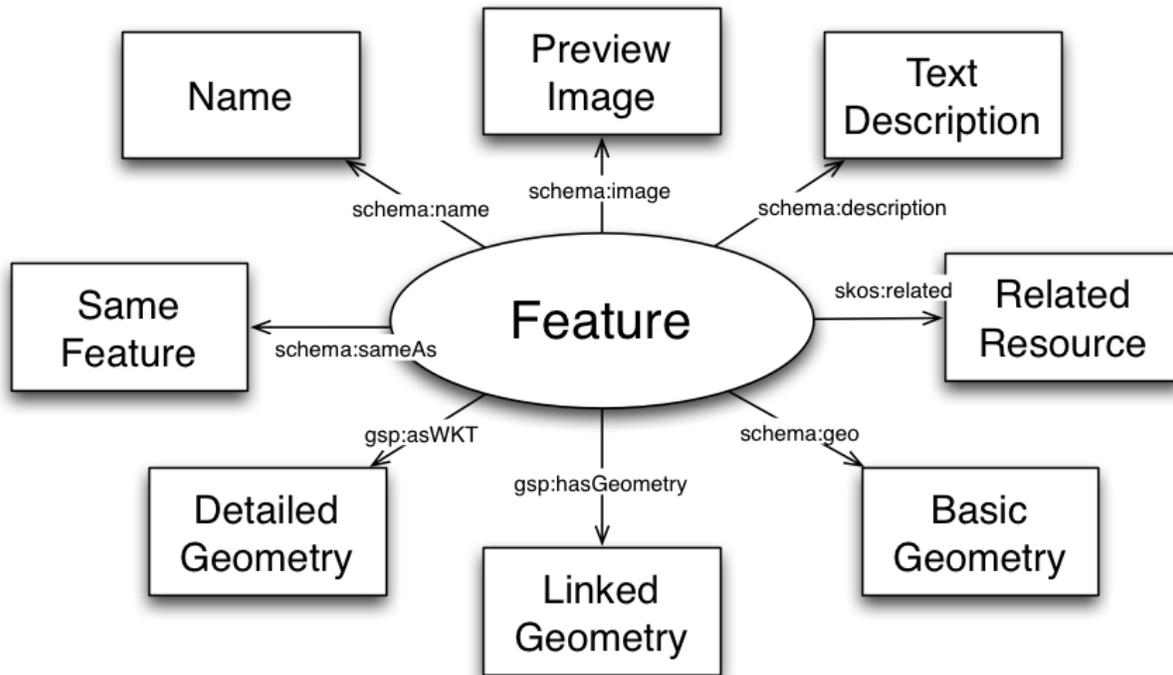


Comprehensive Understanding of Interacting Processes



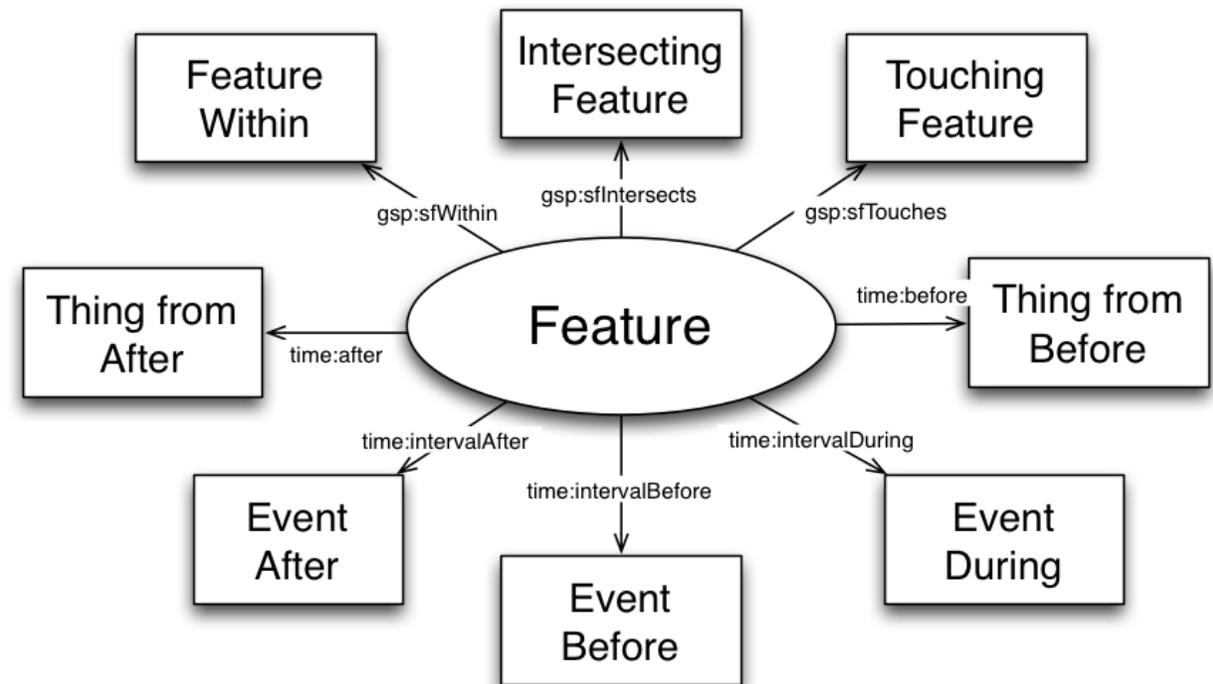
- Functional linked data graph views... preview, network.

Preview



"schema": "http://schema.org/"
"skos": "https://www.w3.org/TR/skos-reference/"
"gsp": "http://www.opengeospatial.org/standards/geosparql"

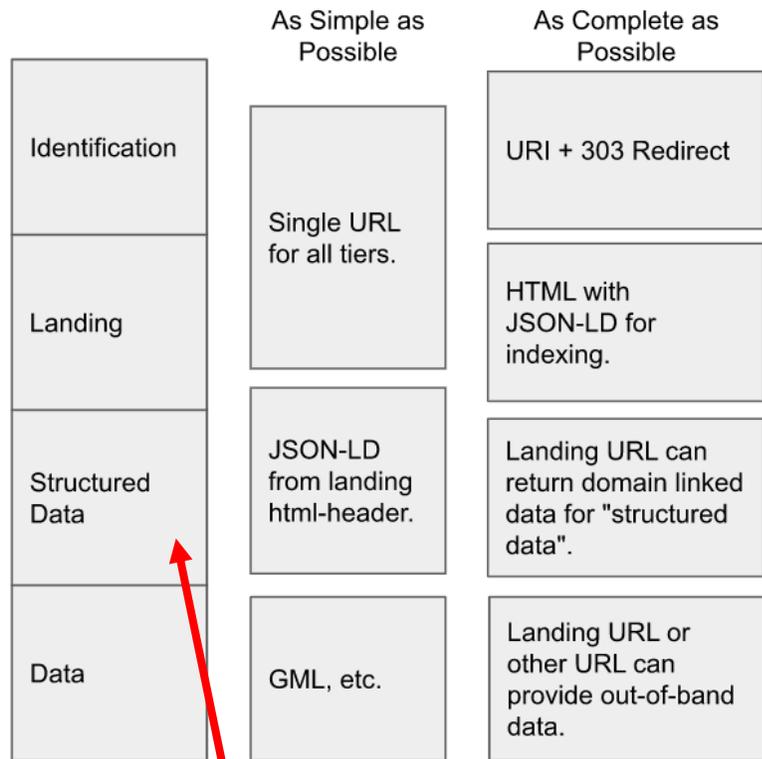
Network



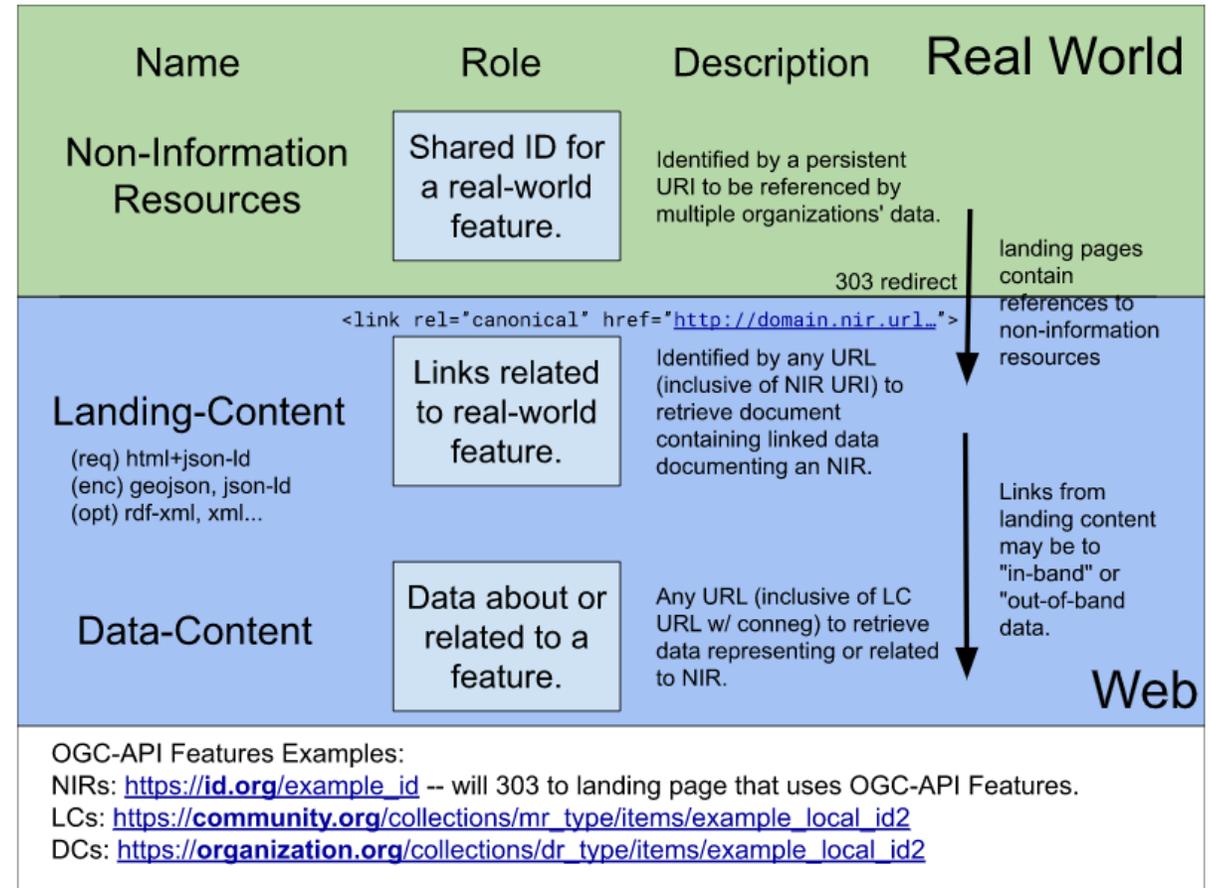
"gsp": "http://www.opengeospatial.org/standards/geosparql/"
"time": "https://www.w3.org/TR/owl-time/"

Functions and Content Model

As a Web user, I want to find all the information available for an environmental feature, so I can find what I'm looking for and retrieve it.



"resource model" vs "content model"



the four SELFIE "functions"

<https://github.com/opengeospatial/SELFIE>

What is the Hydro Network Linked Data Index?

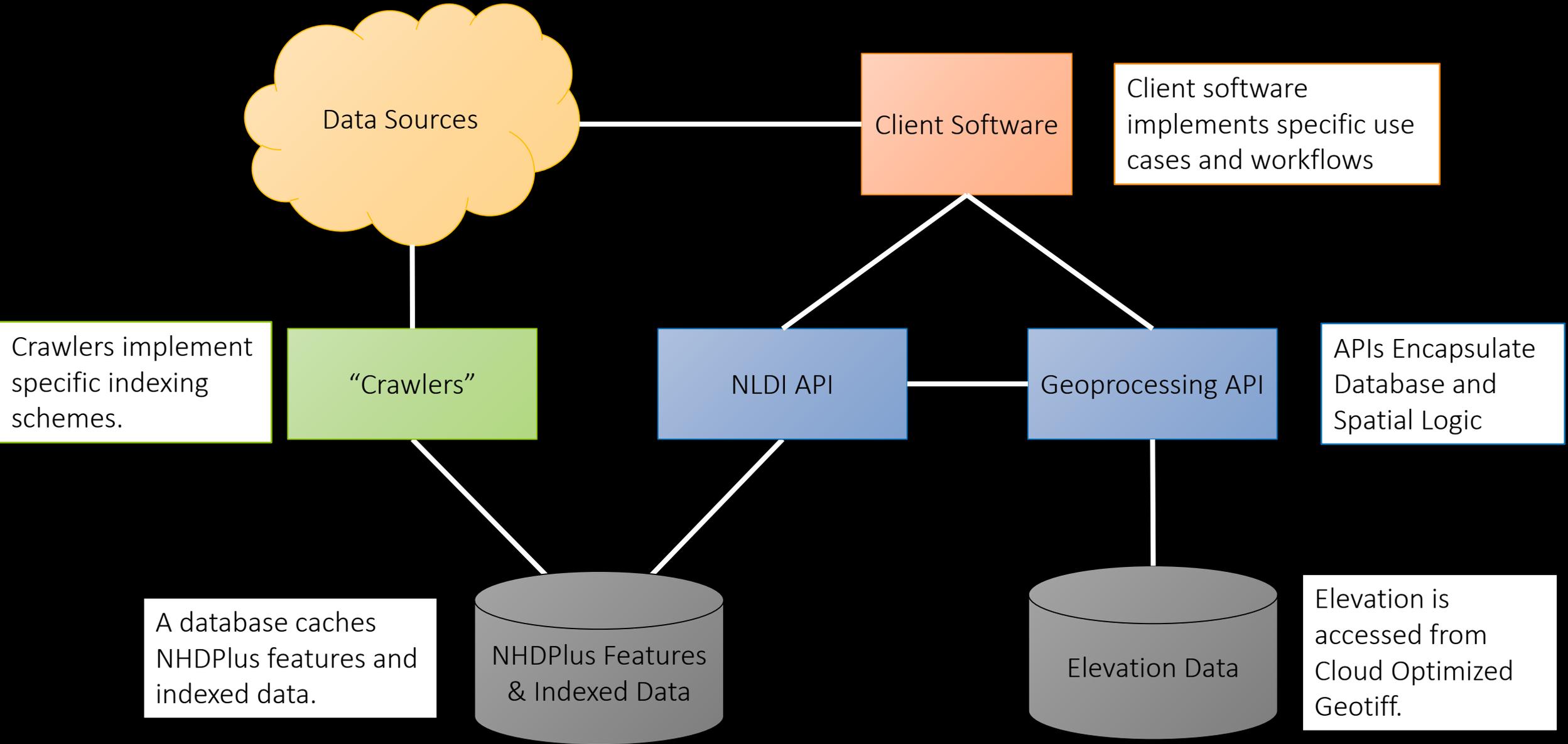
A search engine for data associated with a hydrologic network.

It can index new data and provides search services.

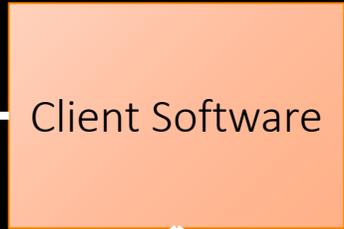
A set of services capable of returning custom hydrologic features.

Network navigation, basin boundaries, downslope trace paths, cross sections.

ie. A convenience API over a set of networked hydrologic features and related data.



Data Sources



Client Software

Client software implements specific use cases and workflows

Crawlers implement specific indexing schemes.



"Crawlers"



NLDI API



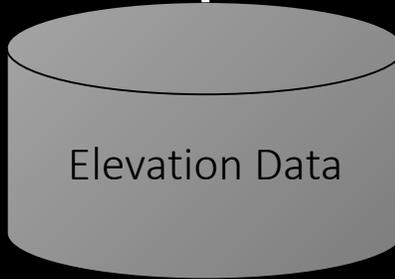
Geoprocessing API

APIs Encapsulate Database and Spatial Logic

A database caches NHDPlus features and indexed data.



NHDPlus Features & Indexed Data



Elevation Data

Elevation is accessed from Cloud Optimized Geotiff.

Persistence

geoconnex.us redirect

Discovery

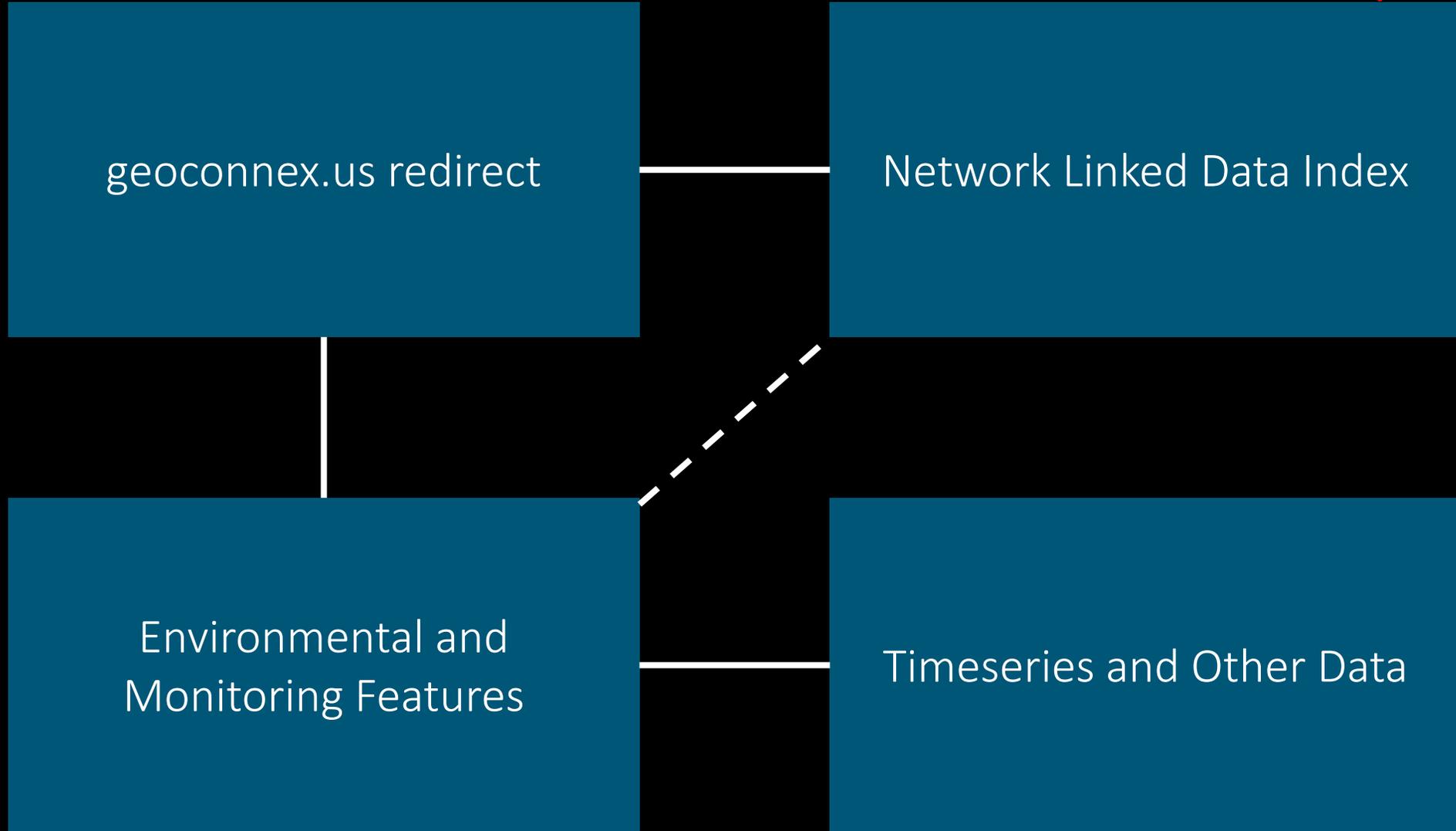
Network Linked Data Index

Environmental and
Monitoring Features

Timeseries and Other Data

Integration

Access



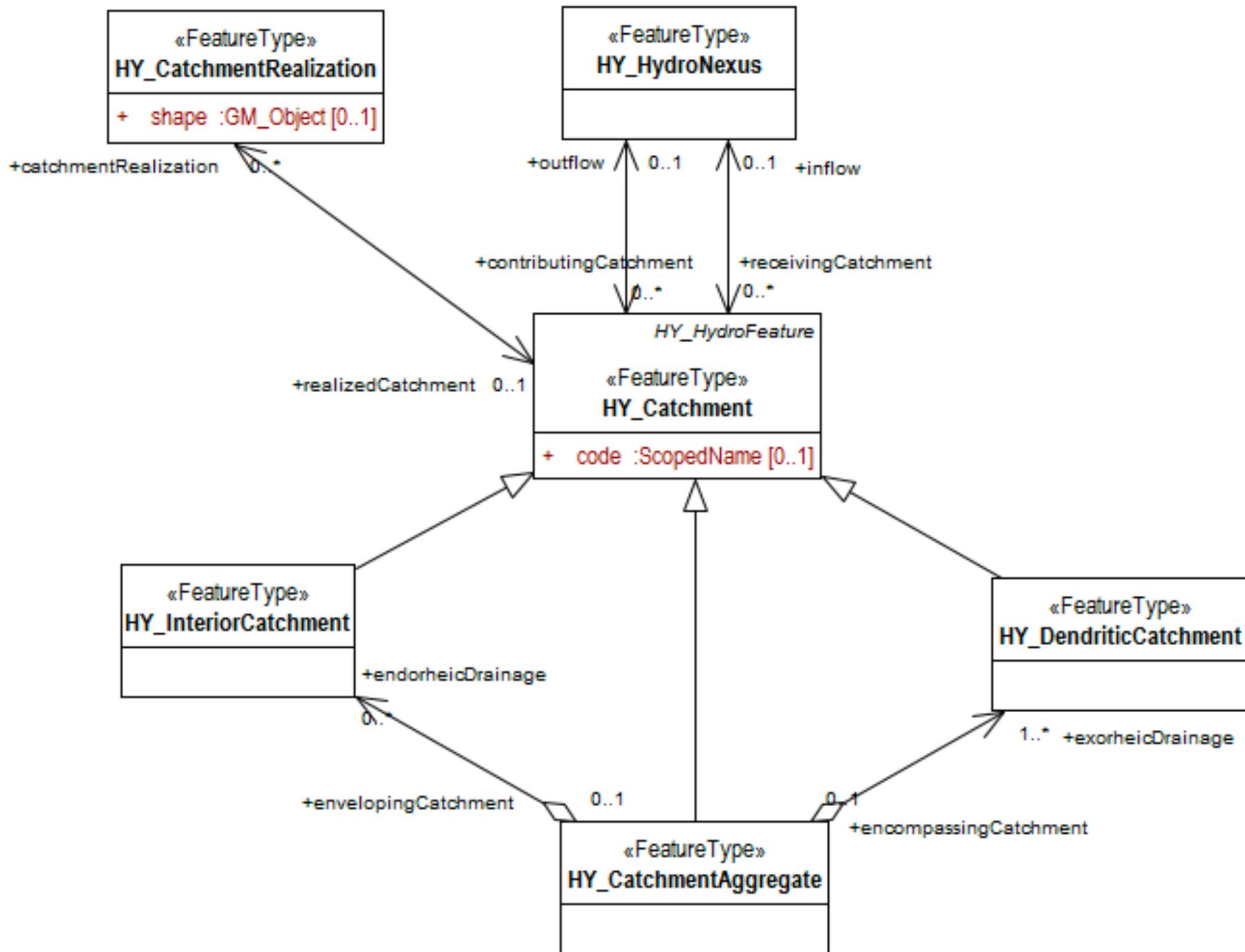
We can decompose a problem in two ways.

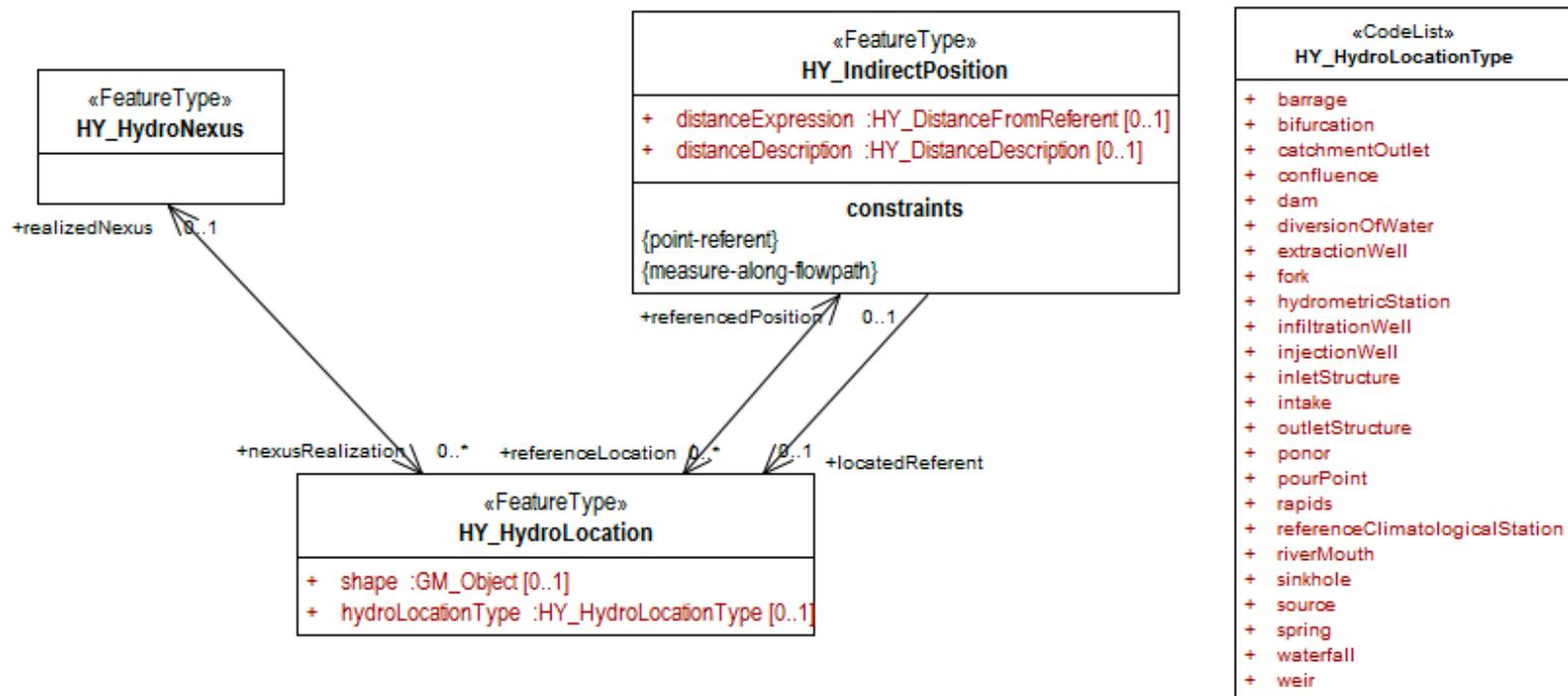
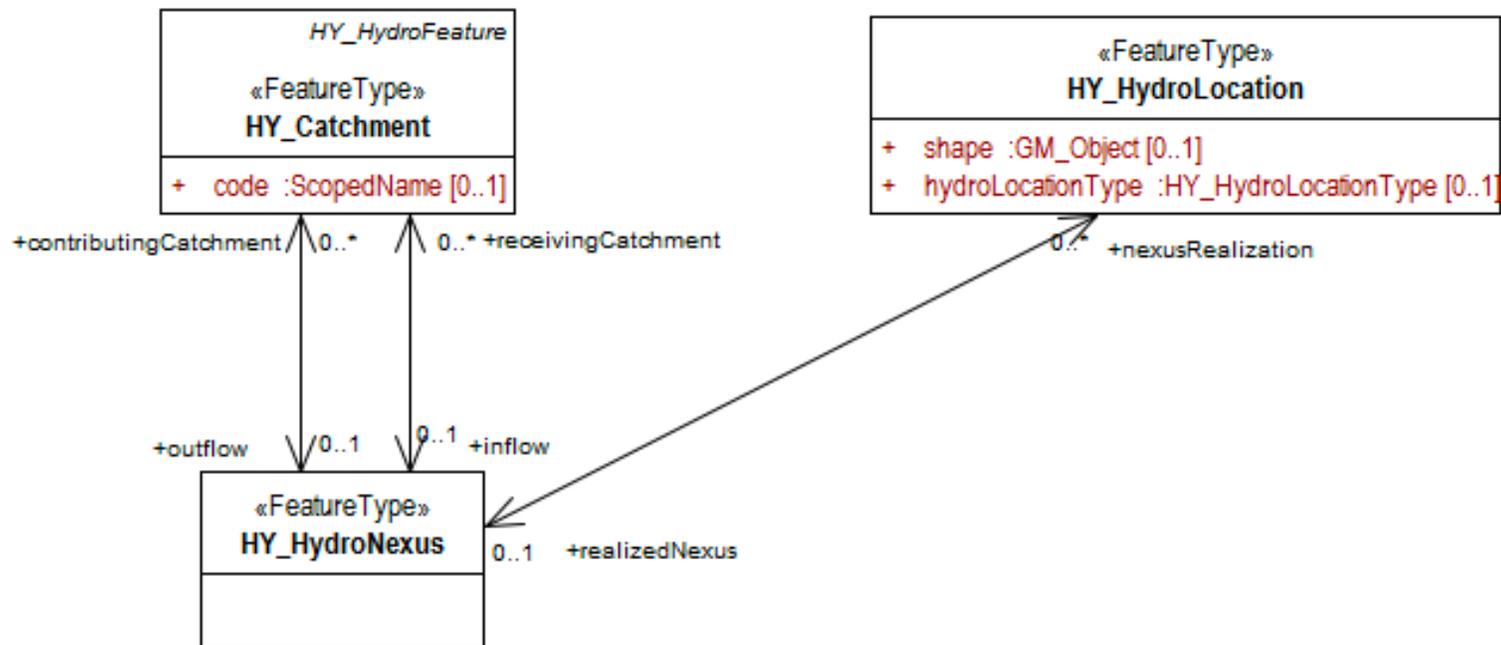
- 1) **Spatial-domain** decomposition for social and engineering reasons.
- 2) **Model-concept-domain** decomposition for flexible system composition.

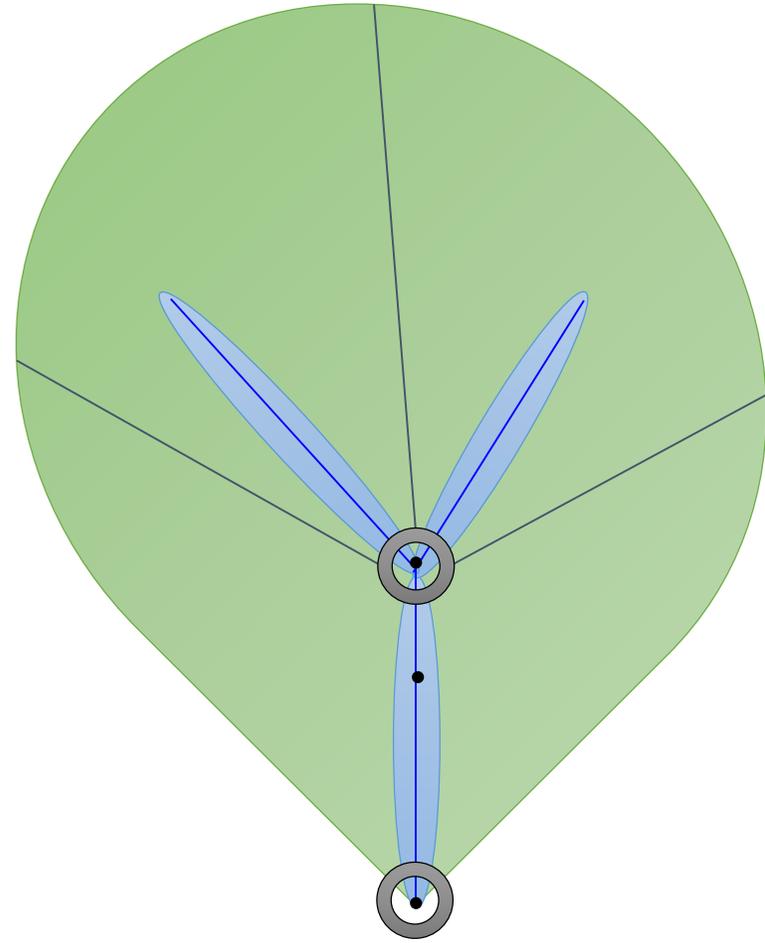
noun: **class**; plural noun: **classes**

a set or category of things having some property or attribute in common and differentiated from others by kind, type, or quality.

HY_Features





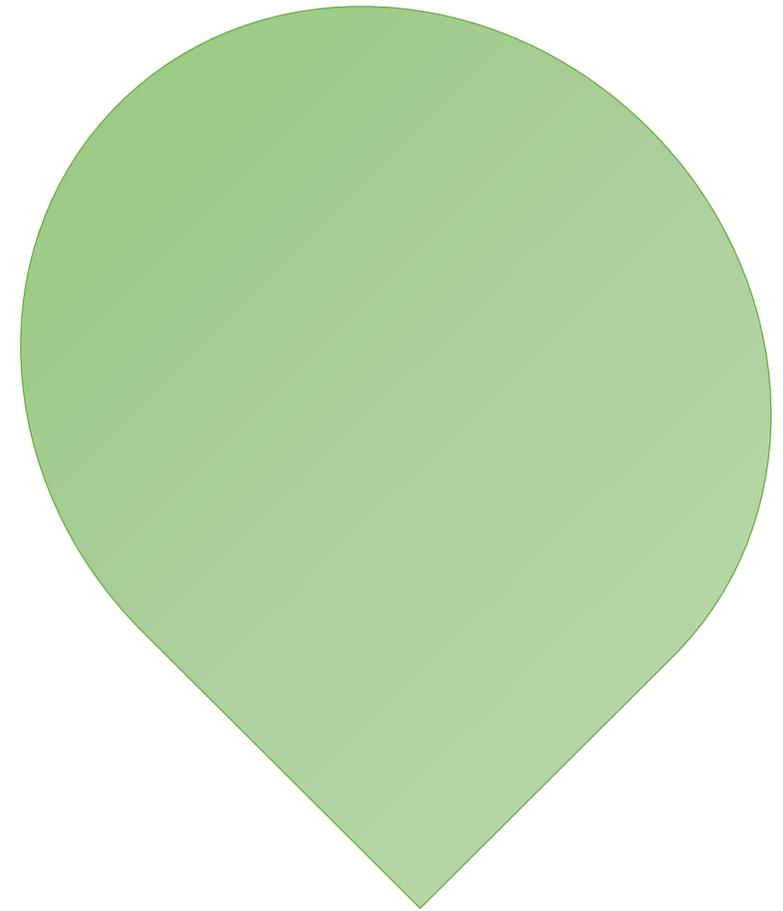


HY_CatchmentArea

Calculates a water budget

Delivers flow to drainage network

How is the catchment area is realized is flexible.



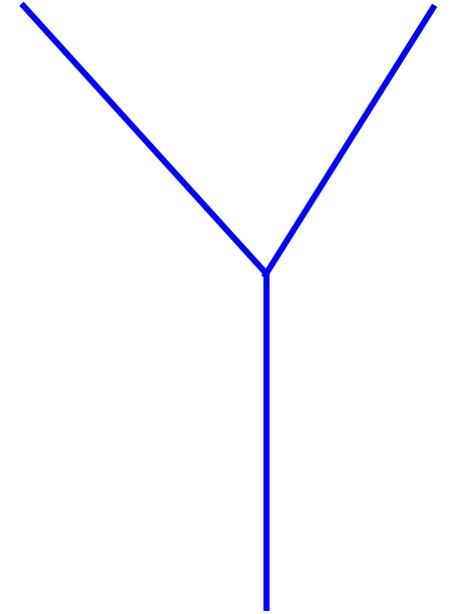
HY_FlowPath

Linear connection from catchment inlet to outlet

Connected to HY_WaterBody via 1:n HY_HydroLocations

Relation between flowpath and waterbody **topology** is flexible / inferred.

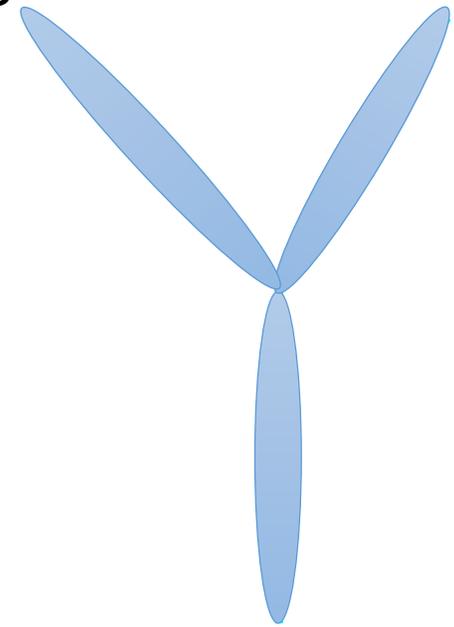
May support **hydrologic** routing directly or associate with HY_WaterBodies.



HY_WaterBody -- HY_River/HY_Lake/HY_Impoundment

Features for **hydrodynamics**.

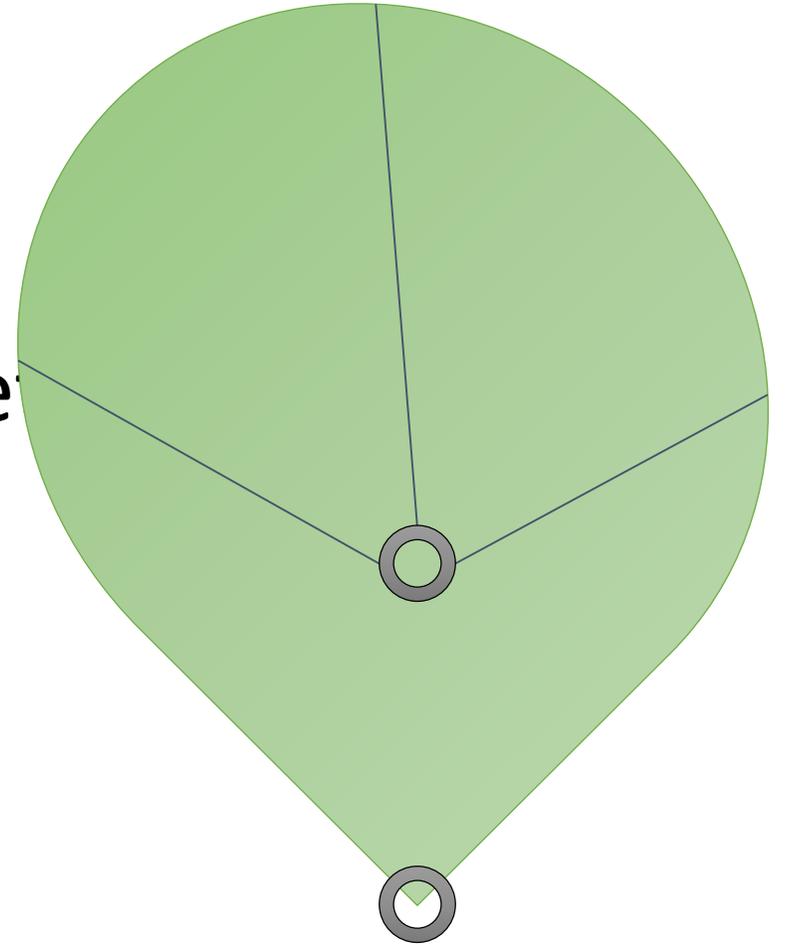
An aggregation of water bodies can be identified as a catchment realization.
This could be how we would get SW/GW coupling



HY_Catchment / HY_HydroNexus

Wholistic feature types track identity and allow flexible implementation.

i.e. A catchment is realized by one:numerous related models, datasets, maps, etc.

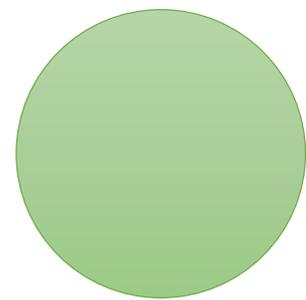
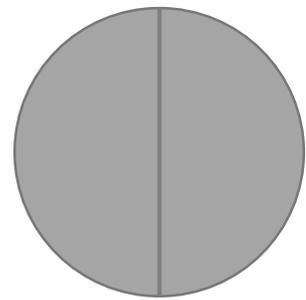
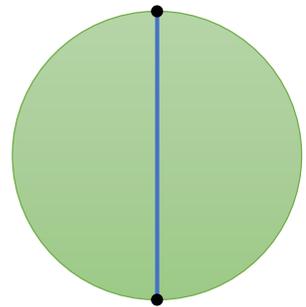
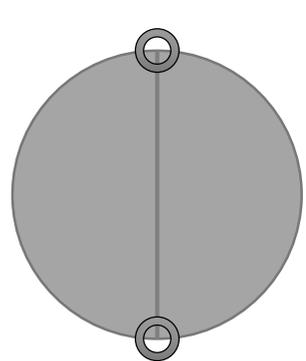


HY_HydroLocation

•

Is a location **on** a flowpath that can be linked to other features.

Gages, cross sections in waterbodies, reporting locations, nexus locations...

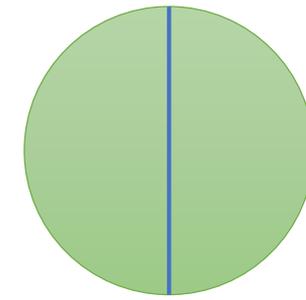


Nexus

Catchment

Catchment Area

Flowpath



Hydro Location

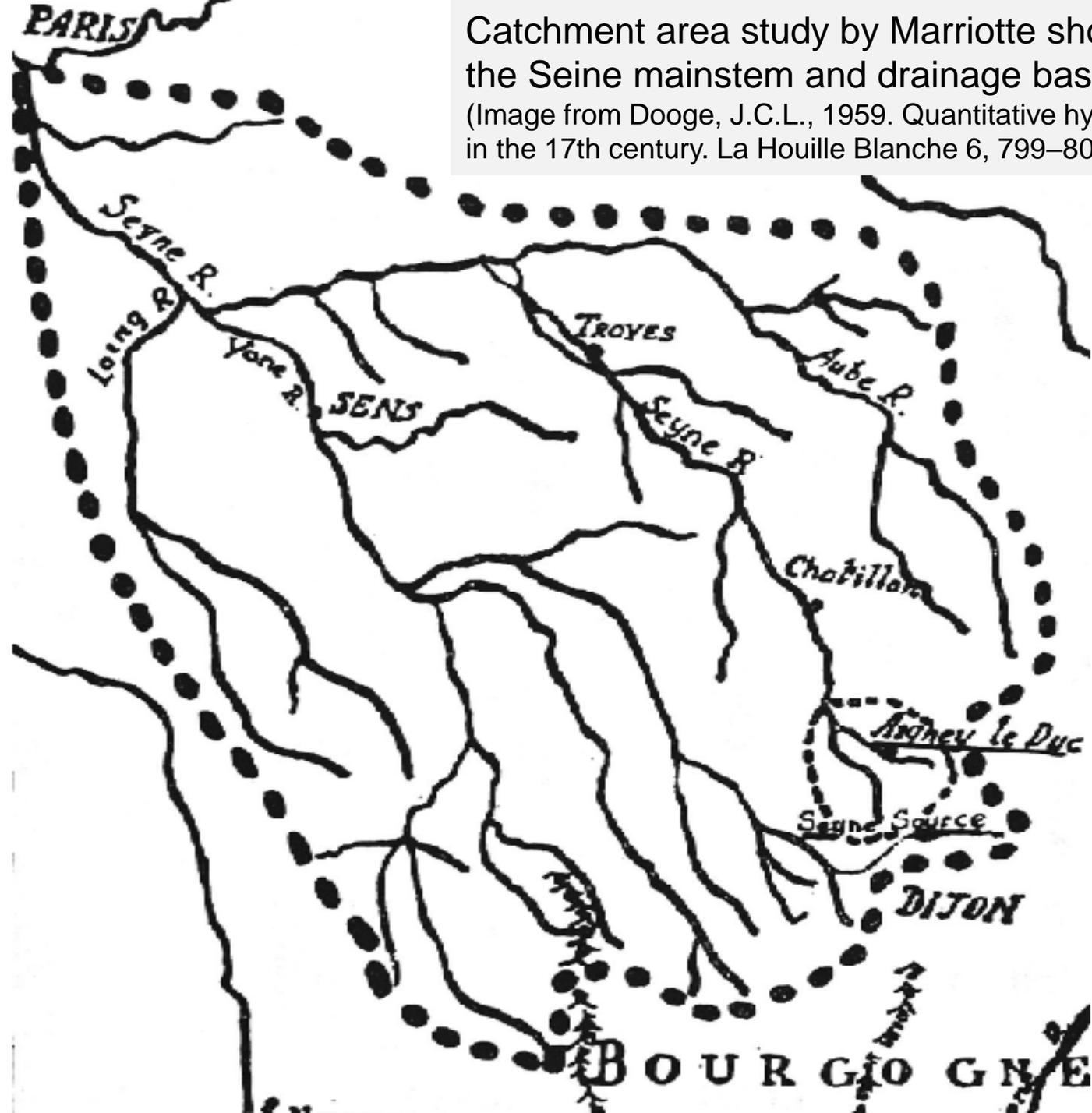
Waterbody

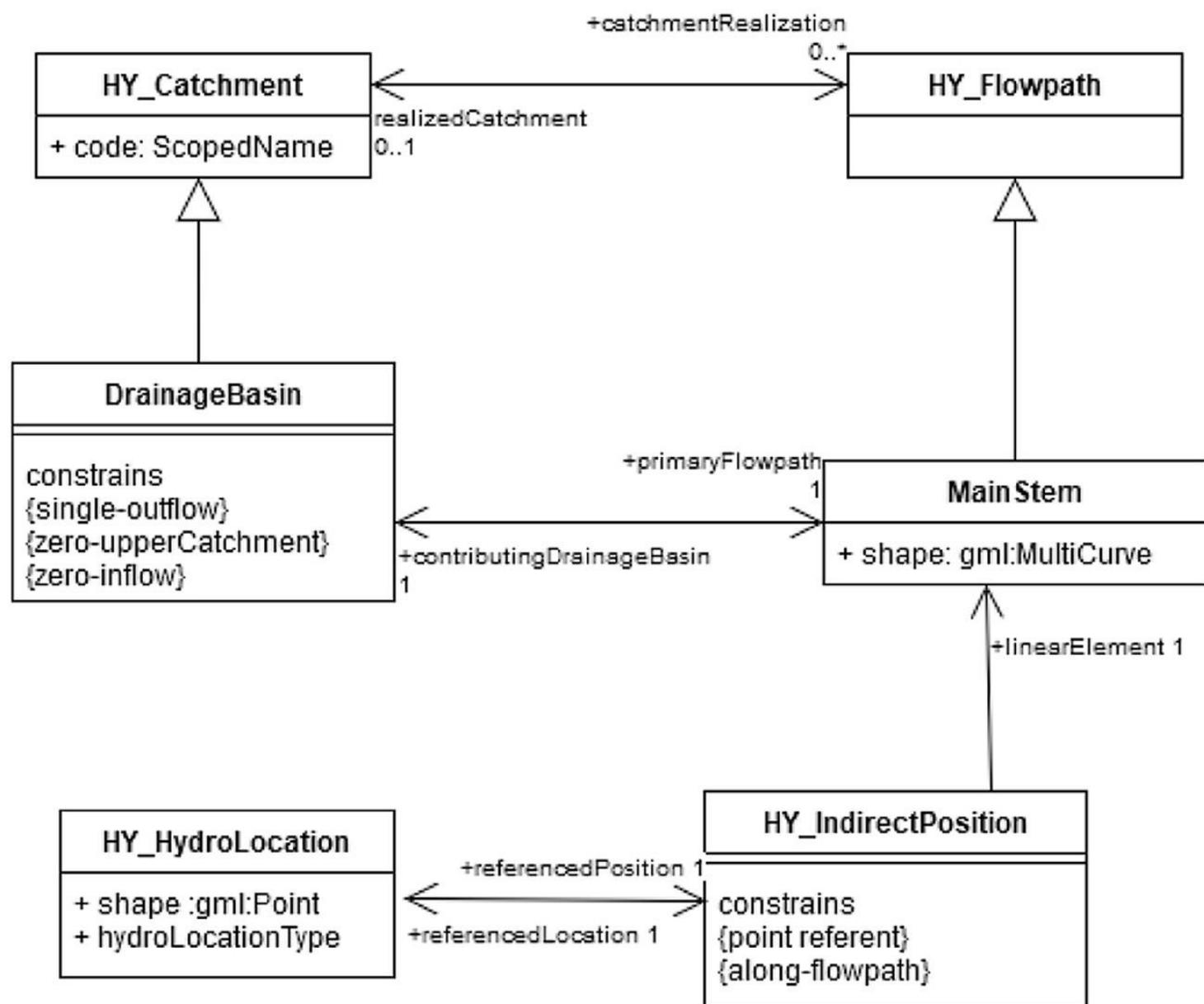
[Combined]
Catchment Realization

Mainstems

<https://doi.org/10.1016/j.envsoft.2020.104927>

Catchment area study by Marriotte showing the Seine mainstem and drainage basin. (Image from Dooge, J.C.L., 1959. Quantitative hydrology in the 17th century. La Houille Blanche 6, 799–807.)





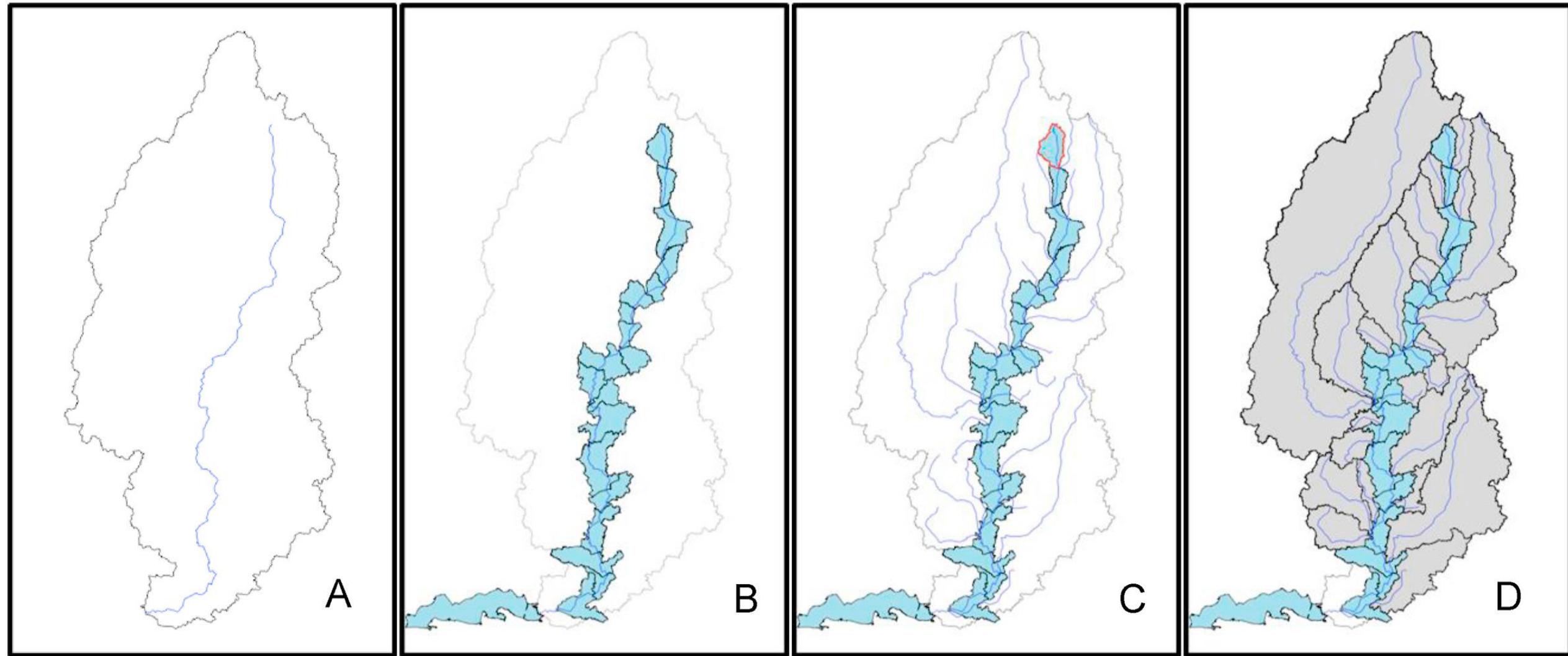


Illustration of how mainstems and drainage basins integrate with an incremental catchment data model.

A) One mainstem flowpath (blue line) and its drainage basin (grey outline).

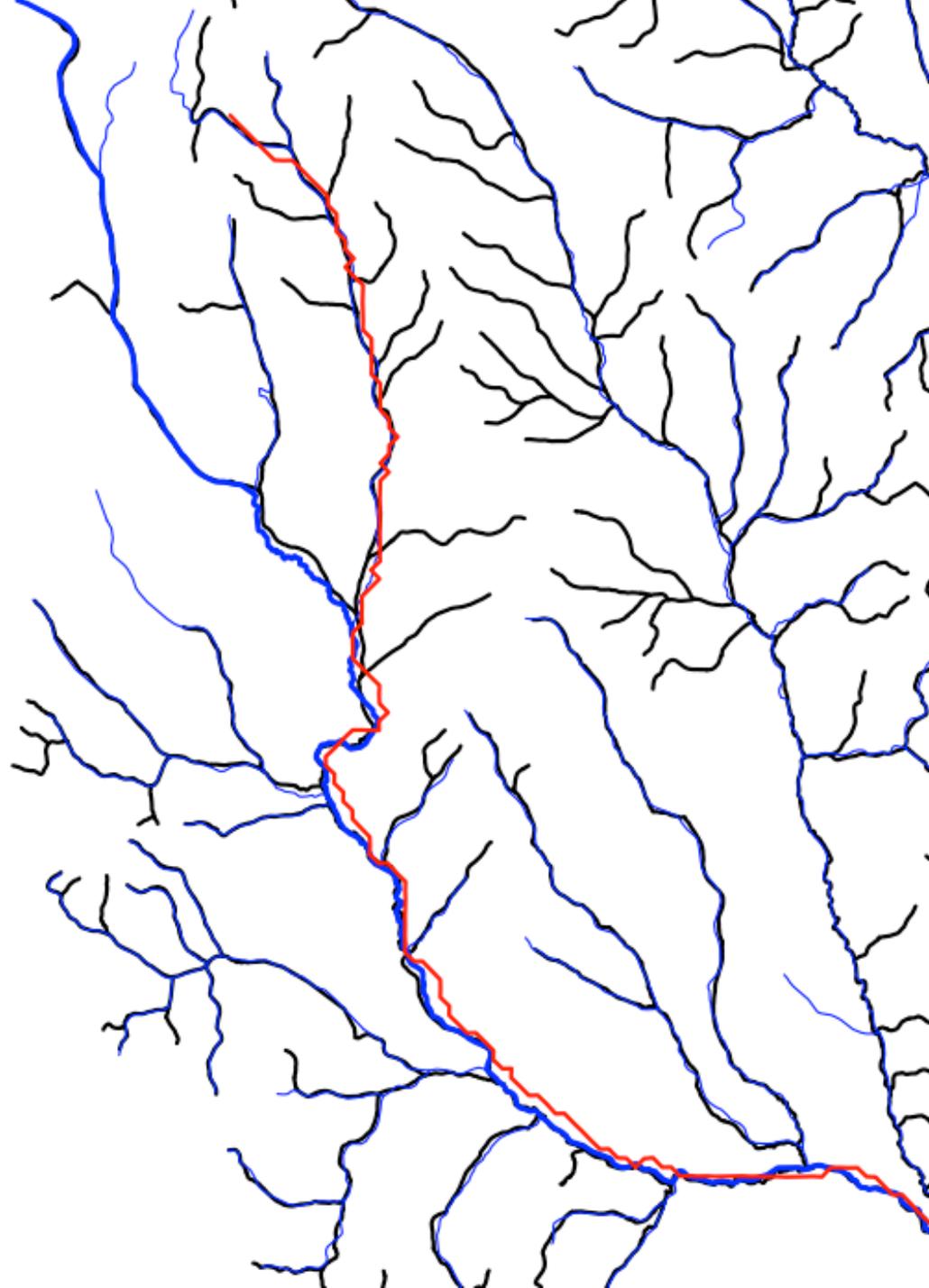
B) Incremental catchments for the mainstem shaded in light blue.

C) Headwater catchment (outlined in red) and tributaries contributing to the mainstem (blue lines outside of incremental catchments).

D) Drainage basins for each tributary shaded in grey and outlined in black.

A core question:

Where is a
“headwater”?



Links

<https://www.usgs.gov/core-science-systems/ngp/national-hydrography/hydrographic-addressing-conceptual-model-tools>

<https://hydrolink.readthedocs.io/en/latest/hydrolink.html#>

<https://maps.usgs.gov/hydrolink/>

https://usgs-r.github.io/nhdplusTools/articles/point_indexing.html

https://usgs-r.github.io/nhdplusTools/reference/disambiguate_flowline_indexes.html