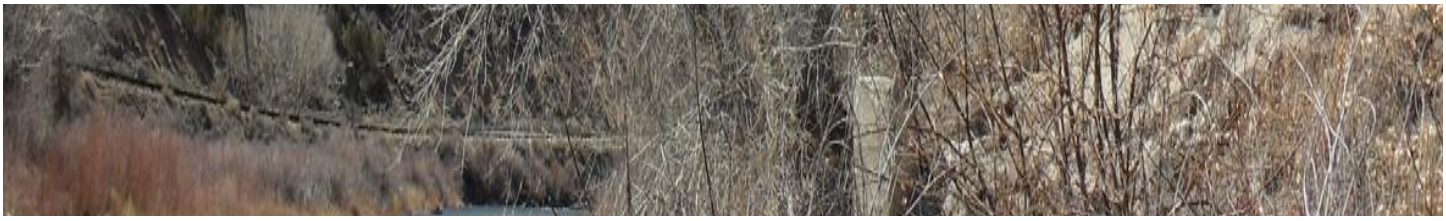

Hydrographic Addressing - Tech Note

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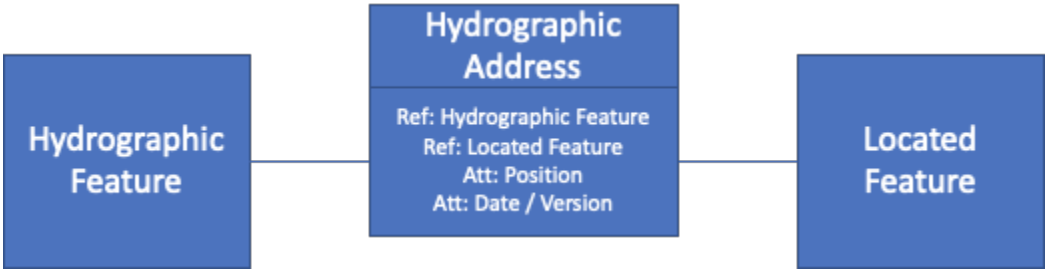
The following content was developed by a hydrographic addressing sub working group of the National Hydrography Infrastructure working group. It is being cross-posted here for reference.

The material was developed in two activities, conceptual model and tools inventory, who's problem statements are provided inline.

More information about how hydrographic addressing relates to the NHGF can be found on the products and deliverables page.



Hydrographic Address Data Model illustrating the three independent classes (types) of information involved in a hydrographic address. Note that an address is not inherently a feature, but rather, an association between two features that may have a derived spatial representation at the address location along the hydrologic feature's geometry.

Activity 1: Conceptual Model

Problem Statement: In order to adequately describe an inventory of existing tools and methods for hydrographic addressing, a shared conceptual model for hydrographic addressing is required. Such a shared conceptual model will also be

useful as a foundation for design work and documentation of all activities of the working group. There are data schema from the NHD and other hydrographic schemes and standard data models such as HY_Features, ISO 19148 (linear referencing), etc. However, in practice, we all use a unique lexicon that is rooted in the context of the work that we do with hydrographically addressed information. To accurately represent the diversity of use, we need to develop a reasonably general set of terms and concepts they are meant to represent in verbal and written communication.

Terms:

- **Hydrographic Feature**: Geographic feature representing a hydrologic entity.
- **Hydrographic Network**: Connected system of hydrographic features.
- **River Address**: Location identified via reference to a rivers identity and position along the river.
- **Network Location**: Generally synonymous with river address but used in more technical context to refer to the hydrographic network (of rivers).
- **Common Hydrography**: A geographic representation of hydrology that is well known and used for integration among more than one organization.
- **Watershed Outlet**: A place on the landscape where, for whatever reason, a contributing watershed has been identified.
- **Catchment Identifier**: An identifier for an established unit of hydrology (NHDPlusV2 Catchment *or* other hydrologic unit) from a common hydrography.
- **Identified [Hydrographic] Feature**: The hydrographic feature referenced in a hydrographic address.
- **Located Feature**: The location that is referenced to a hydrographic feature in a hydrographic address.
- **Persistence:** The notion that a thing (hydrographic feature here) is enduring and reliably identifiable.

Why do we address data to hydrography?

Hydrographic addresses provide a way for organizations to integrate, catalog, and discover hydro-relevant information. By referencing common hydrography, cross-organization information sharing can be accomplished with precise network position. This context is critical for any modeling or analysis application where hydrology is a factor.

- Integration of disparate or different data with common hydrography.

- Cross-organization discovery of hydro-related information.
- Modeling and analysis of addressed watershed outlets.
- Precise relative hydrographic network location.

What is a hydrographic address?

- An identified location on a hydrographic feature.
- A position in a hydrographic network.
- A river address.
- A reference catchment.
- A link between hydrography and another dataset.

More specifically, a hydrographic address is an expression of location that uses an association with an identified hydrographic feature rather than geospatial coordinates. As with a street address, a hydrographic address consists of both a feature identifier and some indication of the position along the feature. (e.g. 470 Main St is an address that indicates the Main St feature identifier and the position indication is 470) A hydrographic address is practically always an *attribute* of a located feature which has a geographic representation independent of the hydrographic feature referenced in an address. (e.g. Using our street address analogy again, the house at 470 Main St has a geographic representation that is independent of Main St itself.) In other words, a hydrographic address is a link between a located feature in one dataset and a hydrographic feature in another dataset.

Classically, in the NHD Reachcode / Measure linear referencing system, a hydrographic address is a linear position along a river but it can also be a link to a specific catchment.

Linear references are commonly known as "events", terminology said to be rooted in emergency response and incidents along roads, and is the approach used in the NHD. A linear reference can provide a highly-precise (1d) point location on a

linear representation of a river. The precision of linear referencing, while useful, means that automated methods of addressing often produce anomalous addresses that require manual review. Linear references must be re-calculated, and potentially re-reviewed, if referenced hydrography is not persistent.

Catchment indexing is commonly used with the NHDPlus to reference landscape characteristics and many other kinds of data to the catchment network. References to Hydrologic Unit Codes from the Watershed Boundary Dataset also fall into this class of hydrographic address. Catchment indexing doesn't necessarily attach information to a specific river. Whether a located feature is on a catchment's flowpath or not can typically be inferred or may be included explicitly in a catchment index. These can be thought of similarly to states, counties, zip codes, etc. The precision of a catchment index is lower than a linear reference, but they require much less manual review when using automated addressing methods. Like linear referencing, if referenced catchments are not persistent, addresses must be recalculated.

What information is involved in a hydrographic address?

- Hydrographic feature: A river or a catchment feature.
- Position along identified feature: Generally as percent along a specified river reach but could be distance from a known location.
- Derived Feature: The location on the hydrographic feature that corresponds to the hydrographic addresses position. (point for linear referencing polygon for catchment indexing)
- Located feature: A feature that is independent of the hydrographic feature (may be another hydrographic feature).
- Date or Version: Important in the case that the hydrographic feature is not persistent.

See the diagram at the top of the page for a graphic depiction of the parts of a Hydrographic Address.

Activity 2: Tools Inventory

Problem Statement: An inventory of existing hydrographic addressing tools is needed to give the NHI stakeholder community an understanding of what tools are available to fill particular needs. As a set of interrelated hydrographic and related data, the National Hydrography Infrastructure is heavily reliant on data that is referenced via hydrographic address. Creation of linked content is a tedious and technically nuanced process without tools that are designed and implemented for a specific need. The problem of describing hydrographic addressing tools should focus on the diversity of use cases while relying on common language and concepts described in the recently finished conceptual model. The inventory does not have to be exhaustive, but should cover the majority of available tools that the Hydrographic Addressing Working Group deems useful to the community.

Outcome Summary

The following provides an overview of hydrographic addressing tools in common use by U.S. hydrologic geospatial practitioners. The tools are categorized by:

- **User:** characterizes the intended audience of the tool
- **Common Hydrography:** describes what (if any) established hydrographic data the tool is designed to work with
- **Hydrographic Addressing Type:** describes the kind of hydrographic address the tool generates
- **Processing Approach:** describes how the tool works in the context of a broader workflow
- **Addressing Method:** describes the method the tool uses to establish hydrographic addresses

These categories are intended to provide both a guide for selection of the best available tool for a particular project and general perspective for what is available and where there are gaps in hydrographic addressing tooling.

While this inventory lists individual tools, it is important to recognize that a liberal definition of "tool" has been used to bring these together in one list. Some of these tools are software libraries that can be assembled into workflows or used as

dependencies in other software while others are stand-alone applications that use software libraries to provide facilitated functionality. The "processing approach" category is most indicative of this distinction.

Product	User	Common Hydrograph
Catchment Indexing Process Tool	5, 7	1
EPA Waters Web Services	5,6,7	1
ESRI Linear Referencing Tools	1, 2	NA
ESRI Spatial Join Tool	1, 2	NA
HydroAdd	4	2
Hydrographic Event Management	1?	2
Hydrolink Python package	5,7	1, 2
HydroLink Web Application	4	1, 2
hydrolinks R package	6	NA
Hydrologic Event Management Server Object Extensions	5,6,7	2
nhdplusTools R package	6	1, 2, NA

User Type	Common Hydrography	Hydrographic Address Types	Processing App
1) ESRI ArcMap User 2) ESRI ArcGIS Pro User 3) QGIS User 4) Science Data Creator - no	1) NHDPlusV2 2) NHD-HR 3) NA: configurable to any hydrography	1) Feature association 2) Linear reference 3) Catchment	1) Individual loc addressing in w UI 2) "Batch" inde in web or deskt

GIS background 5) Python geospatial package user 6) R geospatial package user 7) Application Developer	datasets	index	3) Reproducible data preparatio

Tool Summaries

Hydrographic Event Management link

Hydrography Event Management (HEM) Tools are a set of shared components to allow for creation, management, and refresh of event data that is referenced to the NHD HR. HEM tool allows indexing to any reached feature of the NHD– NHDFlowlines (by linear referencing), NHDWaterbody (by ReachCode), and NHDPoint (by ReachCode). HEM also allows users manage feature-level metadata to track edit history of events. HEM also allows for event synchronization when users when users update their NHD HR with a newer snapshot. Finally, HEM offers a set of userful tools, such batch import and QC, create line events from traces, measure linear distance, and create events from network flags.

HydroAdd (no link yet)

Unreleased. Web-based addressing tool. User must share a service layer from AGOL or other source in HydroAdd schema. Will allow addressing of point, line, and polygon features to reached features in NHD HR, and ultimately to catchments and HUs of the NHDPlus HR. Simple queue-based UI. Queue drives users to unapproved features. Batch QC will be based on proximity to reached feature and existing reachcodes of addressed features. As a future enhancements to QC, results could be weighted by GNIS Name, distance to confluence.

ESRI Linear Referencing Tools (link arcmap) (link pro)

ESRI Spatial Join Tool (link arcmap) (link pro)

HydroLink Web Application: https://doi.org/10.5066/P9KRWCFL

The HydroLink Tool aids in generating a linear reference for point data to flowlines within the NHDPlusV2.1 Medium Resolution and NHD High Resolution datasets. The tool employs a researcher's local, field-based knowledge of sampled locations to improve both the spatial accuracy of the research data and assist in the linkage to these national surface water datasets. After the user uploads their data from a CSV or Shapefile, the tool handles all data and processing using web services requiring minimal geospatial expertise, but does require an ArcGIS Online account.

Hydrolinker command line tool https://hydrolink.readthedocs.io/en/latest/readme.html#getting-started

HydroLinker is a command line tool built into the HydroLink Python package that supports processing of multiple point locations to the NHDPlusV2.1 Medium Resolution or NHD High Resolution. This tool strings together methods from the HydroLink Python package to process point data from an input CSV file. HydroLinker results are returned to the user in a CSV. Users will need basic understanding of how to install a Python package but no need for geospatial expertise.

Hydrolink Python package: https://hydrolink.readthedocs.io

An open source Python package to support linear referencing to the NHDPlusV2.1 Medium Resolution and NHD High Resolution datasets. Currently the package supports addressing point data to waterbody and flowline features using two methods of geospatial proximity and water-name matching. Python users can expand upon methods and build this package into customized workflows. Includes methods to calculate snap distance, water name similarities (between user supplied and GNIS) and distance to closest confluence, allowing user to attribute levels of confidence to each HydroLink record.

Catchment Indexing Process Tool (github link expected July 2020)

Developed by EPA as a cost-effective way to routinely bring state-based sources of hydrography data into a common national framework for monitoring and reporting purposes. It is designed to conflate point, lines and polygons onto the NHDPlus V2 framework, using an initial geospatial overlay that is further refined using VAAs (level path, hydrologic sequence number, etc.) to inform the indexing. Output is a hydrologically connected series of catchments that best represent the input hydrography. By tying EPA water quality information to catchments, we can associate land surface activities with corresponding effects downstream. The tool runs in a batch mode and is written in python using PostgreSQL. The tool is not currently publicly available but plans are being considered for a cloud-based service.

Hydrologic Event Management Server Object Extensions (link homepage) (link documentation)

EPA Waters Web Services https://www.epa.gov/waterdata/waters-web-services

nhdplusTools R package (link)

The nhdplusTools R package is a growing set of building blocks for working with data that loosely adheres to the NHDPlus data model. The documentation home page is: https://usgs-r.github.io/nhdplusTools/ and, at the time of writing, the only hydrographic addressing function supported is described here: https://usgs-r.github.io/nhdplusTools/reference/get_flowline_index.html. The get_flowline_index function accepts a collection of linear hydrographic features and a set of point features to be addressed. The linear hydrographic features are expected to have NHD/NHDPlus attributes COMID, REACHCODE, ToMeasure, and FromMeasure. The output hydrographic address for each located point feature is a linear reference containing the COMID, REACHCODE, REACH_measure, and offest for each point. The hydrographic addressing method is a simple approximate nearest neighbor performed between the to-be-located points and

the individual nodes of the hydrographic features. Densification of hydrographic nodes to provide a higher degree of precision in the output is supported. Additional functionality is planned for implementation in 2020. See tasks in the indexing milestone and the changelog for updates.

hydrolinks R package (link)

Tools to link geographic data with hydrologic network, including lakes, streams and rivers. Includes automated download of U.S. National Hydrography Network and other hydrolayers. Rudimentary but useful for some studies using NHD Waterbodies as a reference layer.