February 2000

The National Hydrography Dataset

Concepts and Contents

Contents

Overview

The National Hydrography Dataset (NHD) is a comprehensive set of digital spatial data that encodes information about naturally occurring and constructed bodies of water, paths through which water flows, and related entities. The information encoded about these features includes classification and other characteristics, delineation, geographic name, position and related measures, a "reach code" through which other information can be related to the NHD, and the direction of water flow. In addition to this geographic information, the dataset contains metadata and information that supports the exchange of future updates and improvements to the data.

The data support many applications, such as:

- Making maps. Positional and descriptive data in the NHD provide the starting point for making many different kinds of maps.
- Geocoding observations. Much like street addresses provide a way to link data to a road network, the NHD's "reach code" provides the means to link data to water features.
- Modeling the flow of water along the Nation's waterways. Information about the direction of flow, when combined with other data, can help users model the transport of materials in hydrographic networks, and other applications.
- Maintaining data. Many organizations would like to share the costs of improving and updating their collections of geographic data. Unique identifiers and other methods encoded in the NHD help to solve technical problems of cooperative data maintenance.

In 1999, coverage was made available for the conterminous United States and Hawaii. Data for Puerto Rico, the Virgin Islands, and parts of Alaska will follow. The production of data for the remainder of Alaska will be ongoing for several years. Efforts to maintain and improve the data will occur continually.

The NHD is the culmination of cooperative efforts of the U.S. Environmental Protection Agency (USEPA) and the U.S. Geological Survey (USGS). Other organizations also contributed to the effort.

This volume describes the concepts and information content of the NHD, including features, reaches, metadata, geographic names, coordinate systems and related measures, and data quality.

Features

Main points:

- **Features** in the NHD include naturally occurring and constructed bodies of water, paths through which water flows, and related entities.
- Features are classified by **feature type**.
- Features may also be described by **characteristics**. These characteristics are encoded using three methods: a **feature code**, a **description field**, and a **series of fields**.
- Features are delineated using **points**, **lines**, or **areas**. For linear features for which the direction of water flow is known, the lines are **oriented** in the direction of flow. Along the coastline, the lines usually are oriented so that the sea or ocean is to the right of the direction of the line.
- The **common identifier** uniquely identifies the occurrence of each feature.
- Features of the types known as **artificial path**, **connector**, and **underpass** serve special functions.

A feature is a defined entity and its representation. In the NHD, features include naturally occurring and constructed bodies of water, paths through which water flows, and related entities. Features are classified by type, may be described by additional characteristics, and are delineated using standard methods.

Feature types and characteristics

Features are classified by type. These feature types, such as "stream/river", "canal/ditch", and "lake/pond", provide the basic description of the features. Each type has a name and a definition. For example, the three most frequently encountered feature types and corresponding definitions are as follows:

Feature Type	Definition
STREAM/RIVER	A body of flowing water.
LAKE/POND	A standing body of water with a predominantly natural shoreline surrounded by land.
CANAL/DITCH	An artificial open waterway constructed to transport water, to irrigate or drain land, to connect two or more bodies of water, or to serve as a waterway for watercraft.

Characteristics, which are traits, qualities, or properties of features, are provided for many feature types. Each characteristic has a name, a definition, and a list of values and corresponding definitions. For example, the features lake/pond and stream/river have the characteristic Hydrographic Category:

	Name	Definition
Characteristic	Hydrographic Category	Portion of the year the feature contains water.
Values	Intermittent	Contains water for only part of the year, but more than just after rainstorms and at snowmelt.
	Perennial	Contains water throughout the year, except for infrequent periods of severe drought.

Appendix A lists the names and characteristics associated with each feature type. The "Standards for National Hydrography Dataset" (USGS, 1999) contains the names and definitions of all feature types, characteristics, and values. The document is available online through http://mapping.usgs.gov/standards/.

Encoding feature types and characteristics

A five-digit feature code encodes the feature type and combinations of characteristics and values that can be assigned to a type. The first three digits encode the feature type, and the last two digits encode a set of characteristics and values. For example, the feature type "dam/weir" has the code "343". There are five combinations of characteristics and values that can be assigned to features of this type. These combinations are assigned the values of "00" through "04". The resulting possible feature codes are listed below:

Feature Code	Feature Type	Characteristic | Value
34300	DAM/WEIR	Feature type only: no attributes
34301	DAM/WEIR	Construction Material|earthen; Operational Status|operational
34302	DAM/WEIR	Construction Material|earthen; Operational Status|under construction
34303	DAM/WEIR	Construction Material|nonearthen; Operational Status|operational
34304	DAM/WEIR	Construction Material|nonearthen; Operational Status|under construction

Feature codes are stored in a data element named "FCODE".

For those who prefer to use text instead of the numeric code, words also are used to encode the feature type, characteristic, and value information in the feature code:

- Feature types are encoded with a character string (for example, "Stream/River") in a data element named "FTYPE".

- Two approaches, which format the same information in different ways, encode characteristics and values using words:

    1. A description field, which holds a character string that contains all characteristics and values associated with a feature code. The description field is encoded in a data element named "DESCRIPT".
    2. A text field for each characteristic associated with a feature code. The name of each field is an abbreviation of the name of the characteristic.

For example, a feature classified as a "Dam/Weir" may have the characteristic of "Construction Material" with a value of "earthen", and the characteristic of "Operational Status" with a value of "operational". This information is encoded as follows:

Information Encoded	Feature Type, Characteristics, and Values	Feature Type	Characteristics and Values		
Method	**Feature Code field**	**Feature Type field**	**Description field**	**Field for each Characteristic**	
Field Name	FCODE	FTYPE	DESCRIPT	COM	OPS
Examples of Values	34300	DAM/WEIR	feature type only: no attributes		
	34301	DAM/WEIR	Construction Material|earthen; Operational Status|operational	Earthen	Operational
	34302	DAM/WEIR	Construction Material|earthen; Operational Status|under construction	Earthen	Under construction

Appendix B lists each feature code and its corresponding description. Appendix C lists the name of the field for each characteristic and the list of values for each characteristic.

A feature type and feature code are assigned to each feature. Description fields, fields for each characteristic, and feature codes are encoded in a lookup table. Associating the lookup table with features by matching the feature codes allows words denoting characteristics and values to be substituted for the numeric feature code.

Delineation rules

The shape and extent of features are delineated using points (including nodes), lines, or areas (see figure 1).

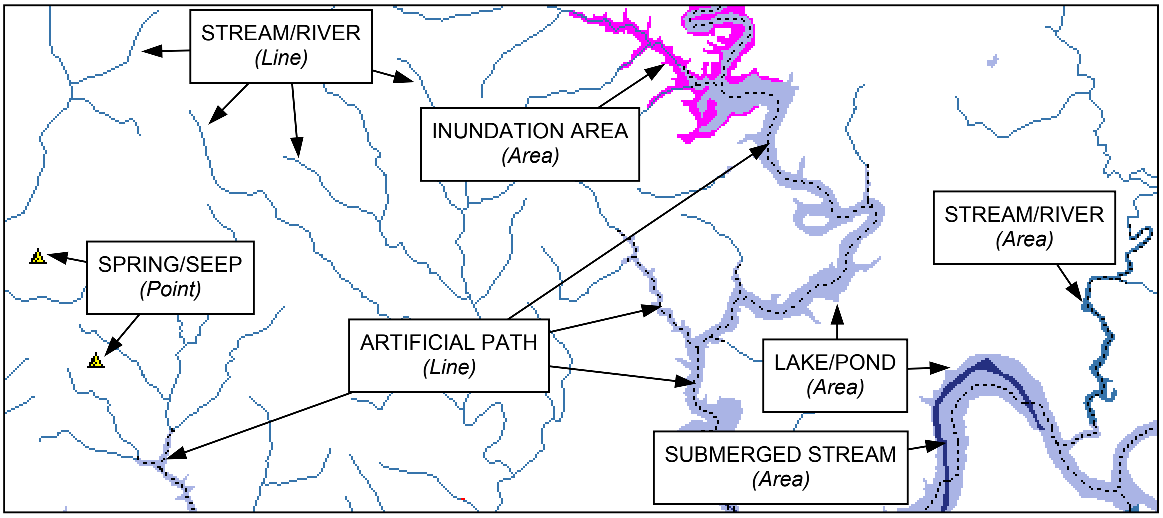

Figure 1. Features are delineated using points, lines, or areas.

The delineation of each feature follows three rules:

1. The delineated feature must be contiguous.
2. The delineated feature must have the same dimensionality; that is, it must be one point, one or more lines, or one or more areas.
3. The delineated feature can have only one feature type and must have the same set of characteristics and choices of values throughout its extent (including values for geographic name, surface elevation, and metadata, which are discussed in later sections).

Delineations of linear and areal features of different types may overlap. Where they overlap, they use the same lines or areas for their delineations. For example (see figure 2) the delineation of linear features of the types canal/ditch and bridge use the same lines where they overlap. Similarly, the delineations of areal features of the types lake/pond and swamp/marsh share the same areas where they overlap.

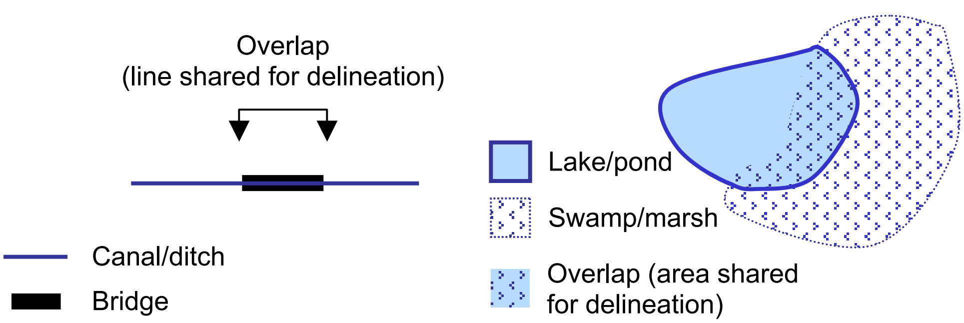

Figure 2. Examples of overlapping delineations of features.

Features delineated with lines have two additional rules: they may not have branches, and they must start and stop at decision or merge points along a network. These points exist where a path represented by a network can branch among two or more choices. For example, a decision point exists at the confluence of two stream/rivers; at the confluence, one can choose among two or more paths. Conversely, a decision point does not exist where features at different elevations cross; travel along the path of each feature is independent from that of the other. For example, a decision point does not exist where a canal/ditch passes over a stream/river.

Lines always have a direction; that is, lines trace a path between places where they start and stop. This characteristic provides a means to encode the direction of the flow of water. For features delineated with lines, for which the direction of flow is a prominent characteristic (the feature types artificial path, canal/ditch, connector, pipeline, and stream/river), and for which the direction of flow is known, the lines are oriented in the direction of the flow of water. Note that the direction of flow is not always known (for example, where source materials are ambiguous) or uniform (for example, in tidal areas), and so the lines are not always oriented in the direction of flow. In addition, along the coastline of the United States, the lines are oriented so that the water is to the right of the direction of the line.

The delineation of features stops at the borders of the United States.

Common identifier

The common identifier is a 10-digit integer value that uniquely identifies the occurrence of each feature. Each value occurs only once throughout the Nation. Once assigned, the value is associated permanently with its feature. When a feature is deleted, the value for its identifier is retired. The common identifier is stored in a data element named "COM_ID".

Special feature types: Artificial Path, Connector, and Underpass

The feature types artificial path, connector, and underpass serve special functions. The artificial path and connector ensure that the hydrographic network is complete. The artificial path represents the flow of water into, through, and out of features[1] delineated using areas (that is, it serves as a centerline) and also delineates the coastline. The connector fills gaps in the delineation of other features.

An underpass and two relations ("above" and "below"), represent places where features cross at different elevations. An example is where a feature of the type canal/ditch passes over a feature of the type stream/river (see figure 3.) The canal/ditch is encoded as being above an underpass, and the stream/river is encoded as being below the (same) underpass.

Common Identifier	**Feature Type**	**Is Above Identifier**	**Is Below Identifier**
<Common Identifier for the Underpass>	UNDERPASS	*<Common Identifier for the Canal/Ditch>*	*<Common Identifier for the Stream/River>*

[1] These feature types are area of complex channels, estuary, ice mass, lake/pond, playa, reservoir, swamp/marsh, wash, and wide canal/ditch and stream/river.

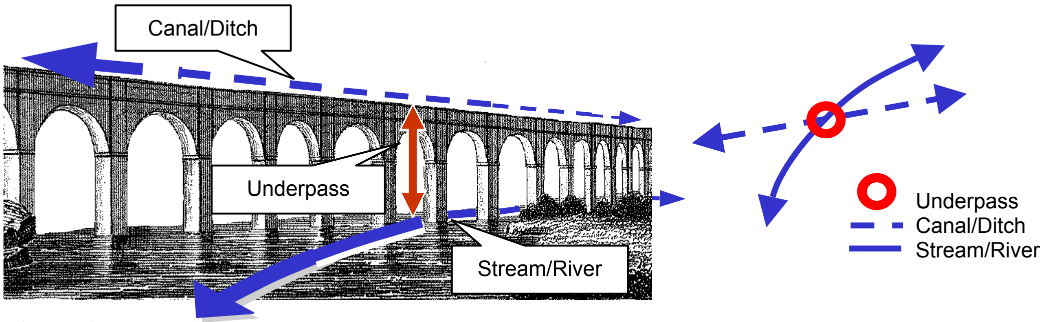

Figure 3. Encoding an underpass.

Appendix A identifies the feature types that may be related to an underpass. Note that underpasses are encoded only where they can be observed from source materials.

Reaches

<u>Main points</u>:

- **Reaches** are segments of surface water with similar hydrologic characteristics.
- Three types of reaches are in use: **transport**, **coastline**, and **waterbody** reaches. A fourth type, the **shoreline** reach, has not been implemented.
- **Transport** and **coastline reaches** are based on **linear** features. For transport reaches for which direction of water flow is known, the lines are **oriented** in the direction of flow. For coastline reaches, the lines usually are oriented so that the water is to the right of the reach.
- **Waterbody reaches** are based on **areal** features, most often of the type lake/pond.
- A **reach code** uniquely labels each reach.
- The **common identifier** uniquely identifies the occurrence of each reach.

A reach is a continuous, unbroken stretch or expanse of surface water. In the NHD, this idea has been expanded to define a reach as a significant segment of surface water that has similar hydrologic characteristics, such as a stretch of stream/river between two confluences, or a lake/pond. Reaches also are defined for unconnected (isolated) features, such as an isolated lake/pond.

Once a reach is defined for a segment of water and assigned a reach code, the reach will rarely be changed, if at all. Many activities for improving and updating the data, such as the integration of more accurate coordinate data, the replacement of linear feature delineations with areas, or the addition of smaller features, change only the alignment of existing reaches and do not require that they be redefined.

The stability of reach definition and reach code assignment makes reaches a useful foundation for geocoding observations and statistics. Changes to the surface waters (for example, the creation of a new reservoir) and corrections to erroneous delineations of reaches, of course, would change reaches and reach codes.

The NHD is the latest refinement of reaches and reach codes. Information about earlier implementations is in Appendix D

Reach types and delineation

Three types of reaches are in use: transport, coastline, and waterbody reaches. A fourth type, shoreline reach, has not been implemented.

Transport reach

A transport reach represents the pathway for the movement of water through a drainage network. These reaches also are used to encode the direction in which water flows along the reach when the direction is known. They provide a basis on which locations of observations can be geocoded and linked to the drainage network.

Delineation

Lines delineate transport reaches. Only lines that delineate features of the types canal/ditch, pipeline, stream/river, artificial path, and connector delineate transport reaches. For transport reaches for which the direction of flow is known, the lines are oriented in the direction of the flow of water. Note that the direction of flow is not always known (for example, where source materials are ambiguous) or uniform (for example, in tidal areas), and so some lines are not oriented in the direction of flow.

Three general rules determine the location of the ends of transport reaches: the underlying feature rule, the confluence-to-confluence rule, and the branched path rule.

Underlying feature rule

The delineation of a transport reach follows that of one or more features. Where two or more features are followed, a transport reach follows delineations of :

- features of the same type (for example, exclusively stream/river) or
- features of the same type, in combination with those of types artificial path and/or connector. For an artificial path to be included, the areal feature through which the artificial path is delineated must be of the same type as the linear feature with which the artificial path makes up the reach. For example, the delineation of a reach may follow an artificial path through an areal canal/ditch and a contiguous linear canal/ditch.

A transport reach always follows the entire delineation of the underlying feature or features; the delineation of a feature is not split among reaches. Transport reaches abut and do not overlap.

Confluence-to-confluence rule

In the confluence-to-confluence rule, a transport reach is a stretch of water between:

- confluences,
- a head and a confluence,
- a confluence and a mouth or other terminus, or
- a head and a mouth or other terminus.

In the application of this rule, divergences serve the same role as confluences. Reaches defined by this rule must be contiguous and may not branch (see figure 4).

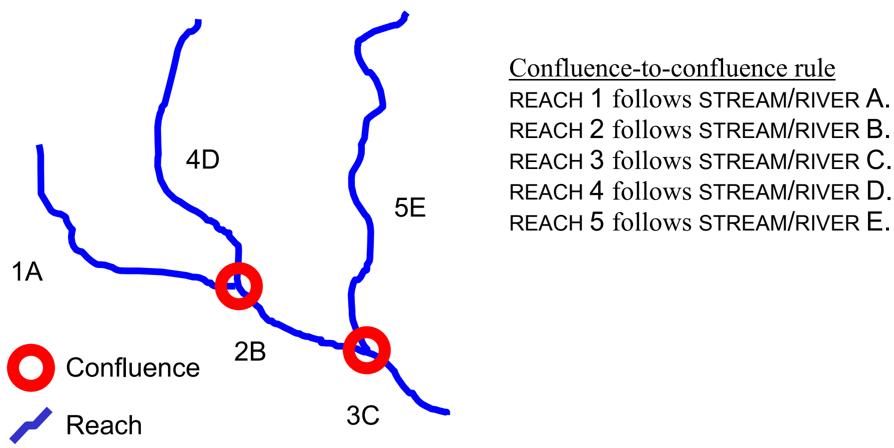

Figure 4. Confluence-to-confluence reach delineation.

Note that some confluences are not considered to be significant enough to break the delineation of a reach. Thus, although transport reaches start and end at confluences, not every confluence causes a transport reach to start or end (see Appendix E for more information).

Branched path rule

A branched path transport reach connects reaches that enter and exit an areal feature (see figure 5). Reaches that follow this rule occur most often in large[2] features of type lake/pond and swamp/marsh, and they also may occur in other areal features. Artificial paths delineated within the areal feature provide the lines needed to delineate this special transport reach. The reach may branch and at times be discontiguous.

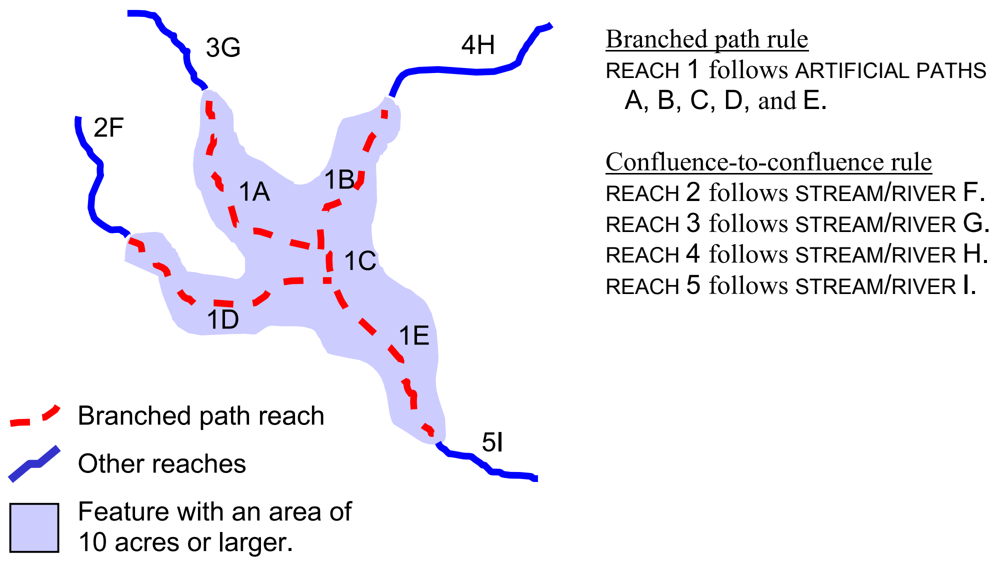

Figure 5. Branched path reach delineation.

The branched path transport reach avoids the need to define flow channels, confluences and divergences, and confluence-based transport reaches in areal features. It is used where the information needed to delineate these items reliably is not available, and at other places.

Application of, and deviation from, the rules

The underlying feature, confluence-to-confluence, and branched path rules govern the delineation of most transport reaches. These rules, however, have exceptions. Unusual configurations of features require modification of the rules, as do the variable condition and ambiguities of information sources. In places where unusual configurations of features or ambiguities in sources occur more often, a larger percentage of reaches delineated using modified rules will be found. Appendix E lists more examples of reach delineation rules and exceptions to the rules.

Coastline Reach

A coastline reach represents a section of coastline along the Atlantic, Pacific, or Arctic Oceans, the Great Lakes, the Gulf of Mexico, or the Caribbean Sea. These reaches provide a basis for geocoding locations of observations along the coastline.

Artificial paths that follow the coastline provide the lines used for coastline reach delineation. The delineation of a coastline reach may follow one or more artificial paths. A coastline reach always follows the entire delineation of the underlying artificial path or paths; the delineation of an artificial path is not split among reaches. Coastline reaches abut and do not overlap.

The lines are usually oriented so that the water is to the right of the line. This results in a general orientation of coastline reaches northward along the Atlantic Ocean, southward along the Pacific Ocean, eastward along the Gulf of Mexico, westward along the Arctic Ocean and the U.S. side of the Great Lakes, and counterclockwise around islands.

[2] Large areal features cover 10 or more acres (approximately 4.05 or more hectares).

A coastline reach is delineated for coastal islands that have a drainage network or more than 5 miles (approximately 8.06 kilometers) of isolated drainage. Other coastal islands may or may not be delineated with a coastline reach.

The ends of coastline reaches occur where transport reaches discharge into the oceans, Gulf of Mexico, Caribbean Sea, or Great Lakes (although not every point of discharge is the end of a coastline reach). At the mouth of an areal stream/river, coastline reaches end where the artificial path used to delineate the transport reach intersects the coastline.

Waterbody reach

A waterbody is a hydrographic feature delineated using areas. Reaches assigned to waterbodies are termed waterbody reaches. These reaches provide a means to geocode observations for areas of water. (In contrast, transport reaches represent the path of a flow of water and provide a means of geocoding observations along the path.) Areal delineations of features provide the areas used to delineate waterbody reaches[3].

Shoreline reach

The shoreline reach has not been implemented and is discussed for information purposes only. A shoreline reach would represent all or part of the shoreline of an inland waterbody. Analogous to coastline reaches, they would provide a basis for geocoding locations of observations along the shoreline. Lines would delineate shoreline reaches. These reaches would abut and not overlap. The types of features that would provide these lines are being investigated, as are questions of the direction, relative to the water, in which these reaches should be ordered, means of handling islands, and rules for deciding where these reaches would start and stop.

Reach code

A reach code is a numeric code that uniquely labels each reach. This 14-digit code has 2 parts: the first 8 digits are the hydrologic unit[4] code for the subbasin in which the reach exists; the last 6 digits are assigned in sequential order, and arbitrarily among the reaches.

Each reach code occurs only once throughout the Nation. Once assigned, a reach code is associated with its reach permanently. If a reach is deleted, its reach code is retired. A reach code should not be altered.

Reach codes can serve to geocode an observation to a reach or a position along a reach. Observations can be geocoded to an entire reach by associating the reach code with the observation data, or to sections of a transport, coastline, or (the planned) shoreline reach by using the reach and reach code as the basis of a linear referencing system.

Reach codes are stored in data elements named "RCH_CODE". In addition to the reach code, the date on which the code was assigned in the NHD is encoded. The date is stored in data elements named "RCH_DATE".

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[3] Features of the type lake/pond most often are the basis for waterbody reach delineation in the initial release. An exception is the State of Washington where, on the basis of work done by a State agency, waterbody reaches are based on areal delineations of the features types ice mass, lake/pond, reservoir, and swamp/marsh. In the future, feature types that could provide the basis for waterbody reach delineation are area of complex channels, estuary, lake/pond, playa, sea/ocean, wash, and areal delineations of canal/ditch and stream/river.

[4] Hydrologic units (Seaber, Kapinos, and Knapp, 1987) provide a systematic means of identifying and subdividing river-basin units. The subbasin is the fourth-level subdivision of hydrologic units. Additional information about hydrologic units is in appendix F.

Common identifier

In addition to identifying each feature, the common identifier uniquely identifies each reach. Each 10-digit integer value occurs only once throughout the Nation. Once assigned, the value is associated permanently with its reach. When a reach is deleted, the value for its identifier is retired. The common identifier is stored in a data element named "COM_ID".

Reach summary

Table 1 summarizes the types, related items, delineation, and underlying features of reaches.

Table 1. Summary of reach organization by type.

Reach Type	Related Information	Delineation	Features Types That Provide Delineation
Coastline	Reach Code Reach Code Assignment Date	Line	Artificial Path
Shoreline	*This reach type has not been implemented.*		
Transport	Reach Code Reach Code Assignment Date	Line	Artificial Path, Canal/Ditch, Connector, Pipeline, Stream/River
Waterbody	Reach Code Reach Code Assignment Date	Area	Only Lake/Pond for the initial release in most places; Ice Mass, Lake/Pond, Reservoir, and Swamp/Marsh in the initial release for Washington State.

Encoding flow relations among transport and coastline reaches

Main points:

- By using **flow relations** to relate **transport and coastline reaches**, surface waters are modeled as a **connected network**.
- **Flow relations** encode:
  - **network connectivity** among reaches.
  - the **direction of water flow** between transport reaches.
  - the **traversal of the coastline** along coastline reaches.
  - the **order of termini** of drainage networks along the coastline.
- **Sequence numbers** order flow relations of transport reaches along the interior of a transport or coastline reach.

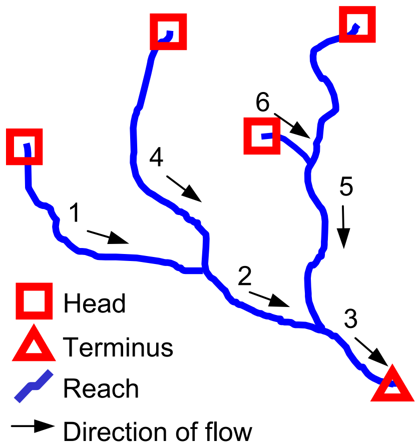
Flow relations among transport and coastline reaches encode drainage network connectivity among reaches independently from their delineations. Relations among transport reaches define a connected hydrographic network and encode the direction of water flow among reaches. This connectivity enables hydrologic sequencing of reaches (what is upstream and downstream of a given point in the hydrographic network) and navigating the network in an upstream or downstream direction. Similarly, relations among coastline reaches allow the traversal of the coastline using reaches. Relations among transport and coastline reaches connect hydrographic networks to the coastline and enable the ordering of the mouths of these networks along the coastline. Flow relations are especially useful in applications that require information about connectivity among, but not about, the underlying delineations and coordinate positions of reaches.

Flow relations are encoded by identifying a pair of reaches that touch and describing the flow of water between the reaches. Note that the direction of flow is not always known (for example, where source materials are ambiguous); in these cases, flow relations are not created.

Direction of flow using flow relations

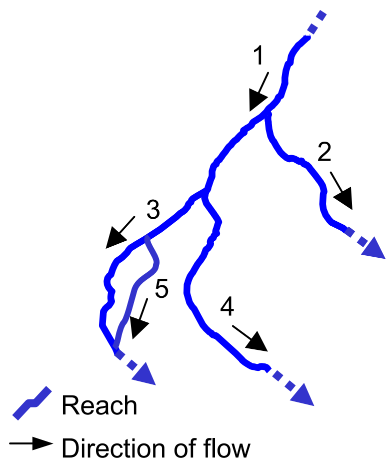
The common identifiers for a pair of reaches and a description of the direction of water flow between the reaches are used to encode flow relations. Five values describe the direction of water flow between transport reaches; a sixth value describes connections between pairs of touching coastline reaches or between touching transport and coastline reaches:

1. in — the first reach flows into the second reach at the top of, or at an interior point along, the second reach. (See Figure 6, Figure 7, Figure 8, and Figure 9.) Most flow relations between transport reaches are of this type.
2. out — the first reach flows from the second reach from an interior point somewhere along the second reach. (See Figure 7.)
3. bidirectional — the first and second reaches touch end-to-end, or the first reach touches an interior point along the second reach, and flow can occur in either direction. *This value has not been implemented.*
4. network start — the second reach starts at a head of the drainage network. (The field for the first reach is null.) (See Figure 6.)
5. network end — the first reach ends at a terminus, other than at the coastline, of a drainage network. (The field for the second reach is null.) (See Figure 6.)
6. non-flowing connection —
   a) between coastline reaches. Coastline reaches are directed so that water is to their right. The flow relation between coastline reaches is ordered so that the end of a coastline reach (the first reach in the relation) connects to the beginning of, or to some point along, the next coastline reach (the second reach in the relation) that continues the traversal of the coastline, with water to the right of the traversal. Flow relations between coastline reaches allow the coastline to be traversed. (See the flow relation between coastline reaches 1 and 4 in Figure 9.)
   b) between a transport and coastline reach. The transport reach connects to the coastline reach that continues the traversal of the coastline from the place where they touch. The flow relation is ordered so that the end of the transport reach (the first reach in the relation) connects to the beginning of, or at some point along, the coastline reach (the second reach in the relation) that continues the traversal of the coastline. Relations between coastline and transport reaches allow the order in which transport reaches intersect the coastline to be computed. (See the flow relation between transport reach 3 and coastline reach 4, and transport reach 6 and coastline reach 1, in Figure 9.)



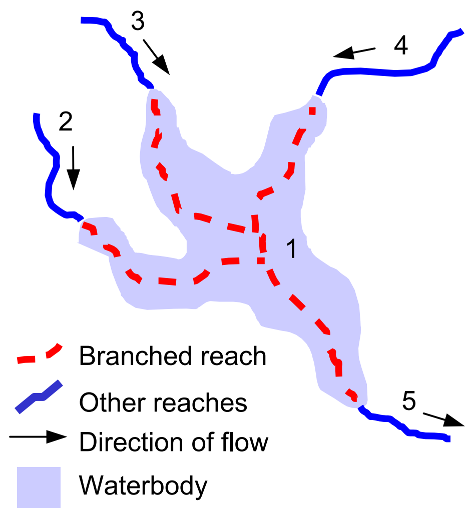
Flow Relations		
Common Identifier for First Reach	Common Identifier for Second Reach	Direction Description
1	2	In
4	2	In
6	5	In
5	3	In
2	3	In
0	1	Network Start
0	4	Network Start
0	6	Network Start
0	5	Network Start
3	0	Network End

Figure 6. Flow relations illustrating in, out, network start, and network end directions. (A common identifier value of "0" represents a null entry.)



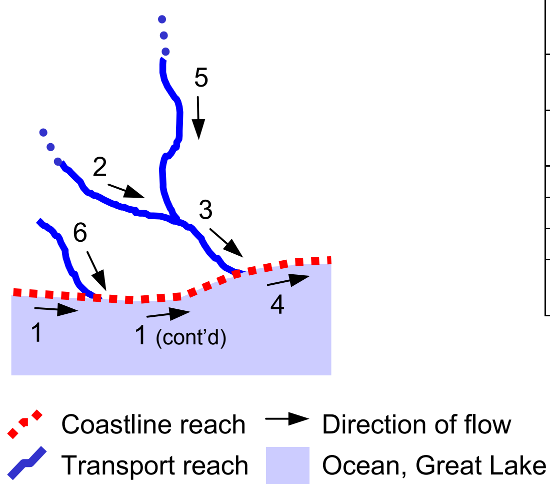
Flow Relations		
Common Identifier for First Reach	Common Identifier for Second Reach	Direction Description
1	3	In
1	4	In
2	1	Out
5	3	Out
5	3	In

Figure 7. Flow relations illustrating out and in directions.



Flow Relations		
Common Identifier for First Reach	Common Identifier for Second Reach	Direction Description
2	1	In
3	1	In
4	1	In
1	5	In

Figure 8. Flow relations for a branched path reach.



Flow Relations		
Common Identifier for First Reach	Common Identifier for Second Reach	Direction Description
1	4	Non-flowing Connection
3	4	Non-flowing Connection
2	3	In
5	3	In
0	6	Network Start
6	1	Non-flowing Connection

Figure 9. Flow relations illustrating non-flowing connections.
(A common identifier value of "0" represents a null entry.)

Flow relations are stored as four data elements. The common identifier for the first reach is stored in a data element named "COM_ID_1". The common identifier for the second reach is stored in a data element named "COM_ID_2". The direction description is stored in two data elements: as a character string in a data element named "DIR_TEXT" and as a numeric alias[5] in a data element named "DIRECTION".

[5] These are the numeric codes for the direction descriptions:
"709" for In.
"710" for Out.
"711" for Bidirectional.
"712" for Network Start.
"713" for Network End.
"714" for Non-flowing Connection.

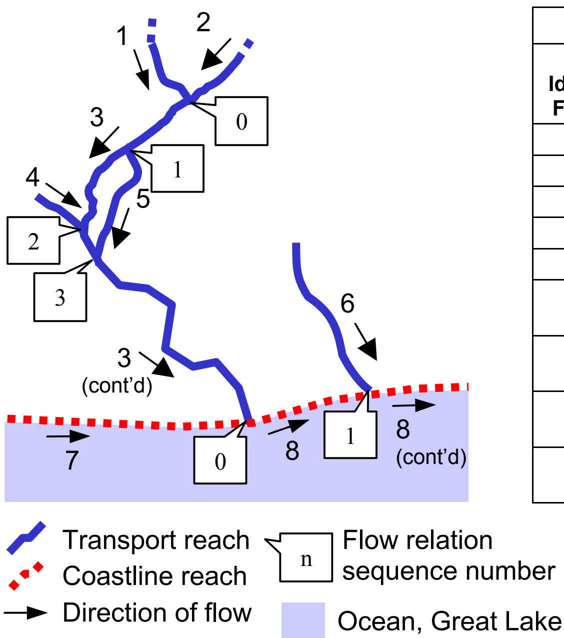
Sequencing flow relations along a reach

Sequence numbers order flow relations of transport reaches that flow into or out of the interior of another transport reach. The reach that flows in or out is always the first reach in the flow relation; the reach along whose interior the inflowing and outflowing reach is being sequenced is the second reach in the flow relation. The flow relations are numbered sequentially, starting with 1, from upstream to downstream along the interior of the second reach.

Sequence numbers also order flow relations of transport reaches that have a non-flowing connection to the interior of a coastline reach. The non-flowing connection flow relations of intersecting transport reaches are numbered sequentially, starting with 1, from start to end along the interior of the coastline reach.

A sequence number of 0 means that the first reach touches the second reach at its end and not along its interior. The sequence number is stored with the flow relations in a data element named "SEQUENCE".

Figure 10 illustrates the sequencing of flow relations.



Flow Relations			
Common Identifier for First Reach	**Common Identifier for Second Reach**	**Direction Description**	**Sequence**
1	3	In	0
2	3	In	0
5	3	Out	1
5	3	In	3
4	3	In	2
3	8	Non-flowing Connection	0
0	6	Network Start	0
6	8	Non-flowing Connection	1
7	8	Non-flowing Connection	0

Figure 10. Sequencing flow relations along transport and coastline reaches.
(A common identifier value of "0" represents a null entry.)

Identifying level paths through the drainage network

Main points:
- A **level path** is a sequence of transport reaches that traces the main stem for a given flow of water.
- **Stream level** identifies the main path to which a transport reach belongs.
- The **delta level** identifies main paths of water flow among flow relations.

Transport reaches and flow relations provide the components of the drainage network. The level path builds on these elements to create a sequence of transport reaches that trace the main stem for a given flow of water. The level path traces the flow between a head and the next largest flow of water or between a head and the ocean. Geographic names often follow these paths.

Level paths are encoded by associating stream levels to transport reaches and by associating a delta level with flow relations.

Stream level

The stream level is a numeric code that identifies each main path of water flow through a drainage network. Stream level is assigned by identifying the terminus of a drainage network (see Figure 11). The lowest value[6] for stream level is assigned to a transport reach at the end of a flow and to upstream transport reaches that trace the main path of flow back to the head. The stream level value is incremented by one and is assigned to all transport reaches that terminate at this path (that is, all tributaries to the path) and to all transport reaches that trace the main path of the flow along each tributary back to its head. The stream level value is incremented again and is assigned to transport reaches that trace the main path of the tributaries to to their heads. This process is continued until all transport reaches for which flow is encoded are assigned a stream level.

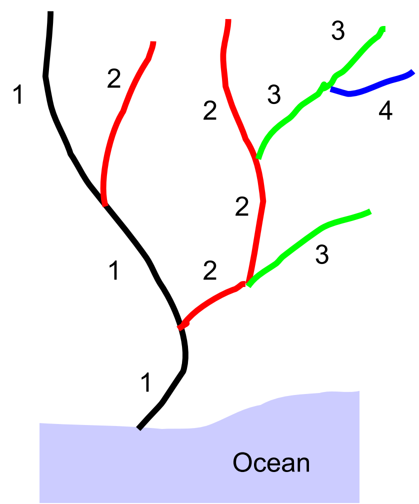


Figure 11. Stream level assignment for a simple drainage network.

For example (see Figure 12), the Mississippi River terminates at the Gulf of Mexico. The transport reaches that trace the main flow of the river, from the head to the mouth on the Gulf, are assigned a stream level of 1. The transport reaches that trace the main flow of each tributary to the Mississippi River (such as the Ohio/Monongahela Rivers) from their heads to their termini on the Mississippi River, are assigned a stream level of 2. The transport reaches that trace the main flow of each tributary to the level 2 tributaries (such as the Tennessee River, which is a tributary to the Ohio/Monongahela Rivers), from each head to each mouth on their level 2 tributary, are assigned a stream level of 3.

---

[6] The lowest value for stream level is:

- "1" for transport reaches that terminate at the Atlantic, Pacific, or Arctic Oceans, the Gulf of Mexico, or the Caribbean Sea.
- "2" for transport reaches that terminate at the Great Lakes or the Great Salt Lake.
- "3" for transport reaches that terminate at the boundary of the United States with Canada or Mexico.
- "4" for transport reaches that terminate at any other place (isolated drainage).

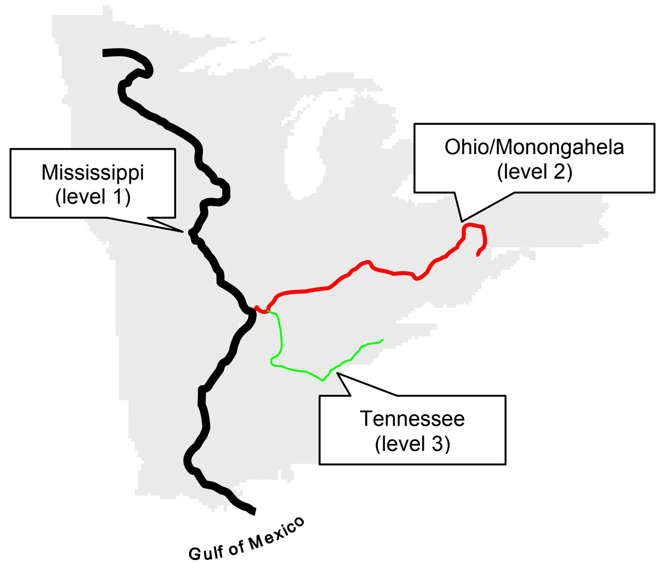


Figure 12. Stream level assignments along the Mississippi River.

Ideally, each main path would trace the flow of the largest volume of water. Stream levels encoded in two predecessors[7] to the NHD were based on flow volume data, and these paths were retained wherever possible. Data about flow volumes were not available for other reaches. Instead, the path with the same geographic name was used to determine the level path. Where a geographic name was not available or known, the longest and straightest path was used to determine a main path. Where this rule did not adequately discriminate among the choices, the rightmost (looking upstream) transport reach was assumed to be the continuation of a main path.

Stream level is stored in a data element named "LEVEL". The special value "-9998" means that a value can be applied to the transport reach but has not been specified. This value usually occurs where flow relations cannot be determined or have not been encoded. Without this information, main paths cannot be identified and stream level cannot be assigned. This value is also assigned to coastline reaches.

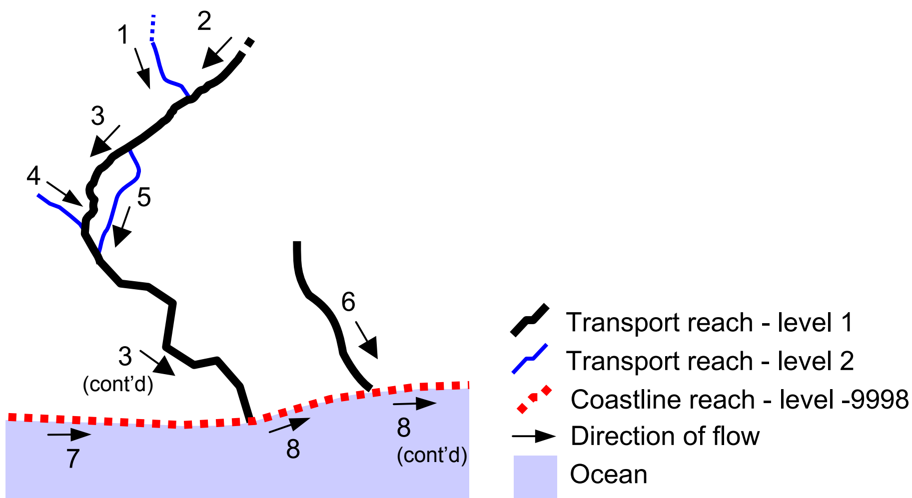
Tracing stream levels among reach flow relations

To help identify main paths in the flow relations table, the difference, or delta level, between the stream levels of inflowing and outflowing reaches is encoded. To calculate this value, the stream level of the second reach in the relation is subtracted from the stream level of the first reach in the relation (see Figure 13).

Delta levels of "0" mean that a relation links two reaches that are on the same main path. In most other cases, the delta level will have a value of "1". Areas of complex divergence and braided stream configurations can yield other values. A special value of "-9999" means that a value for delta level is not applicable to the relation, and this occurs when the direction is bidirectional, network start, network end, or non-flowing connection. A special value of "-9998" means that a value could not be specified because the stream level was not specified for one or both reaches that are associated by the flow relation.

The values are stored with the flow relations in a data element named "DELTA_LVL".

[7] Reach File Versions 1 and 2, which are described in Appendix D.



Flow Relations				
Common Identifier for First Reach	**Common Identifier for Second Reach**	**Direction Description**	**Sequence**	**Delta Level**
1	3	In	0	1
2	3	In	0	0
5	3	Out	1	1
5	3	In	3	1
4	3	In	2	1
3	8	Non-flowing Connection	0	-9999
0	6	Network Start	0	-9999
6	8	Non-flowing Connection	1	-9999
7	8	Non-flowing Connection	0	-9999

Figure 13. Difference in stream levels encoded with flow relations.

Metadata and digital update units

Main points:

- **Metadata**, or data about data, are data that describe the content, quality, condition, or other characteristics of data.
- A **digital update unit** is a collection of one or more features and (or) reaches to which a set of metadata values apply. It provides the means to associate different values for metadata elements with features and reaches.
- In the initial release of the NHD, there are three sets of metadata:
  1. a general **NHD** set of values for metadata elements that apply to all data.
  2. **cataloging unit** digital update units that associate unique values for metadata elements with sets of reaches.
  3. **quadrangle** digital update units that associate unique values for metadata elements with sets of features.
- Metadata are provided in **text files** associated with a data set (for the NHD metadata) or with a digital update unit (for the cataloging unit and quadrangle metadata).

Metadata, or data about data, are data that describe the content, quality, condition, and other characteristics of data. Metadata answer questions such as "How current are these data?"; "How accurate are they?"; "Are there any restrictions on their use?"; "What is their coordinate system?"; and many others. Metadata help organizations manage data, advertise and share data, and make informed use of data.

Metadata for the NHD use data elements from the "Content Standards for Digital Geospatial Metadata" (Federal Geographic Data Committee, 1994). The standard allows the identity, quality, spatial data organization and reference, entity and attribute definitions, distribution sources and forms, and metadata of the data to be documented. The metadata are provided as text files.

For the NHD, a general set of metadata accompanies each set of data. This NHD (for National Hydrography Dataset) metadata provides general information that applies to all data.

Digital update units

Within the NHD, values differ for metadata elements such as currentness and quality. For example, features originate from more than 1,800 datasets of different vintages, and reaches from more than 2,100 datasets. In the future, many organizations will collaborate to maintain and improve the data. These new data will differ in currentness, source, accuracy, and other characteristics. A single document that provides metadata for these dynamic and varied data would be either very general or very unwieldy.

Digital update units associate specific metadata information with selected features and reaches. A digital update unit is a collection of one or more features and (or) reaches to which a set of metadata values applies. These values include only those needed to describe unique aspects of the associated features or reaches. A feature or reach may be a member of one or more digital update units.

Metadata associated with digital update units supplement information provided in the NHD metadata. These digital update unit metadata amplify, and in some cases replace, the more general information provided in the NHD metadata.

In the initial release of the NHD, there are two types of digital update units; subbasin and quadrangle digital update units (see Figure 14):

- subbasin digital update units associate reaches with metadata about sources of information and processing steps used to construct reaches and analysts' notes about unique situations encountered in the process.

- quadrangle digital update units associate features with metadata about the sources of information (including the currentness of the data) and processing steps used to construct features.

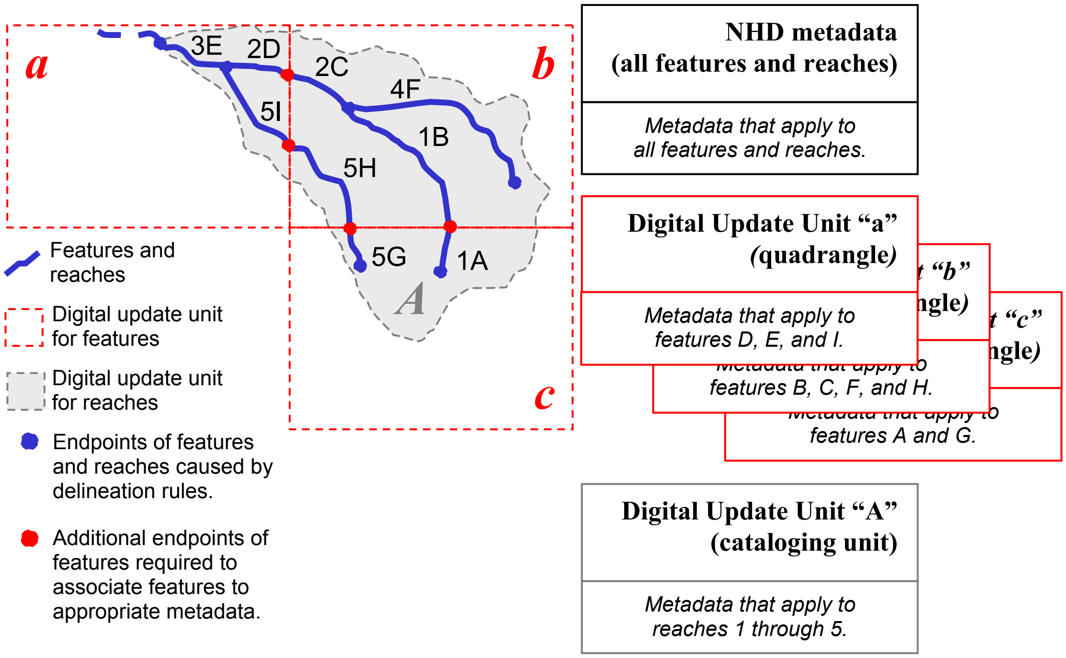


Figure 14. Digital update units associate metadata with a set of features and (or) reaches. Metadata associated with each digital update unit amplify or replace information provided as NHD metadata.

As development and improvement of the data continue, additional digital update units will be created. These may have collections of features, reaches, and shapes different from the digital update units in the initial release. These new digital update units also may have metadata elements different from those included in the digital update units in the initial release.

Digital update units are assigned unique identifiers and stored in data elements named "DUU_ID".

Geographic names

Main points:
- A **geographic name** is the proper name, specific term, or expression by which a particular geographic entity is known.
- **Reaches** carry the geographic name most often; **features** carry names if they do not underlie a reach.

A geographic name is "the proper name, specific term, or expression by which a particular geographical entity is, or was, known" (Orth and Payne, 1997, p. 43). Geographic names designated as being official for Federal use are encoded for many reaches and features. These names were taken from the National Geographic Names Database of the Geographic Names Information System[8] (USGS, 1995), the Federal Government's primary source for identifying official names.

Reaches and features can carry geographic names (see Figure 15 and Table 2). Reaches carry geographic names most often. If there is no reach to carry a name, then the feature carries the name. **Appendix A** lists the types of features that may carry names.

Geographic names are stored in data elements named "NAME". In addition, the eight-digit identifier for a name in the Geographic Names Information System is stored in data elements named "GNIS_ID".

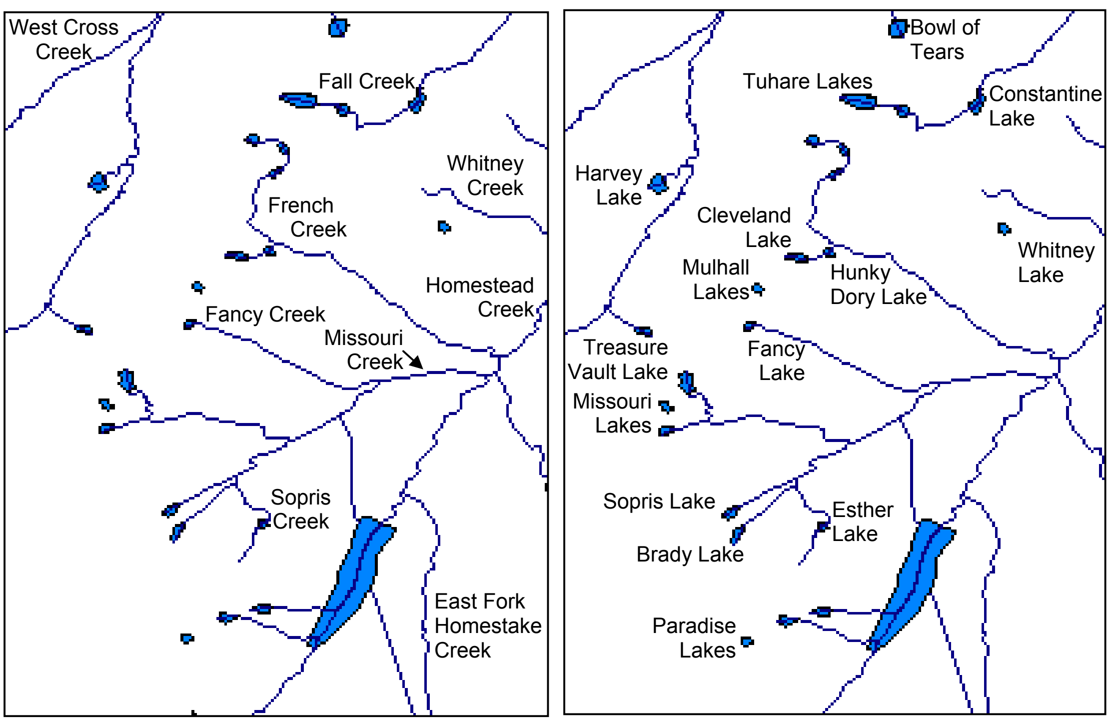


Figure 15. Geographic names applied to transport and waterbody reaches.

Note that geographic names have not been applied to all reaches and features. Names are applied to transport and coastline reaches that were named in the USEPA's Reach File version 3 (see Appendix D). Names are also applied to waterbody reaches and features delineated using points or areas in cases where batch processes can reliably associate the name with the reach or feature.

[8] Information about the Geographic Names Information System is available online at http://mapping.usgs.gov/www/gnis/.

Table 2. Reaches and features that can carry geographic names
(Notes for table: (1) Type: The table lists all reach and feature types defined for the NHD. Note that not all types have been collected in the initial release. (2) Geographic name: An "X" in the column indicates that a geographic name may be associated with reaches or features of this type. Note that geographic names have not been encoded for many reaches and features. (3) An asterisk (*) means that the feature or names are not in the initial release of the NHD. (4) Coastline reaches carry the name of the water feature that they bound. (5) For the State of Washington, waterbody reaches carry the names of the features types ice mass, lake/pond, reservoir, and swamp/marsh. Elsewhere, waterbody reaches carry the names of the features type lake/pond only.)

Type	Geographic Name
Reach	
Coastline	X
Transport	X
Shoreline < *Not implemented* >	
Waterbody	X
Features	
Anchorage *	X *
Area of Complex Channels	
Area To Be Submerged	X
Artificial Path	On Reach
Bay/Inlet *	X *
Bridge	X
Canal/Ditch	On Reach
Connector	On Reach
Crevasse Field *	X *
Dam/Weir	X
Estuary *	X *
Fish Ladder *	
Flume *	X *
Foreshore	X *
Fumarole	X
Gaging Station	
Gate	
Geyser	X
Hazard Zone	
Ice Mass	X, On Reach in Washington State
Inundation Area	X
Lake/Pond	On Reach
Lock Chamber	X
Mud Pot	X
Nonearthen Shore	
Pipeline	On Reach
Playa	X
Post *	
Rapids	X
Reef	X
Reservoir	X, On Reach in Washington State
Rock	X *

Type	Geographic Name
Sea/Ocean	X
Sink/Rise *	X *
Snag/Stump *	
Sounding Datum Line	
Special Use Zone	
Special Use Zone Limit	
Spillway	
Spring/Seep	X
Stream/River	On Reach
Submerged Stream	X
Swamp/Marsh	X, On Reach in Washington State
Tunnel	X
Underpass	
Wall	
Wash	X
Water Intake/Outflow *	
Waterfall	X
Well	X
Wreck *	X *

Characteristics of domestic geographic names

(Adapted from "Principles, policies, and procedures: domestic geographic names" (Orth and Payne, 1997, p. 3); "The national gazetteer of the United States of America: concise: (USGS, 1990, p. xi); and "Geographic Names Information System" (USGS, 1995, p. 7-8).)

Geographic names normally originate in and are influenced by spoken language. It is important to remember this fact because many people are concerned with written forms of names, including matters of spelling, capitalization, word form, and writing marks, that may have little to do with the way names are spoken. Geographic names in the United States most often reflect English, French, and Spanish naming traditions.

Most geographic names are binomial in that they have two parts, denoting specific and generic information. The generic part tells the kind of place, feature, or area to which the name refers and usually is a single topographic term, such as brook, creek, lake, spring, or river. The specific part uniquely identifies the particular place, feature, or area, and it may consist of one or more words. For example:

Geographic Name	Specific	Generic
Hudson River	Hudson	River
Lake Superior	Superior	Lake
Arroyo Chico	Chico	Arroyo
Rio Grande del Rancho	Grande del Rancho	Rio
Foot of the Mountain Run	Foot of the Mountain	Run

The binomial (two-part) form of specific and generic information is strong and in written usage often leads to combining words in the specific part of the name, such as *Threemile* Run and *Redhill* Gulch. The names of some features can be long, especially if the specific part is a prepositional phrase: Cliffs of the Seven Double Pillars, Foot of the Mountain Run, and Cañon del Rajadero de los Negros.

Some geographic names have a "false" generic that does not describe the feature correctly. For features of the type stream/river, common false generics are terms for depressions in the Earth's surface (such as "draw", "gully" or "gulch") that usually are not defined as applying to water flowing through the depression.

Some names have rare generic forms. Examples include colorful American names such as Bowl of Tears (lake), Butlers Toothpick (pinnacle rock), Titans Piazza (hill), and Devils Racepath (ridge). Among variations of the binomial form are one-word names that require a capitalized article: The Canal, The Lagoon, The Lakes, and La Laguna.

Entry conventions for geographic names

The entries for geographic names include uppercase and lowercase alphabetic, numeric, and punctuation and other special characters. Most names are entered in the way they are commonly written; for example "Adams Creek" and "Green Lake". Exceptions include the following:

- *Diacritical mark.* A diacritical mark is a mark near or through a character or combination of characters. The mark indicates a phonetic value (a spoken sound) different from that given the unmarked or otherwise marked character. For example, the acute accent ("´") is the diacritical mark in río, and the tilde ("~") is the diacritical mark in cañada and cañoncito. If the entry for a name has a diacritical mark in the Geographic Names Information System, the mark is retained in the NHD[9].

[9] Geographic names are encoded using the "Latin 1" character set (International Organization for Standardization (ISO) standard 8859-1).

- *Generic part entered last*. Sometimes the generic part of the name may be in the first position, followed by the specific part. For example, the name Rio Grande del Rancho begins with the generic "rio" (from the Spanish río for river). In most of these cases, the geographic name is entered with the position of the generic within the name reversed. For example, Rio Grande del Rancho becomes "Grande del Rancho, Rio". The generic, however, is not reversed if the specific part of the name contains an Arabic number.

- *Initial definite articles entered last.* Some geographic names start with a definite article (for example, "a" and "the" in English, and "el", "la", "los", and "las" in Spanish). Examples include El Capitan Wash and The Cat Hole. In many of these cases, the geographic name is entered so that the initial definite article is provided last. For example, El Capitan Wash becomes "Capitan Wash, El" and The Cat Hole becomes "Cat Hole, The".

Common identifier

Main points:
- The **common identifier** is a 10-digit integer value that uniquely identifies each feature or reach.
- Common identifiers are the **basis for relating** features, underpasses, reaches, and digital update units.
- They are used to **communicate and share corrections and updates** among organizations.
- **Never change** a common identifier.

The common identifier is a 10-digit integer value that uniquely identifies each feature or reach. Each value occurs only once throughout the Nation. Each feature and reach is assigned an identifier, stored in the data element named "COM_ID". Once assigned, the identifier is associated permanently with its feature or reach and should not be altered. When a feature or reach is deleted, its identifier is retired.

Common identifiers serve several purposes. They are the basis for relating features and reaches for several purposes, including the following:

- underpasses: the data elements "ABOVE_ID" and "BELOW_ID" store the common identifiers of the features above and below an underpass respectively.

- reach flow relations: the data elements "COM_ID_1" and "COM_ID_2" store the common identifiers of the reaches that participate in a flow relation.

- linear features and their transport and coastline reaches: the data element "RCH_COM_ID" stores the common identifier of the transport or coastline reach that underlies a linear feature.

- waterbodies and their waterbody reaches: the data element "RCH_COM_ID" stores the common identifier of the waterbody reach that underlies a waterbody.

- waterbodies and linear features they contain: the data element "WB_COM_ID" stores the common identifier of the waterbody that contains a linear feature.

- features and reaches, and their digital update units: the data element "COM_ID", when associated with the data element "DUU_ID", associates features and reaches with their digital update units.

Common identifiers are also the basis for tracking and sharing deletions, additions, and modifications of features, reaches, and relations.

Coordinates and related measures

Main points:

- **Latitude** and **longitude** values are used for horizontal coordinates.
- The horizontal datum is the **North American Datum of 1983**.
- **Lengths** and **areas** of features and reaches, computed from a projected coordinate system, are supplied for convenience.
- **Elevations of surfaces** where water pools are supplied for some features.

Positions are encoded using a common coordinate referencing system. Other measurements, including lengths, areas, and selected surface elevations, also are encoded.

Horizontal coordinate referencing system

The locations of points, lines, and the boundaries of areas are encoded using geographic (longitude-latitude) coordinates. The coordinates are encoded in decimal degrees, with west longitude and south latitude represented by negative values. The horizontal datum is the North American Datum of 1983 (NAD83).

Lengths and areas

Lengths of linear features and areas of areal features are supplied for convenience in applications that require these measures. The coordinate data were projected from longitude-latitude coordinates to the Albers Equal Area projection, and lengths and areas were calculated and saved. The parameters for the projected coordinate systems are shown below:

Geographic Area	Standard Parallels		Central Meridian	Projection Origin
Conterminous United States	29° 30' North	45° 30' North	96° West	23° North
Alaska	55° North	65° North	154° West	50° North
Hawaii	8° North	18° North	157° West	3° North
Puerto Rico and the Virgin Islands	8° North	18° North	66° West	3° North

The North American Datum of 1983 was specified for the projected coordinate system. The distance units of the projected system were meters.

Lengths are computed in meters and stored in data elements named "METERS". Areas are computed in square kilometers and stored in data elements named "SQ_KM".

Elevations of water surfaces

The elevation of water surfaces where water pools is encoded for a few features. Water surface elevations may be encoded for features of the type area to be submerged, canal/ditch, inundation area, lake/pond, reservoir, and stream/river. Note that these elevations have not been entered for most features. The vertical datum for the conterminous United States and Alaska is the National Geodetic Vertical Datum of 1929. For Puerto Rico and the Virgin Islands, the datum is Local Mean Sea Level.

Elevations are recorded in meters and stored in data elements named "ELEV". Two encoded values have special meanings. A value of -9999 means that an elevation value will not be applied to the feature. A value of -9998 means that a value can be applied to the feature but has not been specified.

In addition to the elevation, the prevailing condition (for example, “average water elevation”) to which the elevation applies is provided. The condition is stored as a text string in data elements named "STAGE". Where the "ELEV" field has a value of -9999 or -9998, the "STAGE" field is blank.

Data Quality

Main points:

- Because of **variations** within the NHD, it is difficult to make general statements about data quality. **Metadata** associated with the **digital update units** are the best source of information for a place.
- Statements of data quality **vary geographically**. Different general statements are made for (1) most of the conterminous United States, Hawaii, Puerto Rico, and the Virgin Islands, (2) the Pacific Northwest, and (3) Alaska.
- **For the conterminous United States (excluding the Pacific Northwest), Hawaii, Puerto Rico, and the Virgin Islands:**
  - Lineage:
    - Two main sources of information are digital line graph and Reach File Version 3 data. The most prominent map scale for sources is 1:100,000; larger scale data are being integrated as part of data improvement activities.
    - Data processing efforts concentrated on creating features, adding artificial paths to areal features, integrating features with reaches and geographic names, orienting features and reaches in the direction of water flow, constructing flow relations, and validating the results of these efforts.
  - Attribute accuracy assessments are based on those for the digital line graph data; geographic name entries are the same as those found in the Geographic Names Information System.
  - Points, nodes, lines, and areas follow topological rules.
  - The data reflect the completeness of the source materials; these sources vary in completeness.
  - The accuracy of horizontal and vertical positions is based on the assessments for the source materials; these sources conformed to the National Map Accuracy Standard.
- Similar approaches are being used to develop data for the **Pacific Northwest** and **Alaska**. Specific statements will be provided when these data are released.

The NHD resulted from a multiyear effort to process and integrate datasets containing delineations and classification of features, reaches, hydrologic units, and geographic names. This section provides an overview of the production processes, sources of information used in these processes, and other statements related to data quality.

This section describes what is "generally true" about the initial release of the data for the conterminous United States, Hawaii, Puerto Rico, and the Virgin Islands. The NHD, even in its initial release, has variations in currentness, processes, and other characteristics. It is important to note that, even before the initial release of the data, collaborative efforts are under way to correct and improve the data. Completion of these efforts will contradict even these "generally true" statements for places where the improvements are made. It is important to review the metadata to understand the condition of data.

Conterminous United States (excluding the Pacific Northwest), Hawaii, Puerto Rico, and the Virgin Islands

The discussion below applies to the conterminous United States (excluding the Pacific Northwest[10]), Hawaii, Puerto Rico, and the Virgin Islands.

[10] In this data quality discussion, the "Pacific Northwest" includes the Pacific Northwest hydrologic region (region 17) and the Williamson, Sprague, and Upper Klamath Lake (Oregon) subbasins (18010201, -02, and –03, respectively). This area includes the State of Washington, most of Idaho and Oregon, and parts of western Montana and Wyoming.

Lineage

Figure 16 illustrates the information sources and processes used to develop the data.

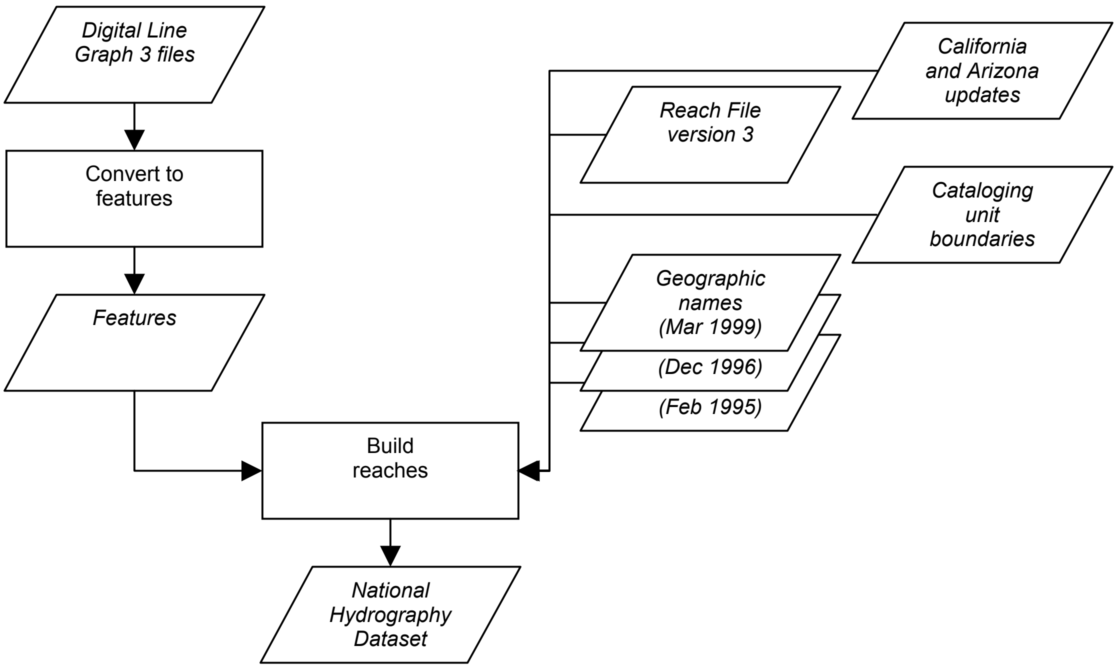


Figure 16. Information sources and processes used to create the NHD.

Information Sources

Sources of information used to construct the initial release of the NHD include:

- Digital line graph 3 (DLG-3) data. These data, captured from USGS topographic maps and unpublished source materials, provide the delineations and classification of features (except for artificial paths in areal features and connectors). The data were organized in the DLG optional format, were tiled in quadrangles, were edge-matched, were from the DLG "hydrography" data category, and were in the Universal Transverse Mercator coordinate system, North American Datum of 1927 (NAD27). The scales of the map source materials used for the initial release of the data are shown below:

Geographic Area	Map Scale of Source Information
Conterminous United States and Hawaii	1:100,000
Puerto Rico	1:20,000 and 1:30,000
Virgin Islands	1:24,000

  Efforts are under way to improve the NHD; most of these involve the collecting data for the conterminous United States from 1:24,000-scale maps, and digital images with positional accuracies commensurate with 1:12,000 and larger scales. Currentness varies by individual maps; see digital update units for more information.

- Reach File Version 3 (RF3) data. These data, developed by the USEPA, provide the starting point for reach delineation, reach codes, direction of water flow information, and positions of geographic names for the feature type stream/river. These data were developed on 1:100,000-scale DLG data for the conterminous United States and Hawaii as part of a previous project.

- Subbasin boundaries. These data, developed by different agencies, are used to assign features and reaches to subbasins.

Geographic Area	Map Scale of Source Information	Originator
Conterminous United States (States of Connecticut, Delaware, Florida, Kentucky, Minnesota, Montana, North Carolina, Oklahoma, South Carolina, and West Virginia)	1:100,000	State agencies in respective States
Conterminous United States (remainder)	1:250,000	USGS
Puerto Rico	1:20,000	USEPA
Hawaii and the Virgin Islands	*< No boundaries needed. Subbasins are based on islands. >*	

- Geographic names.
  - Final version. Extracted in March 1999 from the National Geographic Names Database of the USGS's Geographic Names Information System, these data were the final source of geographic name entries.
  - Earlier versions. Two earlier extracts from the Geographic Names Information System were used to assign names to reaches (December 1996 extract) and waterbodies (February 1995 extract).

- Features. These quadrangle-tiled data, containing features and characteristics, were created from the DLG-3 data.

- California and Arizona updates. These data from California and Arizona State agencies contain additional name assignments and minor spatial and attribute corrections to Reach File Version 3 data.

Processes

Convert DLG data to features

This process converted DLG data to features and associated characteristics and converted the coordinate system to geographic (longitude-latitude) coordinates in the NAD83 in five steps:

1. The USGS's "Batch DLG-3 to DLG-F Conversion System" converted DLG-3 nodes, lines, areas, and associated attribute codes to temporary features and associated characteristics. Known conditions for which conversions could not be reliably made were flagged for later inspection. Only known conversion problems were flagged, and no additional steps were taken to detect or repair discrepancies in the original DLG-3 or the converted NHD.
2. A default value of a characteristic was added in cases where the description was incomplete.
3. All instances in which data were flagged were inspected and resolved interactively.
4. Feature delineation rules were applied to the temporary features in a batch process to create the final version of features.
5. Coordinate values were converted to geographic coordinates and to the NAD83 using the NADCON software version 2.1 (National Geodetic Survey, n.d.).

This process generated the "features" data.

Build reaches

The basic steps for building reaches are as follows:

1. Convert RF3 to RF3" (RF3 double prime). This batch operation processed Reach File Version 3 to delete duplicate reaches, reassign reaches to the correct subbasin, validate geographic names assigned to reaches against data from the Geographic Names Information System (December 1996 extract), apply updates supplied by the States of California and Arizona, redelineate reaches on the basis of standards used for the NHD, and identify inflow/outflow points where transport reaches entered and exited waterbodies.

2. Create artificial paths. Using waterbodies from the feature data and inflow/outflow points extracted from RF3", this process automatically generated the centerlines used to delineate artificial paths within waterbodies by using subroutines within the ARC/INFO®[11] GRID module.
3. Blind pass. This batch step conflated features and RF3" reaches and transferred reach information (reach code, reach date, name, stream level, and flow relationships) to the features. It also integrated the artificial paths generated in the previous step with the other features, built reaches on the artificial paths, and assigned geographic names (February 1995 extract) to waterbodies.
4. Quadrangle-based visual pass. During this interactive step, analysts ensured that the data developed in the previous batch processes conformed to reach delineation rules and that reaches were assigned to the appropriate subbasin. Batch procedures identified and developed a list of possible errors. (Errors not detected by the software may continue in the data.) Using the list, software presented each case to analysts to make appropriate edits to the data. Analysts recorded notes about repairs that could not be made and about other errors in the data. (These notes are encoded in the subbasin digital update units.)
5. Build superquads. After the quadrangle-based visual pass was complete, all quadrangles that cover all or part of each subbasin were paneled into a superquad. In this batch process, reaches that cross quad boundaries were corrected to conform to reach delineation rules.
6. Subbasin-based visual pass. As they did with the quadrangle-based visual pass, analysts ensured that reaches conformed to reach delineation rules. Batch procedures identified and developed a list of possible errors. (Errors not detected by the software may continue in the data.) Analysts examined each error and corrected the data. Analysts recorded notes about repairs that could not be made and about other errors in the data. (These notes are encoded in the subbasin digital update units.)
7. Central quality assurance/quality control. This step (1) confirmed that integrity checks were performed successfully during the visual pass activity, and (2) assessed statistics gathered during the earlier processes to determine if additional review of data was needed. A check of data from the subbasin-based visual pass was run in batch; any data that did not pass the procedure were reviewed interactively. If substantive changes were required, the data were reprocessed using procedures (as required) described in previous steps. The edited data then were rechecked using the central quality assurance/quality control process.
8. Data preparation and database load. This batch procedure performed final processing to the data emerging from the quality assurance/quality control step. Some of the activities included assigning the final reach codes, building waterbody reaches, adding final artificial paths in waterbodies, and implementing any recent changes in standards for the NHD. The spelling of geographic names was replaced using the March 1999 data extract from the Geographic Names Information System. After this, reaches, features, characteristics, geographic names, and relations were loaded into the database that holds the NHD.
9. Flow relation correction and validation. The flow relations were checked for consistency through a batch procedure, which generated a list of possible errors. Software presented possible errors to analysts, who corrected flow relations and, occasionally, the delineation of reaches. Changes were posted to the database.
10. Extract distribution copies of data. Data for a subbasin were extracted from the database and converted into an ARC/INFO® workspace containing coverages and other files. Data available in the Spatial Data Transfer Standard format were developed from the workspaces. The workspaces and the Spatial Data Transfer Standard-formatted files were made available to the public.

Attribute accuracy

The accuracy of the attributes of the DLG data is estimated to be 98.5 percent. One or more of the following methods was used to test attribute accuracy:

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- the source was manually compared with hardcopy plots.
- a symbolized display was done of the DLG on an interactive computer graphics system.
- selected attributes that could not be visually verified on plots or on screen were interactively queried and verified.

In addition, software was used to validate feature types and characteristics against a master set of types and characteristics, to check that combinations of types and characteristics were valid, and to check that types and characteristics were valid for the delineation of the feature. Feature types, characteristics, and other attributes conform to the "Standards for National Hydrography Dataset" (USGS, 1999) as of the date they were loaded into the database.

The entry and identifier for geographic names match those in the Geographic Names Information System as of March 1999. The association of each name to reaches has not been methodically checked, and so a name may be applied to the wrong reaches. Anecdotal reviews indicate that 80 percent or more of the named reaches have the correct name.

Reaches were delineated with a batch procedure and were checked extensively during the "visual pass" steps of processing. According to automated quality assurance/quality control checks performed at various intervals during the processing, it is estimated that approximately 99 percent of the reaches are delineated according to standards.

Logical consistency

Points, nodes, lines, and areas conform to topological rules. Lines intersect only at nodes, and all nodes anchor the ends of lines. Lines do not "overshoot" or "undershoot" other lines where they are supposed to meet. There are no duplicate lines within a dataset. Lines bound areas, and lines identify the areas to the left and right of the lines. Gaps and overlaps among areas do not exist. All areas close.

Completeness

The completeness of the data reflects the content of the sources, which in the initial release of the NHD, are most often USGS topographic maps. Features found on the ground may have been eliminated or generalized on the source graphic because of scale and legibility constraints. In general, streams longer than 1mile (approximately 1.6 kilometers) were collected. Most streams that flow from a lake were collected regardless of their length. Only definite channels were collected, so not all swamp/marsh features have stream/rivers delineated through them. Lake/ponds having an area greater than 6 acres (approximately 2.4 hectares) were collected.

Note, however, that these general rules were applied unevenly among maps during compilation. Some map quadrangles have a much sparser pattern of hydrography than do adjoining maps, and these differences continue in the digital rendition of these features. Rectification of these differences is a priority for maintenance of the NHD.

Transport reaches are defined on almost all of the features of types stream/river, canal/ditch, pipeline, artificial path, and connector. Waterbody reaches are defined on the subset of lake/pond features that were identified as waterbodies during the development of Reach File Version 3.

Most attention in applying geographic names was given to transport reaches that follow stream/rivers and to waterbody reaches.

Near the international boundaries with Canada and Mexico, only the parts of features within the United States are delineated.

Detailed capture conditions are provided for every feature type in the "Standards for National Hydrography Dataset" (USGS, 1999), available online through http://mapping.usgs.gov/standards/.

Horizontal positional accuracy

Statements of horizontal positional accuracy are based on accuracy statements made for USGS topographic quadrangle maps. These maps were compiled to meet National Map Accuracy Standards. For horizontal accuracy, this standard is met if at least 90 percent of points tested are within 0.02 inch (at map scale) of their true positions.[12] Additional offsets to positions may have been introduced where there are many features to improve the legibility of map symbols. In addition, the digitizing of maps is estimated to contain a horizontal positional error of less than or equal to 0.003-inch standard error (at map scale) in the two component directions relative to the source maps. Visual comparison between the map graphic (including digital scans of the graphic) and plots or digital displays of points, lines, and areas is used to assess the positional accuracy of digital data.

Linear features of the same type along the adjoining edges of data sets are aligned if they are within a 0.02-inch tolerance (at map scale). To align the features, the midpoint between the end of the corresponding features is computed, and the ends of features are moved to this point. Features outside the tolerance are not moved; instead, a feature of the type connector was added to join the features.

Vertical positional accuracy

Statements of vertical positional accuracy for elevation of water surfaces are based on accuracy statements made for USGS topographic quadrangle maps. These maps were compiled to meet National Map Accuracy Standards. For vertical accuracy, this standard is met if at least 90 percent of well-defined points tested are within one-half contour interval of the correct value. Elevations of water surface printed on the published map meet this standard; the contour intervals of the maps vary. These elevations were transcribed into the digital data; the accuracy of this transcription was checked by visual comparison between the data and the map.

Pacific Northwest and Alaska

Similar approaches are being used to develop data for the Pacific Northwest and Alaska. Specific statements will be provided when these data are released.

[12] At 1:100,000 scale, 0.02 inch is approximately 167 feet (50.8 meters), and at 1:24,000 scale, 40 feet (approximately 12.2 meters).

Glossary

(The main sources for the definitions include Darcy and Boston (1988); Federal Geographic Data Committee (1994, 1997); Merriam-Webster (1998); Padmanabhan, Yoon, and Leipnik (1992); and Stamp and Clark (1979).)

ARC/INFO®[13] — Geographic information systems software developed by the Environmental Systems Research Institute of Redlands, California.

area — A generic term for a bounded, continuous, two-dimensional object that may or may not include its boundary. *See line, node, and point.*

cataloging unit — Currently known as subbasin.

characteristic — A distinguishing trait, quality, or property.

coastline — A line that follows the main outline of the land, including bays, but crosses rivers at their mouths. In the NHD, the outlines of selected coastal islands are included as part of the coastline. *See shoreline.*

coastline reach — A reach that represents a section of *coastline*.

common identifier — A 10-digit integer value that uniquely identifies each feature or reach in the NHD.

conflation — A process by which two sets of map data for the same region may be aligned and merged on the basis of matches of corresponding features portrayed in both sets.

confluence — Flowing together; the junction and union of two or more streams or moving fluids. In the NHD, this idea has been generalized to allow the feature types of artificial path, canal/ditch, connector, pipeline, and stream/river to meet at a confluence. *See divergence.*

conterminous — Having a common boundary; enclosed within a common boundary.
conterminous United States — the lower 48 States and the District of Columbia.

contiguous — Touching along a boundary or at a point; touching or connected throughout in an unbroken sequence.

contour — An imaginary line on the ground, all points of which are at the same *elevation*.

contour interval — The difference in elevation between two adjacent contours.

coordinate reference system — A set of points, lines, and (or) surfaces and a set of rules that creates a reference frame whereby each point in a given surface can be identified uniquely by a set of numbers.

coordinates — Linear and (or) angular quantities that describe the location of a point in relation to a given *coordinate reference system*.

coverage — A digital version of a map forming the basic unit of vector data storage in *ARC/INFO®*.

datum — Any quantity, or set of quantities, that may serve as a reference or basis for the calculation of other quantities. In relation to mapping and geographic information systems, datum usually refers to a set of quantities that serve as a reference for the calculation of positions. *See horizontal datum, linear referencing system, and vertical datum.*

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decimal degree — Representation of the measure of an angle using whole and decimal fractions of a *degree*.
DECIMAL DEGREE = DEGREES + (MINUTES/60) + (SECONDS/3600). *See latitude, longitude.*

degree — An angular unit of measure equal to 1/360th of the circumference of a circle. *See decimal degree, latitude, and longitude.*

delineate — To mark the outline of; to describe, portray, or set forth with accuracy or in detail.

delineation — The act of delineating; something made by delineating.

diacritical mark — A mark near or through a character or combination of characters that indicates a phonetic value (a spoken sound) different from that given the unmarked or otherwise marked character.

digital update unit — A collection of one or more *features* and (or) *reaches* to which a set of *metadata* elements apply.

divergence — Flowing apart; the junction and separation of a stream or moving fluids into two or more paths. In the NHD, this idea has been generalized to allow the feature types of artificial path, canal/ditch, connector, pipeline, and stream/river to meet at a divergence. *See confluence.*

elevation — The vertical distance above or below a *vertical datum* to a point or object on the Earth's surface.

entity — Generally, something that has separate and distinct existence and objective or conceptual reality. In a database, an object of interest about which data can be collected.

feature — A defined *entity* and its representation. In the NHD, features include naturally occurring and constructed bodies of water, paths through which water flows, and related entities. These spatial phenomena are classified into defined *feature types*, are described by additional *characteristics*, and are *delineated* in standard ways.

feature code — A numeric value that encodes the type and values for a set of *characteristics* of a *feature*. This five-digit code has two parts: the first three digits encode the *feature type*; the last two digits encode values for a set of characteristics associated with the feature.

feature type — A member of a classification scheme for *features*. For example, in the NHD, features can be classified by types such as canal/ditch, lake/pond, and stream/river.

field — A single piece of information, the smallest unit normally manipulated by a database management system.

geocode — A location identifier. More specifically, a geocode is a data value assigned to a spatial object that encodes the location of the object (or a place along the object). A geocode can be used to associate other data with the object (or a place along the object). The term geocode also denotes the process of assigning a location identifier to an object. In the NHD, *reach codes* provide a starting point for geocoding observations to or along hydrographic features.

geographic name — The proper name, specific term, or expression by which a particular geographical *entity* is, or was, known.

head — The source of a stream.

horizontal datum — A set of constants to which horizontal *coordinates* are referred; a reference for position.

hydrography — (1) The science comprising the description, study, and mapping of the waters of the Earth's surface (the seas, lakes, rivers, and so on), including their forms and physical features. (2) The subject matter of this science, the hydrographic features of the globe or part of it; the distribution of water on the Earth's surface.

hydrologic unit — A member of the hierarchical system for identifying and subdividing river-basin units of the United States. Hydrologic units are used for the collection and organization of hydrologic data. The levels of the hierarchy, listed in order of largest to smallest in area, are region, subregion, accounting unit, and *subbasin.* For example:

region — New England region: the drainage within the United States that ultimately discharges into: (a) the Bay of Fundy, (b) the Atlantic Ocean within and between the States of Maine and Connecticut, (c) Long Island Sound north of the New York-Connecticut state line, and (d) the Riviere St. Francois, a tributary of the St. Lawrence River.

subregion — Connecticut: the Connecticut River basin.

accounting unit — Lower Connecticut: the Connecticut River basin below Vernon Dam.

subbasin — Chicopee.

Each hydrologic unit is identified uniquely with a *hydrologic unit code.*

hydrologic unit code — A hierarchical, numeric code that uniquely identifies *hydrologic units*. The first two digits identify the region, the first four digits identify subregions, the first six digits identify accounting units, and the full eight digits identify *subbasin*. For example, from the example provided with the definition of *hydrologic unit*, the *hydrologic unit codes* are:

01 — the region (New England)

0108 — the subregion (Connecticut)

010802 — the accounting unit (Lower Connecticut)

01080204 — the subbasin (Chicopee)

Zeroes in the two-digit accounting unit field indicate that the accounting unit and the subregion are the same. Zeroes in the two-digit subbasin field indicate that the subbasin and the accounting unit are the same.

latitude — Distance north or south of the Equator, measured as an angle with the center of the Earth. In the NHD, latitude values are encoded in *decimal degrees. See longitude.*

level path — A sequence of *transport reaches* that trace the main stem for a given flow of water.

line — A generic term for a one-dimensional object having a length and direction. *See area, node, and point.*

linear referencing system — A set of *datums*, networks, and linear referencing methods, whereby each point along a network can be identified uniquely by specifying the direction and distance from any known point on the network.

longitude — Distance east or west on the Earth's surface, measured by the angle that the meridian of a particular place makes with the Prime (Greenwich) Meridian. In the NHD, longitude values are encoded in *decimal degrees. See latitude*.

lookup table — A table that provides the ability to use a known value to locate an unknown value. In the NHD, the *feature code* links *features* to the textual descriptions of their associated *characteristics*.

map scale — The relationship between a distance on a map, chart, or photograph and the corresponding distance on the Earth. For map scales commonly associated with the NHD, see the following table:

Scale	1 inch equals	1 centimeter equals
1:100,000	1.6 miles (approximate)	1 kilometer
1:63,360	1 mile	0.63 kilometer (approximate)
1:30,000	2,500 feet	0.30 kilometer
1:24,000	2,000 feet	0.24 kilometer
1:20,000	1,667 feet (approximate)	0.20 kilometer
1:12,000	1,000 feet	0.12 kilometer

metadata — Data about data; data that describe the content, quality, condition, and other characteristics of data.

mouth — The place where a stream enters a larger body of water.

node — A zero-dimensional object that is the topological junction of two or more lines, or an end point of a line. *See area, line, and point.*

point — A zero-dimensional object that specifies geometric location. *See area, line, and node.*

quadrangle — A four-sided area, bounded by parallels of *latitude* and meridians of *longitude*, used as an areal unit in mapping.

reach — A continuous unbroken stretch or expanse of surface water. In the NHD, this idea has been expanded to define reach as a significant segment of surface water that has similar hydrologic characteristics. Reaches have standard types and *delineations*. *See coastline reach, shoreline reach, transport reach, and waterbody reach.*

reach code — A numeric code that uniquely identifies a reach. This 14-digit code has 2 parts: the first 8 digits are the *hydrologic unit code* for the *subbasin* in which the reach is located; the last 6 digits are a sequentially ordered, arbitrarily assigned number.

relation — In a database, a named association among sets of *entities*.

shoreline — The line where water and land meet. In the NHD, shoreline applies to inland waters only. *See coastline*.

shoreline reach — A reach that represents all or part of a *shoreline*. *This type of reach has not been implemented.*

stage — The *elevation* of the surface of a body of water measured relative to a *vertical datum*.

subbasin — The fourth level of subdivision of *hydrologic units*. A subbasin represents the geographic area of part or all of a surface drainage basin, a combination of drainage basins, or a distinct hydrologic feature. Subbasins are uniquely identified with an eight-digit *hydrologic unit code*.

terminus *(plural* termini*)* — A finishing point; a part that forms the end.

topology — A branch of geometrical mathematics concerned with order, contiguity, and relative position rather than actual linear dimensions. Topology is used to establish and describe spatial relationships among features.

transport reach — A *reach* that represents the pathway for the flow of water through a drainage network.

traverse — To move or pass along.
traversal — An instance of traversing.

tributary — A stream or river that flows into a larger one. In the NHD, this idea has been generalized to allow *transport reaches* with underlying feature types of artificial path, canal/ditch, connector, pipeline, and stream/river to have or be tributaries.

vertical datum — A set of constants specifying a coordinate system to which *elevations* are referred.

waterbody — A *hydrographic feature* that is *delineated* using *areas*.

waterbody reach — A *reach* that represents a *waterbody*. (In contrast, a *transport reach* represents the flows of water through such areas.)

workspace — A directory containing geographic datasets for use with *ARC/INFO®*.

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Appendix A. Overview of features, reaches, and related items.

Table 1A. Feature types and related items
Notes on table: (1) Feature type: The table lists all feature types and characteristics defined for the NHD. Note that not all feature types have been collected. (2) Geo(graphic) name: An X in the column indicates that a geographic name may be associated with features of this type. Note that geographic names have not been encoded for many features. (3) For the State of Washington, waterbody reaches carry the geographic names of lake/pond, reservoir, ice mass, and swamp/marsh. (4) Surface elevation: An X in the column indicates that the elevation of the surface of the water may be associated with the features of this feature type. Note that the surface elevations have not been encoded for most features. (5) An asterisk (*) means that the item is not in the initial release of the NHD.

Feature Type	Characteristics	Geo Name	Possible Delineation	Surface Elevation	Can relate to Underpass
Anchorage *	Anchorage Type *	X *	Point *, Area *		
Area of Complex Channels			Area		
Area To Be Submerged		X	Area	X	
Artificial Path		On Reach	Line		X
Bay/Inlet *		X *	Area *		
Bridge		X	Line, Area		
Canal/Ditch	Canal/Ditch Type	On Reach	Line, Area	X	X
Connector		On Reach	Line		
Crevasse Field *		X *	Area *		
Dam/Weir	Construction Material Operational Status	X	Line, Area		
Estuary *		X *	Area *		
Fish Ladder *			Point *, Line *, Area *		
Flume *		X *	Line *, Area *		
Foreshore		X *	Area		
Fumarole		X	Point		
Gaging Station			Point		
Gate	Gate Type		Point, Line		
Geyser		X	Point		
Hazard Zone	Hazard Zone Category		Area		
Ice Mass	Ice Mass Category Glaciation Category *	X, On Reach in Washington State	Area		
Inundation Area	Inundation Control Status Inundation Area Type	X	Area	X	
Lake/Pond	Hydrographic Category Water Characteristics	On Reach	Area	X	
Lock Chamber		X	Point, Line, Area		
Mud Pot		X	Point		
Nonearthen Shore			Line		
Pipeline	Product Pipeline Type Relationship to Surface	On Reach	Line		
Playa		X	Area		

Feature Type	Characteristics	Geo Name	Possible Delineation	Surface Elevation	Can relate to Underpass
Post [*]	Post Type [*]		Point [*]		
Rapids		X	Point, Line, Area		
Reef		X	Line		
Reservoir	Construction Material Cover Status Hydrographic Category Reservoir Type	X, On Reach in Washington State	Point [*], Area	X	
Rock	Relationship to Surface	X [*]	Point		
Sea/Ocean	Sea/Ocean Category	X	Area		
Sink/Rise [*]		X [*]	Point [*], Line [*]		
Snag/Stump [*]	Snag/Stump Type [*] Relationship to Surface [*]		Point [*]		
Sounding Datum Line	Positional Accuracy		Line		
Special Use Zone	Operational Status Special Use Zone Type		Area		
Special Use Zone Limit	Positional Accuracy		Line		
Spillway			Area		
Spring/Seep	Water Characteristics	X	Point		
Stream/River	Hydrographic Category Positional Accuracy	On Reach	Line, Area	X	X
Submerged Stream		X	Area		
Swamp/Marsh		X, On Reach in Washington State	Area		
Tunnel		X	Line		
Underpass			Point		*Not applicable*
Wall	Wall Type		Line		
Wash		X	Area		
Water Intake/Outflow [*]	Water Intake/Outflow Type [*]		Point [*], Area [*]		
Waterfall		X	Point, Line		
Well	Flow Status Product Water Characteristics	X	Point		
Wreck [*]	Abovewater Portion [*] Relationship to Surface [*]	X [*]	Point [*]		

Table 2A. Reaches and related items

Notes on table: (1) Geo(graphic) name: An X in the column indicates that a geographic name may be associated with the reaches of this type. Note that geographic names have not been encoded for many reaches, especially those that follow the feature types canal/ditch or pipeline. Coastline reaches carry the name of the water feature that they bound. (2) Stream level: For coastline reaches, stream level is assigned the value of "-9998", which means that no value has been specified.

Reach Type	Related Items	Geo Name	Delineation	Features Types That Provide Delineation	Participates in the Reach Flow Relation
Coastline	Reach Code Reach Code Assignment Date Stream Level	X	Line	Artificial Path	X
Shoreline	*This reach type has not been implemented.*				
Transport	Reach Code Reach Code Assignment Date Stream Level	X	Line	Artificial Path, Canal/Ditch, Connector, Pipeline, Stream/River	X
Waterbody	Reach Code Reach Code Assignment Date	X	Area	Only Lake/Pond for the initial release in most places. Ice Mass, Lake/Pond, Reservoir, and Swamp/Marsh in the initial release for Washington State.	

Appendix B. Feature code and description field structures and definitions

Feature code structure

The general format of the feature code is as follows:

FFFCC, in which

FFF is the three-digit code for a feature type.

CC is the two-digit code for a combination of values for characteristics associated with a feature type. If only the feature type is identified, these last two digits are assigned the value "0".

For example, the feature type "Dam/Weir" has the three-digit identifier "343". This number serves as the first three digits of the feature code. A code of "34300" is used if no characteristics are encoded for the feature.

A feature classified as "Dam/Weir" also may have the characteristic of "Construction Material" with the values of "earthen" and "nonearthen", and the characteristic of "Operational Status" with the values of "operational" and "under construction". The codes used to encode the combinations of values are shown below:

Dam/Weir (Feature Type Number 343)		Operational Status	
		operational	under construction
Construction Materials	Earthen	34301	34302
	Nonearthen	34303	34304

Table 1B and Table 2B list all feature codes and their meanings.

Description field structure

The description field uses a single character string to encode one or more characteristics and values for each feature code. The general format of the character string is shown below:

characteristic|value, in which

"characteristic" is the name of the characteristic.

The vertical line character ("|") separates the characteristic and value.

"value" is the value of the characteristic for the feature code.

When two or more characteristics are encoded by a feature code, these characteristic-value pairs are separated by the semicolon and space characters ("; "). If no characteristics are encoded (that is, if the code ends in "00"), the text "Feature type only: no attributes" is encoded.

For example, from the "Dam/Weir" characteristics and values described above, the following character strings are encoded for the feature codes:

Feature Code	Description
34300	Feature type only: no attributes
34301	Construction Material|earthen; Operational Status|operational
34302	Construction Material|earthen; Operational Status|under construction
34303	Construction Material|nonearthen; Operational Status|operational
34304	Construction Material|nonearthen; Operational Status|under construction

Table 1B and Table 2B list all character strings.

The document "Standards for National Hydrography Dataset" (USGS, 1999) contains the names and definitions of all feature types, characteristics, and values. The document is available online through http://mapping.usgs.gov/standards/.

Table 1B. Feature code definitions listed numerically by feature code (FCODE)
(Note that many of the listed codes were not required in the initial release of the NHD. **Appendix A** lists feature types and characteristics that were not encoded.)

FCODE	Feature Type	Description
30200	ANCHORAGE	feature type only: no attributes
30201	ANCHORAGE	Anchorage Type|explosives isolation
30202	ANCHORAGE	Anchorage Type|quarantine
30203	ANCHORAGE	Anchorage Type|seaplane
30700	AREA TO BE SUBMERGED	feature type only: no attributes
31200	BAY/INLET	feature type only: no attributes
31800	BRIDGE	feature type only: no attributes
33400	CONNECTOR	feature type only: no attributes
33600	CANAL/DITCH	feature type only: no attributes
33601	CANAL/DITCH	Canal/Ditch Type|aqueduct
33602	CANAL/DITCH	Canal/Ditch Type|unspecified
34000	CREVASSE FIELD	feature type only: no attributes
34300	DAM/WEIR	feature type only: no attributes
34301	DAM/WEIR	Construction Material|earthen; Operational Status|operational
34302	DAM/WEIR	Construction Material|earthen; Operational Status|under construction
34303	DAM/WEIR	Construction Material|nonearthen; Operational Status|operational
34304	DAM/WEIR	Construction Material|nonearthen; Operational Status|under construction
36000	FISH LADDER	feature type only: no attributes
36100	PLAYA	feature type only: no attributes
36200	FLUME	feature type only: no attributes
36400	FORESHORE	feature type only: no attributes
36600	FUMAROLE	feature type only: no attributes
36700	GAGING STATION	feature type only: no attributes
36900	GATE	feature type only: no attributes
36901	GATE	Gate Type|drydock
36902	GATE	Gate Type|floodgate
36903	GATE	Gate Type|lock
36904	GATE	Gate Type|tidegate
36905	GATE	Gate Type|unspecified
37000	GEYSER	feature type only: no attributes
37300	HAZARD ZONE	feature type only: no attributes
37301	HAZARD ZONE	Hazard Zone Category|unspecified
37302	HAZARD ZONE	Hazard Zone Category|crib area
37303	HAZARD ZONE	Hazard Zone Category|foul ground
37304	HAZARD ZONE	Hazard Zone Category|mine danger area
37305	HAZARD ZONE	Hazard Zone Category|piling area
37306	HAZARD ZONE	Hazard Zone Category|platform area
37307	HAZARD ZONE	Hazard Zone Category|reef area
37308	HAZARD ZONE	Hazard Zone Category|rock area
37309	HAZARD ZONE	Hazard Zone Category|shoal
37310	HAZARD ZONE	Hazard Zone Category|snag/stump area
37311	HAZARD ZONE	Hazard Zone Category|well area

FCODE	Feature Type	Description
37312	HAZARD ZONE	Hazard Zone Category|wreckage
37800	ICE MASS	feature type only: no attributes
37801	ICE MASS	Ice Mass Category|alpine glacier
37802	ICE MASS	Ice Mass Category|continental glacier; Glaciation Category|ice shelf
37803	ICE MASS	Ice Mass Category|continental glacier; Glaciation Category|inland ice sheet
37804	ICE MASS	Ice Mass Category|pack ice
37805	ICE MASS	Ice Mass Category|snowfield
37806	ICE MASS	Ice Mass Category|unspecified
39000	LAKE/POND	feature type only: no attributes
39001	LAKE/POND	Hydrographic Category|intermittent; Water Characteristics|salt
39002	LAKE/POND	Hydrographic Category|intermittent; Water Characteristics|unspecified
39003	LAKE/POND	Hydrographic Category|perennial; Water Characteristics|salt
39004	LAKE/POND	Hydrographic Category|perennial; Water Characteristics|unspecified
39800	LOCK CHAMBER	feature type only: no attributes
40300	INUNDATION AREA	feature type only: no attributes
40301	INUNDATION AREA	Inundation Control Status|controlled; Inundation Area Type|debris basin
40302	INUNDATION AREA	Inundation Control Status|controlled; Inundation Area Type|dewatering area
40303	INUNDATION AREA	Inundation Control Status|controlled; Inundation Area Type|duck pond
40304	INUNDATION AREA	Inundation Control Status|controlled; Inundation Area Type|general case
40305	INUNDATION AREA	Inundation Control Status|controlled; Inundation Area Type|percolation basin
40306	INUNDATION AREA	Inundation Control Status|controlled; Inundation Area Type|retarding basin
40307	INUNDATION AREA	Inundation Control Status|not controlled
40900	MUD POT	feature type only: no attributes
41100	NONEARTHERN SHORE	feature type only: no attributes
42200	POST	feature type only: no attributes
42201	POST	Post Type|dolphin
42202	POST	Post Type|piling
42800	PIPELINE	feature type only: no attributes
42801	PIPELINE	Product|water; Pipeline Type|aqueduct; Relationship to Surface|at or near
42802	PIPELINE	Product|water; Pipeline Type|aqueduct; Relationship to Surface|elevated
42803	PIPELINE	Product|water; Pipeline Type|aqueduct; Relationship to Surface|underground
42804	PIPELINE	Product|water; Pipeline Type|aqueduct; Relationship to Surface|underwater
42805	PIPELINE	Product|water; Pipeline Type|general case; Relationship to Surface|at or near
42806	PIPELINE	Product|water; Pipeline Type|general case; Relationship to Surface|elevated
42807	PIPELINE	Product|water; Pipeline Type|general case; Relationship to Surface|underground
42808	PIPELINE	Product|water; Pipeline Type|general case; Relationship to Surface|underwater
42809	PIPELINE	Product|water; Pipeline Type|penstock; Relationship to Surface|at or near
42810	PIPELINE	Product|water; Pipeline Type|penstock; Relationship to Surface|elevated
42811	PIPELINE	Product|water; Pipeline Type|penstock; Relationship to Surface|underground
42812	PIPELINE	Product|water; Pipeline Type|penstock; Relationship to Surface|underwater
42813	PIPELINE	Product|water; Pipeline Type|siphon; Relationship to Surface|unspecified
43100	RAPIDS	feature type only: no attributes
43400	REEF	feature type only: no attributes
43600	RESERVOIR	feature type only: no attributes
43601	RESERVOIR	Reservoir Type|aquaculture; Construction Material|unspecified
43602	RESERVOIR	Reservoir Type|decorative pool; Construction Material|nonearthen

FCODE	Feature Type	Description
43603	RESERVOIR	Reservoir Type|decorative pool; Construction Material|unspecified
43604	RESERVOIR	Reservoir Type|disposal-tailings pond; Construction Material|earthen
43605	RESERVOIR	Reservoir Type|disposal-tailings pond; Construction Material|unspecified
43606	RESERVOIR	Reservoir Type|disposal-unspecified; Construction Material|unspecified
43607	RESERVOIR	Reservoir Type|evaporator; Construction Material|unspecified
43608	RESERVOIR	Reservoir Type|swimming pool; Construction Material|nonearthen
43609	RESERVOIR	Reservoir Type|treatment-cooling pond; Construction Material|unspecified
43610	RESERVOIR	Reservoir Type|treatment-filtration pond; Construction Material|unspecified
43611	RESERVOIR	Reservoir Type|treatment-settling pond; Construction Material|unspecified
43612	RESERVOIR	Reservoir Type|treatment-sewage treatment pond; Construction Material|unspecified
43613	RESERVOIR	Reservoir Type|water storage; Construction Material|nonearthen; Cover Status|covered; Hydrographic Category|unspecified
43614	RESERVOIR	Reservoir Type|water storage; Construction Material|earthen; Cover status|not covered; Hydrographic Category|intermittent
43615	RESERVOIR	Reservoir Type|water storage; Construction Material|earthen; Cover status|not covered; Hydrographic Category|perennial
43616	RESERVOIR	Reservoir Type|water storage; Construction Material|nonearthen; Cover status|not covered; Hydrographic Category|unspecified
43617	RESERVOIR	Reservoir Type|water storage; Construction Material|unspecified; Cover status|unspecified; Hydrographic Category|unspecified
43618	RESERVOIR	Reservoir Type|unspecified; Construction Material|earthen
43619	RESERVOIR	Reservoir Type|unspecified; Construction Material|nonearthen
43620	RESERVOIR	Reservoir Type|unspecified; Construction Material|unspecified
44100	ROCK	feature type only: no attributes
44101	ROCK	Relationship to Surface|abovewater
44102	ROCK	Relationship to Surface|underwater
44500	SEA/OCEAN	feature type only: no attributes
44501	SEA/OCEAN	Sea/Ocean Category|reef pool
44502	SEA/OCEAN	Sea/Ocean Category|unspecified
45000	SINK/RISE	feature type only: no attributes
45200	SNAG/STUMP	feature type only: no attributes
45201	SNAG/STUMP	Snag/Stump Type|snag; Relationship to Surface|abovewater
45202	SNAG/STUMP	Snag/Stump Type|snag; Relationship to Surface|underwater
45203	SNAG/STUMP	Snag/Stump Type|stump; Relationship to Surface|abovewater
45204	SNAG/STUMP	Snag/Stump Type|stump; Relationship to Surface|underwater
45400	SPECIAL USE ZONE	feature type only: no attributes
45401	SPECIAL USE ZONE	Special Use Zone Type|dump site; Operational Status|operational
45402	SPECIAL USE ZONE	Special Use Zone Type|dump site; Operational Status|abandoned
45403	SPECIAL USE ZONE	Special Use Zone Type|spoil area; Operational Status|operational
45404	SPECIAL USE ZONE	Special Use Zone Type|spoil area; Operational Status|abandoned
45500	SPILLWAY	feature type only: no attributes
45800	SPRING/SEEP	feature type only: no attributes
45801	SPRING/SEEP	Water Characteristics|unspecified
45802	SPRING/SEEP	Water Characteristics|alkaline
45803	SPRING/SEEP	Water Characteristics|hot
45804	SPRING/SEEP	Water Characteristics|sulphur
46000	STREAM/RIVER	feature type only: no attributes

FCODE	Feature Type	Description
46001	STREAM/RIVER	Hydrographic Category|intermittent; Positional Accuracy|definite
46002	STREAM/RIVER	Hydrographic Category|intermittent; Positional Accuracy|indefinite
46003	STREAM/RIVER	Hydrographic Category|intermittent; Positional Accuracy|not applicable
46004	STREAM/RIVER	Hydrographic Category|perennial; Positional Accuracy|definite
46005	STREAM/RIVER	Hydrographic Category|perennial; Positional Accuracy|indefinite
46006	STREAM/RIVER	Hydrographic Category|perennial; Positional Accuracy|not applicable
46100	SUBMERGED STREAM	feature type only: no attributes
46600	SWAMP/MARSH	feature type only: no attributes
47800	TUNNEL	feature type only: no attributes
48100	UNDERPASS	feature type only: no attributes
48300	WALL	feature type only: no attributes
48301	WALL	Wall Type|general case
48302	WALL	Wall Type|sea
48400	WASH	feature type only: no attributes
48500	WATER INTAKE/OUTFLOW	feature type only: no attributes
48501	WATER INTAKE/OUTFLOW	Water Intake/Outflow Type|intake
48502	WATER INTAKE/OUTFLOW	Water Intake/Outflow Type|outflow
48700	WATERFALL	feature type only: no attributes
48800	WELL	feature type only: no attributes
48801	WELL	Product|heat
48802	WELL	Product|water; Flow Status|flowing; Water Characteristics|unspecified
48803	WELL	Product|water; Flow Status|unspecified; Water Characteristics|alkaline
48804	WELL	Product|water; Flow Status|unspecified; Water Characteristics|hot
48805	WELL	Product|water; Flow Status|unspecified; Water Characteristics|sulphur
48806	WELL	Product|water; Flow Status|unspecified; Water Characteristics|unspecified
49200	WRECK	feature type only: no attributes
49201	WRECK	Relationship to Surface|abovewater; Abovewater Portion|hull and/or superstructure
49202	WRECK	Relationship to Surface|abovewater; Abovewater Portion|mast and/or funnel
49203	WRECK	Relationship to Surface|underwater
49300	ESTUARY	feature type only: no attributes
50300	SOUNDING DATUM LINE	feature type only: no attributes
50301	SOUNDING DATUM LINE	Positional Accuracy|approximate
50302	SOUNDING DATUM LINE	Positional Accuracy|definite
53300	SPECIAL USE ZONE LIMIT	feature type only: no attributes
53301	SPECIAL USE ZONE LIMIT	Positional Accuracy|definite
53302	SPECIAL USE ZONE LIMIT	Positional Accuracy|indefinite
53700	AREA OF COMPLEX CHANNELS	feature type only: no attributes
55800	ARTIFICIAL PATH	feature type only: no attributes

Table 2B. Feature code definitions listed alphabetically by feature type
(Note that many of the listed codes were not required in the NHD. **Appendix A** lists feature types and characteristics that were not encoded.)

Feature Type	FCODE	Description
ANCHORAGE	30200	feature type only: no attributes
ANCHORAGE	30201	Anchorage Type|explosives isolation
ANCHORAGE	30202	Anchorage Type|quarantine
ANCHORAGE	30203	Anchorage Type|seaplane
AREA OF COMPLEX CHANNELS	53700	feature type only: no attributes
AREA TO BE SUBMERGED	30700	feature type only: no attributes
ARTIFICIAL PATH	55800	feature type only: no attributes
BAY/INLET	31200	feature type only: no attributes
BRIDGE	31800	feature type only: no attributes
CANAL/DITCH	33600	feature type only: no attributes
CANAL/DITCH	33601	Canal/Ditch Type|aqueduct
CANAL/DITCH	33602	Canal/Ditch Type|unspecified
CONNECTOR	33400	feature type only: no attributes
CREVASSE FIELD	34000	feature type only: no attributes
DAM/WEIR	34300	feature type only: no attributes
DAM/WEIR	34301	Construction Material|earthen; Operational Status|operational
DAM/WEIR	34302	Construction Material|earthen; Operational Status|under construction
DAM/WEIR	34303	Construction Material|nonearthen; Operational Status|operational
DAM/WEIR	34304	Construction Material|nonearthen; Operational Status|under construction
ESTUARY	49300	feature type only: no attributes
FISH LADDER	36000	feature type only: no attributes
FLUME	36200	feature type only: no attributes
FORESHORE	36400	feature type only: no attributes
FUMAROLE	36600	feature type only: no attributes
GAGING STATION	36700	feature type only: no attributes
GATE	36900	feature type only: no attributes
GATE	36901	Gate Type|drydock
GATE	36902	Gate Type|floodgate
GATE	36903	Gate Type|lock
GATE	36904	Gate Type|tidegate
GATE	36905	Gate Type|unspecified
GEYSER	37000	feature type only: no attributes
HAZARD ZONE	37300	feature type only: no attributes
HAZARD ZONE	37301	Hazard Zone Category|unspecified
HAZARD ZONE	37302	Hazard Zone Category|crib area
HAZARD ZONE	37303	Hazard Zone Category|foul ground
HAZARD ZONE	37304	Hazard Zone Category|mine danger area
HAZARD ZONE	37305	Hazard Zone Category|piling area
HAZARD ZONE	37306	Hazard Zone Category|platform area
HAZARD ZONE	37307	Hazard Zone Category|reef area
HAZARD ZONE	37308	Hazard Zone Category|rock area
HAZARD ZONE	37309	Hazard Zone Category|shoal

Feature Type	FCODE	Description
HAZARD ZONE	37310	Hazard Zone Category|snag/stump area
HAZARD ZONE	37311	Hazard Zone Category|well area
HAZARD ZONE	37312	Hazard Zone Category|wreckage
ICE MASS	37800	feature type only: no attributes
ICE MASS	37801	Ice Mass Category|alpine glacier
ICE MASS	37802	Ice Mass Category|continental glacier; Glaciation Category|ice shelf
ICE MASS	37803	Ice Mass Category|continental glacier; Glaciation Category|inland ice sheet
ICE MASS	37804	Ice Mass Category|pack ice
ICE MASS	37805	Ice Mass Category|snowfield
ICE MASS	37806	Ice Mass Category|unspecified
INUNDATION AREA	40300	feature type only: no attributes
INUNDATION AREA	40301	Inundation Control Status|controlled; Inundation Area Type|debris basin
INUNDATION AREA	40302	Inundation Control Status|controlled; Inundation Area Type|dewatering area
INUNDATION AREA	40303	Inundation Control Status|controlled; Inundation Area Type|duck pond
INUNDATION AREA	40304	Inundation Control Status|controlled; Inundation Area Type|general case
INUNDATION AREA	40305	Inundation Control Status|controlled; Inundation Area Type|percolation basin
INUNDATION AREA	40306	Inundation Control Status|controlled; Inundation Area Type|retarding basin
INUNDATION AREA	40307	Inundation Control Status|not controlled
LAKE/POND	39000	feature type only: no attributes
LAKE/POND	39001	Hydrographic Category|intermittent; Water Characteristics|salt
LAKE/POND	39002	Hydrographic Category|intermittent; Water Characteristics|unspecified
LAKE/POND	39003	Hydrographic Category|perennial; Water Characteristics|salt
LAKE/POND	39004	Hydrographic Category|perennial; Water Characteristics|unspecified
LOCK CHAMBER	39800	feature type only: no attributes
MUD POT	40900	feature type only: no attributes
NONEARTHERN SHORE	41100	feature type only: no attributes
PIPELINE	42800	feature type only: no attributes
PIPELINE	42801	Product|water; Pipeline Type|aqueduct; Relationship to Surface|at or near
PIPELINE	42802	Product|water; Pipeline Type|aqueduct; Relationship to Surface|elevated
PIPELINE	42803	Product|water; Pipeline Type|aqueduct; Relationship to Surface|underground
PIPELINE	42804	Product|water; Pipeline Type|aqueduct; Relationship to Surface|underwater
PIPELINE	42805	Product|water; Pipeline Type|general case; Relationship to Surface|at or near
PIPELINE	42806	Product|water; Pipeline Type|general case; Relationship to Surface|elevated
PIPELINE	42807	Product|water; Pipeline Type|general case; Relationship to Surface|underground
PIPELINE	42808	Product|water; Pipeline Type|general case; Relationship to Surface|underwater
PIPELINE	42809	Product|water; Pipeline Type|penstock; Relationship to Surface|at or near
PIPELINE	42810	Product|water; Pipeline Type|penstock; Relationship to Surface|elevated
PIPELINE	42811	Product|water; Pipeline Type|penstock; Relationship to Surface|underground
PIPELINE	42812	Product|water; Pipeline Type|penstock; Relationship to Surface|underwater
PIPELINE	42813	Product|water; Pipeline Type|siphon; Relationship to Surface|unspecified
PLAYA	36100	feature type only: no attributes
POST	42200	feature type only: no attributes
POST	42201	Post Type|dolphin
POST	42202	Post Type|piling
RAPIDS	43100	feature type only: no attributes
REEF	43400	feature type only: no attributes

Feature Type	FCODE	Description
RESERVOIR	43600	feature type only: no attributes
RESERVOIR	43601	Reservoir Type|aquaculture; Construction Material|unspecified
RESERVOIR	43602	Reservoir Type|decorative pool; Construction Material|nonearthen
RESERVOIR	43603	Reservoir Type|decorative pool; Construction Material|unspecified
RESERVOIR	43604	Reservoir Type|disposal-tailings pond; Construction Material|earthen
RESERVOIR	43605	Reservoir Type|disposal-tailings pond; Construction Material|unspecified
RESERVOIR	43606	Reservoir Type|disposal-unspecified; Construction Material|unspecified
RESERVOIR	43607	Reservoir Type|evaporator; Construction Material|unspecified
RESERVOIR	43608	Reservoir Type|swimming pool; Construction Material|nonearthen
RESERVOIR	43609	Reservoir Type|treatment-cooling pond; Construction Material|unspecified
RESERVOIR	43610	Reservoir Type|treatment-filtration pond; Construction Material|unspecified
RESERVOIR	43611	Reservoir Type|treatment-settling pond; Construction Material|unspecified
RESERVOIR	43612	Reservoir Type|treatment-sewage treatment pond; Construction Material|unspecified
RESERVOIR	43613	Reservoir Type|water storage; Construction Material|nonearthen; Cover Status|covered; Hydrographic Category|unspecified
RESERVOIR	43614	Reservoir Type|water storage; Construction Material|earthen; Cover status|not covered; Hydrographic Category|intermittent
RESERVOIR	43615	Reservoir Type|water storage; Construction Material|earthen; Cover status|not covered; Hydrographic Category|perennial
RESERVOIR	43616	Reservoir Type|water storage; Construction Material|nonearthen; Cover status|not covered; Hydrographic Category|unspecified
RESERVOIR	43617	Reservoir Type|water storage; Construction Material|unspecified; Cover status|unspecified; Hydrographic Category|unspecified
RESERVOIR	43618	Reservoir Type|unspecified; Construction Material|earthen
RESERVOIR	43619	Reservoir Type|unspecified; Construction Material|nonearthen
RESERVOIR	43620	Reservoir Type|unspecified; Construction Material|unspecified
ROCK	44100	feature type only: no attributes
ROCK	44101	Relationship to Surface|abovewater
ROCK	44102	Relationship to Surface|underwater
SEA/OCEAN	44500	feature type only: no attributes
SEA/OCEAN	44501	Sea/Ocean Category|reef pool
SEA/OCEAN	44502	Sea/Ocean Category|unspecified
SINK/RISE	45000	feature type only: no attributes
SNAG/STUMP	45200	feature type only: no attributes
SNAG/STUMP	45201	Snag/Stump Type|snag; Relationship to Surface|abovewater
SNAG/STUMP	45202	Snag/Stump Type|snag; Relationship to Surface|underwater
SNAG/STUMP	45203	Snag/Stump Type|stump; Relationship to Surface|abovewater
SNAG/STUMP	45204	Snag/Stump Type|stump; Relationship to Surface|underwater
SOUNDING DATUM LINE	50300	feature type only: no attributes
SOUNDING DATUM LINE	50301	Positional Accuracy|approximate
SOUNDING DATUM LINE	50302	Positional Accuracy|definite
SPECIAL USE ZONE	45400	feature type only: no attributes
SPECIAL USE ZONE	45401	Special Use Zone Type|dump site; Operational Status|operational
SPECIAL USE ZONE	45402	Special Use Zone Type|dump site; Operational Status|abandoned
SPECIAL USE ZONE	45403	Special Use Zone Type|spoil area; Operational Status|operational

Feature Type	FCODE	Description
SPECIAL USE ZONE	45404	Special Use Zone Type|spoil area; Operational Status|abandoned
SPECIAL USE ZONE LIMIT	53300	feature type only: no attributes
SPECIAL USE ZONE LIMIT	53301	Positional Accuracy|definite
SPECIAL USE ZONE LIMIT	53302	Positional Accuracy|indefinite
SPILLWAY	45500	feature type only: no attributes
SPRING/SEEP	45800	feature type only: no attributes
SPRING/SEEP	45801	Water Characteristics|unspecified
SPRING/SEEP	45802	Water Characteristics|alkaline
SPRING/SEEP	45803	Water Characteristics|hot
SPRING/SEEP	45804	Water Characteristics|sulphur
STREAM/RIVER	46000	feature type only: no attributes
STREAM/RIVER	46001	Hydrographic Category|intermittent; Positional Accuracy|definite
STREAM/RIVER	46002	Hydrographic Category|intermittent; Positional Accuracy|indefinite
STREAM/RIVER	46003	Hydrographic Category|intermittent; Positional Accuracy|not applicable
STREAM/RIVER	46004	Hydrographic Category|perennial; Positional Accuracy|definite
STREAM/RIVER	46005	Hydrographic Category|perennial; Positional Accuracy|indefinite
STREAM/RIVER	46006	Hydrographic Category|perennial; Positional Accuracy|not applicable
SUBMERGED STREAM	46100	feature type only: no attributes
SWAMP/MARSH	46600	feature type only: no attributes
TUNNEL	47800	feature type only: no attributes
UNDERPASS	48100	feature type only: no attributes
WALL	48300	feature type only: no attributes
WALL	48301	Wall Type|general case
WALL	48302	Wall Type|sea
WASH	48400	feature type only: no attributes
WATER INTAKE/OUTFLOW	48500	feature type only: no attributes
WATER INTAKE/OUTFLOW	48501	Water Intake/Outflow Type|intake
WATER INTAKE/OUTFLOW	48502	Water Intake/Outflow Type|outflow
WATERFALL	48700	feature type only: no attributes
WELL	48800	feature type only: no attributes
WELL	48801	Product|heat
WELL	48802	Product|water; Flow Status|flowing; Water Characteristics|unspecified
WELL	48803	Product|water; Flow Status|unspecified; Water Characteristics|alkaline
WELL	48804	Product|water; Flow Status|unspecified; Water Characteristics|hot
WELL	48805	Product|water; Flow Status|unspecified; Water Characteristics|sulphur
WELL	48806	Product|water; Flow Status|unspecified; Water Characteristics|unspecified
WRECK	49200	feature type only: no attributes
WRECK	49201	Relationship to Surface|abovewater; Abovewater Portion|hull and/or superstructure
WRECK	49202	Relationship to Surface|abovewater; Abovewater Portion|mast and/or funnel
WRECK	49203	Relationship to Surface|underwater

Appendix C. Encoding characteristics using field names

Fields provide another text-based means of encoding characteristics and values. Each field encodes the value for one characteristic. The name of each field is an abbreviation of the name of the corresponding characteristic. The entries for a field are the values for the characteristic.

For example, a feature classified as "Dam/Weir" may also have the characteristic of "Construction Material" with the values of "earthen" and "nonearthen", and the characteristic of "Operational Status" with the values of "operational" and "under construction". Using fields for characteristics, the following fields and entries can be encoded:

Characteristic:	**COM** (Construction Material)	**OPS** (Operational Status)
Values:	*<no entry>*	*<no entry>*
	earthen	Operational
	earthen	under construction
	nonearthen	Operational
	nonearthen	under construction

Table 1C contains the names of fields and the corresponding characteristics.

Table 1C. Field names used for characteristics and related domains of values, listed alphabetically by field name

(Note that several characteristics were not used in the initial release of the NHD. **Appendix A** lists feature types and characteristics that were not encoded. The "Standards for National Hydrography Dataset" (USGS, 1999) contains the names and definitions of all characteristics and values. It also lists the values that can be applied for each feature type. The document is available online through http://mapping.usgs.gov/standards/.)

Field Name	Characteristic Name	Domain of Values
ABW	Abovewater Portion	hull and/or superstructure mast and/or funnel
ANT	Anchorage Type	explosives isolation quarantine seaplane
CDY	Canal/Ditch Type	aqueduct unspecified
COM	Construction Material	earthen nonearthen unspecified
COS	Cover Status	covered not covered unspecified
FLO	Flow Status	flowing unspecified
GTT	Gate Type	drydock floodgate lock tidegate unspecified
CGC	Glaciation Category	ice shelf inland ice sheet

Field Name	Characteristic Name	Domain of Values
HZT	Hazard Zone Category	crib area foul ground mine danger area piling area platform area reef area rock area shoal snag/stump area unspecified well area wreckage
HYC	Hydrographic Category	intermittent perennial unspecified
IMC	Ice Mass Category	alpine glacier continental glacier pack ice snowfield unspecified
IAT	Inundation Area Type	debris basin dewatering area duck pond general case percolation basin retarding basin
ICS	Inundation Control Status	controlled not controlled
OPS	Operational Status	abandoned operational under construction
PIT	Pipeline Type	aqueduct general case penstock siphon
POA	Positional Accuracy	approximate definite indefinite not applicable
POT	Post Type	dolphin piling
PRD	Product	heat water
RTS	Relationship to Surface	abovewater at or near elevated underground underwater unspecified
RET	Reservoir Type	aquaculture decorative pool disposal-tailings pond disposal-unspecified evaporator swimming pool treatment-cooling pond treatment-filtration pond treatment-settling pond treatment-sewage treatment pond unspecified water storage

Field Name	Characteristic Name	Domain of Values
SOC	Sea/Ocean Category	reef pool unspecified
STT	Snag/Stump Type	snag stump
SZT	Special Use Zone Type	dump site spoil area
WAT	Wall Type	general case sea
WAC	Water Characteristics	alkaline hot salt sulphur unspecified
WIT	Water Intake/Outflow Type	intake outflow

Appendix D. Development of Reach Files and related concepts

(Adapted from "The U.S. EPA Reach File Version 3.0 alpha release (RF-3 Alpha) technical reference" (USEPA, 1994).)

Purpose and approach

In the 1970's, the U.S. Environmental Protection Agency (USEPA) began creating a series of hydrographic databases of the surface waters of the conterminous United States and Hawaii. The structure and content of these Reach File databases were created to establish hydrologic sequencing, to perform hydrologic navigation for modeling applications, and to provide unique identifiers, called reach codes, for each surface water feature.

A key characteristic of the Reach Files is the use of relations among reaches to define a connected hydrographic network. These relations provide connectivity among reaches even if their delineations do not form a topologically connected set of lines. The direction of water flow is also encoded using these relations. This connectivity enables hydrologic sequencing of reaches (identifying what is upstream and downstream of a given point in the hydrographic network), as well as navigating the network in an upstream or downstream direction.

The unique reach codes assigned to each reach have been used to geocode the locations of many water-related observations. Examples include USEPA national databases for surface waters, such as STORET Water Quality Sampling Sites, Municipal and Industrial Facility Discharges, and Drinking Water Intakes. Using the reach code, observations in these databases can be associated with their locations on surface water features.

Reach file development

The Reach File was first conceived in the early 1970's with a proof-of-concept file, known as Reach File Version 1.0 Alpha (RF1A), completed in 1975. The first full implementation, referred to as "Reach File Version 1.0" (RF1), was completed in 1982. The source for RF1 was the USGS 1:250,000-scale hydrography that had been photoreduced to a scale of 1:500,000 by the National Oceanic and Atmospheric Administration. RF1 consists of approximately 68,000 reach segments comprising 650,000 miles of stream.

Although RF1 still supports broad-based national applications, the need to provide a more detailed hydrologic network motivated the development of Reach File Version 2.0 (RF2) in the late 1980's. RF2 was created by using the Feature File (now called the National Geographic Names Database) of the USGS Geographic Names Information System (GNIS) to add one new level of reach segments to RF1. RF2 contains 170,000 reach segments.

Widespread interest in providing a more comprehensive, nationally consistent hydrologic database led to the development of the Reach File Version 3-Alpha (RF3-Alpha). This database combines data from RF1 and RF2, the GNIS, and the 1988 edition of USGS 1:100,000-scale digital line graph (DLG) hydrography data. RF3-Alpha contains nearly 3,200,000 individual hydrographic features (reaches) and more than 93,000,000 coordinate points.

The NHD is the fourth in the series of continuing improvements to reach data. This database supplements attribute-based connectivity with reach delineations that provide spatial connectivity, common classification of features that underlie the reaches, and a design that encourages cooperative data maintenance and improvements among many organizations.

Appendix E. Transport reach delineation rules and examples

A transport reach represents the pathway for the movement of water through a drainage network and encodes the direction in which water flows along the reach. Transport reaches provide a basis through which locations of observations can be geocoded and linked to the drainage network. Encoding flow relations among the reaches provides the ability to navigate through a drainage network and is the basis for determining hydrologic sequencing in the network.

Lines delineate transport reaches. Linear delineations of the feature types canal/ditch, pipeline, and stream/river provide the lines for most transport reach delineations.

By themselves, however, these features may not depict all flows through a drainage network. For areal features of the type area of complex channels, estuary, ice mass, lake/pond, playa, reservoir, swamp/marsh, wash, canal/ditch, and stream/river, "artificial path" features complete the network to represent the flow of water into, through, and out of features that are delineated by using areas. "Connector" features fill gaps in the delineation of features through which water flows.

For transport reaches for which the direction of flow is known, the lines are oriented in the direction of the flow of water. Note that the direction of flow is not always known (for example, when source materials are ambiguous) or uniform (for example, in tidal areas), and so the lines are not always oriented in the direction of flow.

Three general rules determine the location of the ends of transport reaches:
- the underlying feature rule,
- the confluence-to-confluence rule, and
- the branched path rule.

These rules govern the delineation of most transport reaches and make the delineation of most reaches a straightforward process. The rules do have exceptions, however. Unusual configurations of features require modification of the rules, as do the variable condition and ambiguities of information sources. In places where unusual configurations of feature or ambiguities in sources predominate, a larger percentage of reaches using modified rules will be encountered. This appendix describes the conditions that most often influence transport reach delineation.

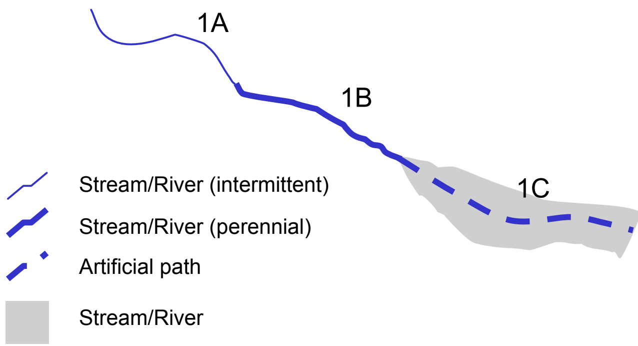
Underlying feature rule

The delineation of a transport reach follows those of one or more linear features. Where two or more features are followed, a transport reach follows delineations of :

- features of the same feature type (for example, exclusively stream/river) or
- features of the type of canal/ditch or stream/river, in combination with features of types artificial path and (or) connector. For an artificial path and a linear canal/ditch or stream/river to be combined to form a reach, the areal feature through which the artificial path is delineated must be of the same type as the linear feature to which the artificial path connects. For example, an artificial path through an areal canal/ditch can be combined with a linear canal/ditch to create one reach

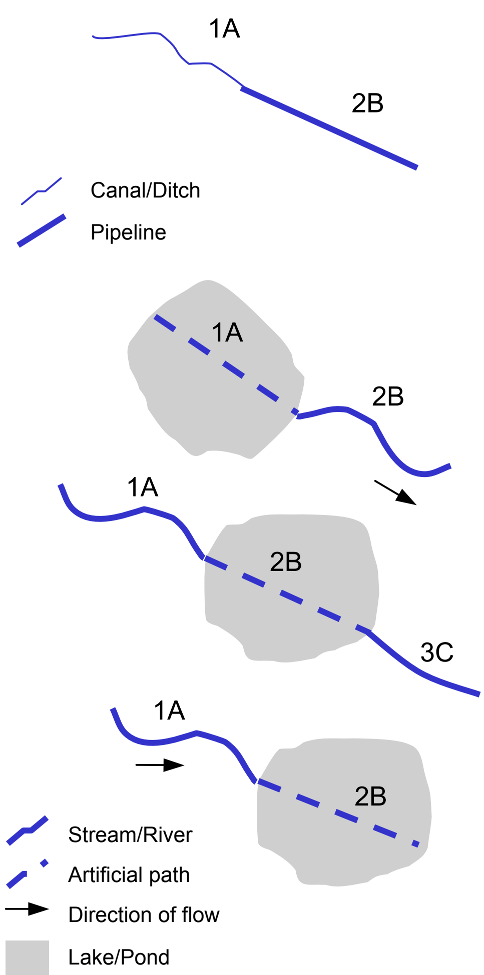
- each feature of the type pipeline is formed into a reach. Pipelines are never combined with artificial paths to form reaches.

Figure 1E illustrates the delineation of a reach that follows features of the same type, or, in the case of the artificial path, acts as surrogates for the same type. Different reaches follow features of different types (see Figure 2E).



Underlying feature rule (same type, including surrogates of the same type):
REACH 1 follows STREAM/RIVER A and B, and ARTIFICIAL PATH C (which acts as a surrogate for the areal stream/river).

Figure 1E. Transport reach delineation for features of the same type.



Underlying feature rule (different types):
REACH 1 follows CANAL/DITCH A
REACH 2 follows PIPELINE B.

Underlying feature rule (different types; head lake/pond):
REACH 1 follows ARTIFICIAL PATH A (which acts as a surrogate for the lake/pond).
REACH 2 follows STREAM/RIVER B.

Underlying feature rule (different types; inline lake/pond):
REACH 1 follows STREAM/RIVER A.
REACH 2 follows ARTIFICIAL PATH B (which acts as a surrogate for the lake/pond).
REACH 3 follows STREAM/RIVER C.

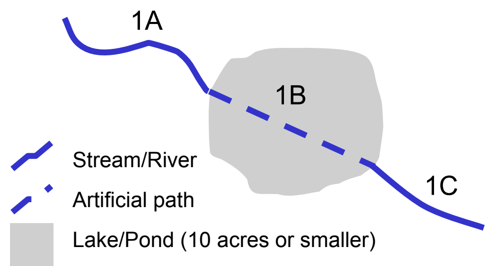
Underlying feature rule (different types; terminal lake/pond):
REACH 1 follows STREAM/RIVER A.
REACH 2 follows ARTIFICIAL PATH B (which acts as a surrogate for the lake/pond).

Figure 2E. Transport reach delineation for features of different types.

A transport reach always follows the entire delineation of the underlying feature or features; the delineation of a feature is not split among reaches. Transport reaches abut and do not overlap.

Exception: Insignificant lake/pond features (10-acre rule)

An exception to the underlying feature rule is made for artificial paths that represent flow through lake/pond features of 10 acres (4.05 hectares) or less. In these cases, the lake/pond feature is ignored for the purpose of reach delineation. The artificial path is treated as an extension of the inflowing and outflowing linear feature and is not designated as a separate transport reach (see Figure 3E).



Underlying feature rule
(insignificant lake/pond):
REACH 1 follows STREAM/RIVER A, ARTIFICIAL PATH B (which acts as a surrogate for the insignificant lake/pond), and STREAM/RIVER C.

Figure 3E. Transport reach delineation for insignificant lake/pond features.

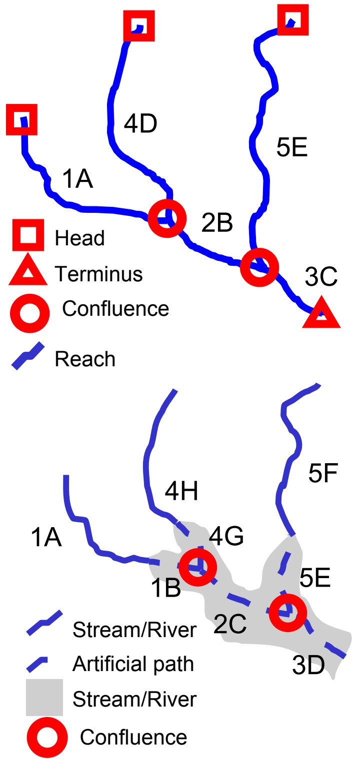
Confluence-to-confluence rule

Like feature types (and their surrogates)

In the "confluence-to-confluence" rule, a transport reach is a stretch of water between:

- confluences,
- a head and a confluence,
- a confluence, and a mouth or terminus, or
- a head, and a mouth or terminus.

This rule applies where the features are of the same type or are of types (that is, artificial path and connector) that act as surrogates for features of the same type. These reaches must be contiguous and may not branch (see Figure 4E).

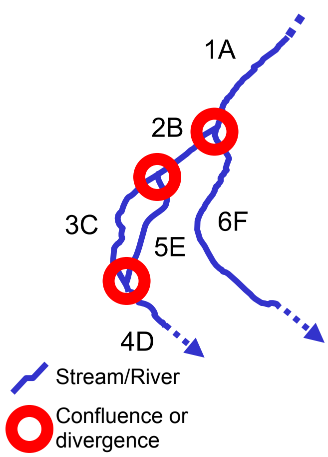


<u>Confluence-to-confluence rule</u>
REACH 1 follows STREAM/RIVER A.
REACH 2 follows STREAM/RIVER B.
REACH 3 follows STREAM/RIVER C.
REACH 4 follows STREAM/RIVER D.
REACH 5 follows STREAM/RIVER E.

<u>Confluence-to-confluence rule</u>
REACH 1 follows STREAM/RIVER A and ARTIFICIAL PATH B (which acts as a surrogate for the stream/river).
REACH 2 follows ARTIFICIAL PATH C (which acts as a surrogate for the stream/river).
REACH 3 follows ARTIFICIAL PATH D (which acts as a surrogate for the stream/river).
REACH 4 follows STREAM/RIVER H and ARTIFICIAL PATH G (which acts as a surrogate for the stream/river).
REACH 5 follows STREAM/RIVER F and ARTIFICIAL PATH E (which acts as a surrogate for the stream/river).

Figure 4E. Confluence-to-confluence delineation among like feature types.

Generally, divergences and confluences are treated as "confluences" for reach delineation. Separate reaches are delineated for each channel (see Figure 5E).

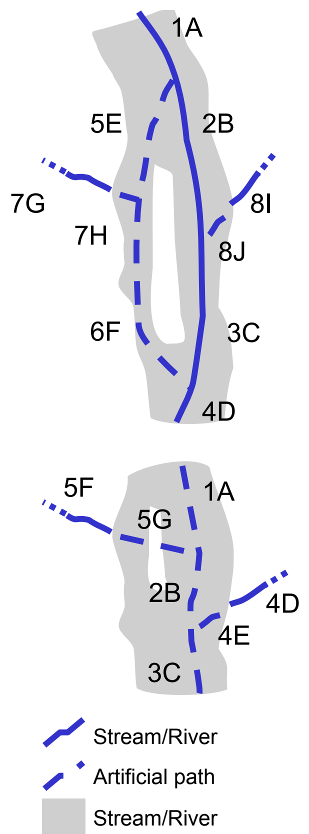


<u>Confluence-to-confluence rule</u> (divergences)
REACH 1 follows STREAM/RIVER A.
REACH 2 follows STREAM/RIVER B.
REACH 3 follows STREAM/RIVER C.
REACH 4 follows STREAM/RIVER D.
REACH 5 follows STREAM/RIVER E.
REACH 6 follows STREAM/RIVER F.

Figure 5E. Confluence-to-confluence delineation for multiple channels.

When an areal feature of type stream/river splits into two channels, a decision must be made as to whether or not reach delineation (that is, the addition of artificial paths and creation reaches) should be performed in the secondary channel. The following rules (see Figure 6E) guide reach delineation for the channels:

- Select the primary channel. The channel with the most tributaries or, if tributaries are not present, the widest channel is designated as the primary channel and reaches always should be delineated on this channel.
- Decide if reaches should be delineated on the secondary channel. The size and shape of the land that separates the channels and the presence of tributaries on the secondary channel help determine if the secondary channel is significant (and should have a reach delineated). If the land separating the channels is small or if there are no tributaries, the secondary channel is minor (and need not have reaches delineated).



Confluence-to-confluence rule (both channels significant)
REACH 1 follows ARTIFICIAL PATH A.
REACH 2 follows ARTIFICIAL PATH B.
REACH 3 follows ARTIFICIAL PATH C.
REACH 4 follows ARTIFICIAL PATH D.
REACH 5 follows ARTIFICIAL PATH E.
REACH 6 follows ARTIFICIAL PATH F.
REACH 7 follows STREAM/RIVER G and ARTIFICIAL PATH H.
REACH 8 follows STREAM/RIVER I and ARTIFICIAL PATH J.

Confluence-to-confluence rule (one channel significant)
REACH 1 follows ARTIFICIAL PATH A.
REACH 2 follows ARTIFICIAL PATH B.
REACH 3 follows ARTIFICIAL PATH C.
REACH 4 follows STREAM/RIVER D and ARTIFICIAL PATH E.
REACH 5 follows STREAM/RIVER F and ARTIFICIAL PATH G.

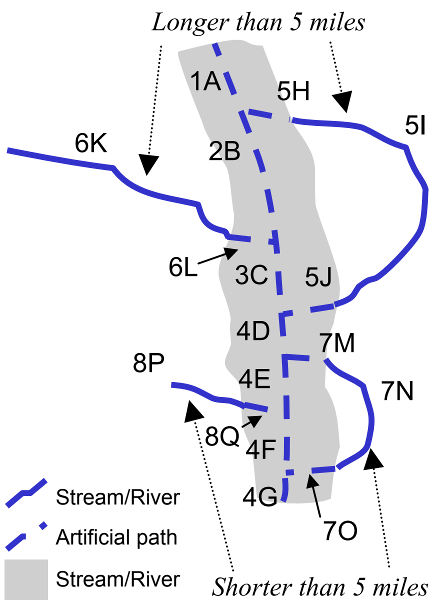
Figure 6E. Transport reach delineation for multiple divergent channels.

When the land separating the channels is large or long, it may be clear that the primary and the secondary channels are different stream/rivers and, therefore, both channels have reaches delineated. Regardless of the size and shape of the land, the presence of tributaries to the secondary channel weighs heavily in determining that it will have reaches delineated.

Exception: Insignificant confluences (5-mile rule)

Where a simple[14] tributary or divergence of less than 5 miles (approximately 8.06 kilometers) in length intersects an areal feature of type stream/river, the intersection is not considered to be a confluence for delineating the reach along the areal stream/river (see Figure 7E). This approach avoids breaking major stream/rivers into unnecessarily small reaches caused by the confluence of small tributaries and divergences.

[14] A simple tributary or divergence is a reach that has no tributaries.

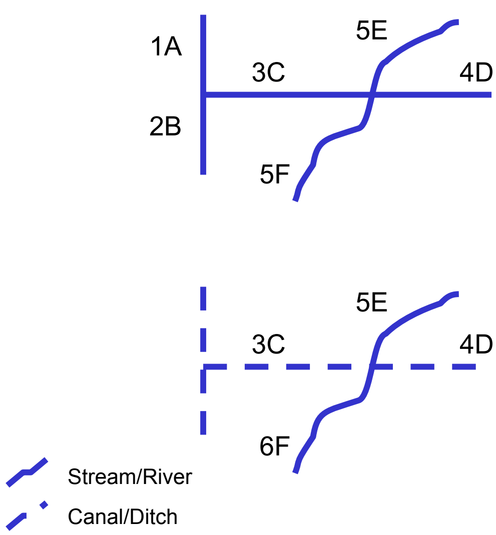


Confluence-to-confluence rule (significant and insignificant tributaries and divergences):
REACH 1 follows ARTIFICIAL PATH A.
REACH 2 follows ARTIFICIAL PATH B.
REACH 3 follows ARTIFICIAL PATH C.
(Reaches 1 through 3 have confluences with significant tributaries and divergences.)
REACH 4 follows ARTIFICIAL PATHS D, E, F, and G *(has confluences with only insignificant tributaries and divergences).*
REACH 5 follows ARTIFICIAL PATH H, STREAM/RIVER I, and ARTIFICIAL PATH J.
REACH 6 follows STREAM/RIVER K and ARTIFICIAL PATH L.
REACH 7 follows ARTIFICIAL PATH M, STREAM/RIVER N, and ARTIFICIAL PATH O.
REACH 8 follows STREAM/RIVER P and ARTIFICIAL PATH Q.

Figure 17. Significant and insignificant confluences in reach delineation.

Unlike feature types: stream/river and canal/ditch

The intersection of features types stream/river and canal/ditch that occurs at the same elevation (see Figure 8E) generally is treated as a confluence for the canal/ditch but not for the stream/river. An alternate approach treats the intersection as a confluence for both feature types.



Confluence-to-confluence rule (preferred approach: stream/river with canal/ditch):
REACH 3 follows CANAL/DITCH C.
REACH 4 follows CANAL/DITCH D.
REACH 5 follows STREAM/RIVER E and F.

Other confluence-to-confluence delineations:
REACH 1 follows CANAL/DITCH A.
REACH 2 follows CANAL/DITCH B.

Confluence-to-confluence rule (alternate approach: stream/river with canal/ditch):
REACH 3 follows CANAL/DITCH C.
REACH 4 follows CANAL/DITCH D.
REACH 5 follows STREAM/RIVER E.
REACH 6 follows STREAM/RIVER F.

Figure 8E. Confluence of stream/river and canal/ditch.

No confluence: underpasses and pipelines

Because fluids carried by features do not flow together at an underpass (where features intersect at different elevations), there is no confluence, and so the confluence-to-confluence rule does not apply and the reaches are not broken at the intersection.

With the information available during the development of the initial release of the NHD, it was not possible to determine if fluids carried by pipelines flow together with those carried by other features (for example, stream/river and canal/ditch) with which a pipeline intersects on a map. The assumption is that the fluids do not flow together. So there is no confluence, the confluence-to-confluence rule does not apply, and the reaches are not broken at the intersection. (When it is known that a pipeline exchanges fluids with another feature of a different type, it will be treated as a confluence of unlike feature types.)

Branched path rule

A branched path transport reach connects reaches that enter and exit an areal feature (see Figure 9E). The branched path transport reach avoids the need to define flow channels, confluences and divergences, and confluence-based transport reaches in areal features. It is used where information needed to delineate these items reliably is not available and in other places at the analyst's discretion.

Reaches that follow this rule occur most often in large[15] features of type lake/pond and swamp/marsh and may occur in other areal features. Artificial paths delineated within the areal feature provide the lines needed to delineate this special transport reach. The reach may branch and, infrequently, may be discontiguous (see Figure 10E).

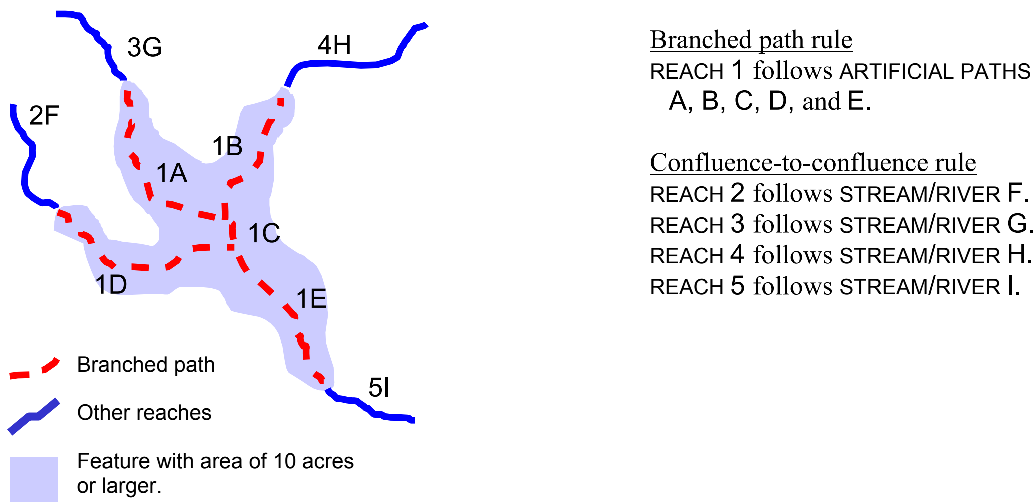
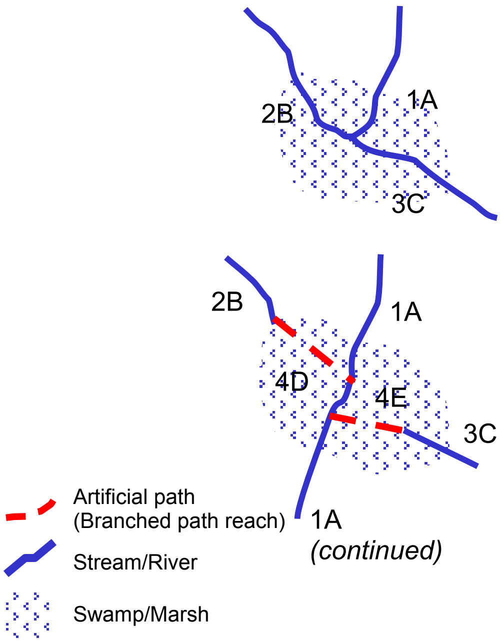


Figure 9E. Branched path reach delineation.

In cases where channels and confluences are delineated, confluence-based reaches are delineated, and branched path transport reaches are not needed. If the flow channels delineated within a feature are incomplete, a branched path transport reach is added to provide connectivity (see Figure10E).

[15] Large areal features cover 10 or more acres (approximately 4.05 or more hectares).



Confluence-to-confluence rule
REACH 1 follows STREAM/RIVER A.
REACH 2 follows STREAM/RIVER B.
REACH 3 follows STREAM/RIVER C.

Branched path rule
NONE. *The stream/river features provide the basis for confluence-to-confluence reaches.*

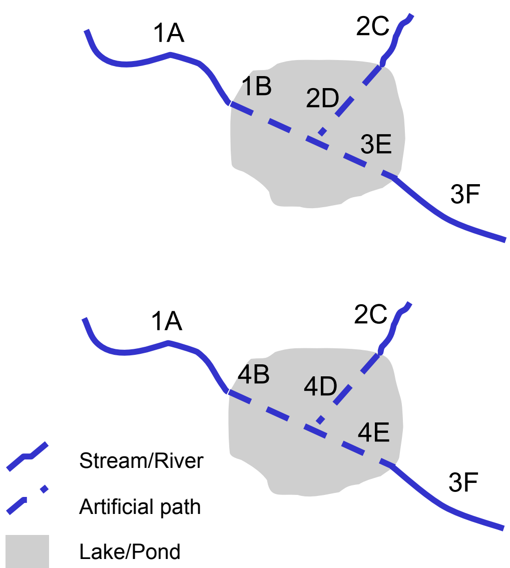
Confluence-to-confluence rule
REACH 1 follows STREAM/RIVER A.
REACH 2 follows STREAM/RIVER B.
REACH 3 follows STREAM/RIVER C.

Branched path rule (discontiguous reach)
REACH 4 follows ARTIFICIAL PATHS D and E (which act as a surrogate for the swamp/marsh).

Figure 10E. Use of branched path reaches where other features provide flow channels through areal features.

Exception: Insignificant lake/pond features (10-acre rule)

An exception to the branched path rule is made for artificial paths that represent flow through lake/pond features of 10 acres (4.05 hectares) or less. In these cases, the artificial paths are treated as extensions of the inflowing and outflowing linear features, and the confluence-to-confluence delineation rule is used for transport reaches within the lake/pond (see Figure11E).



Confluence-to-confluence rule (lake/pond 10 acres or smaller)
REACH 1 follows STREAM/RIVER A and ARTIFICIAL PATH B.
REACH 2 follows STREAM/RIVER C and ARTIFICIAL PATH D.
REACH 3 follows ARTIFICIAL PATH E and STREAM/RIVER F.

Branched path rule (lake/pond larger than 10 acres)
REACH 1 follows STREAM/RIVER A.
REACH 2 follows STREAM/RIVER C.
REACH 3 follows STREAM/RIVER F.
REACH 4 follows ARTIFICIAL PATHS B, D, and E.

Figure 11E. Transport reach delineation in significant and insignificant lake/pond features.

Appendix F. Organization and examples of hydrologic units

(Adapted from "Hydrologic unit maps" (Seaber, Kapinos, and Knapp, 1987)).

A hydrologic unit is a member of the hierarchical system for identifying and subdividing river-basin units of the United States. Such units are used by water resource organizations for locating, storing, retrieving, and exchanging hydrologic data; for indexing and inventorying hydrologic data in cataloging water-data acquisition activities; and in a variety of other applications.

A standard four-level hierarchy[16] of hydrologic units exists for the Nation. The levels in this hierarchy, listed from largest to smallest in area, are region, subregion, accounting unit, and subbasin:

- *Regions* contain either the drainage area of a major river, such as the Missouri region, or the combined drainage areas of a series of rivers, such as the Texas-Gulf region, which includes a number of rivers draining into the Gulf of Mexico. There are 21 regions: 18 for the conterminous United States, and 1 each for Alaska, Hawaii, and Puerto Rico and other outlying Caribbean areas.
- The second level of classification divides the 21 regions into 222 *subregions*. A subregion includes the area drained by a river system, a part of a river and the tributaries to that part, one or more closed basin(s), or a group of streams forming a coastal drainage area.
- The third level subdivides many of the subregions into *accounting units*. These 379 units nest within, or are equivalent to, the subregions.
- The fourth level of classification is the *subbasin*. This hydrologic unit is a geographic area representing part or all of a surface drainage basin, a combination of drainage basins, or a distinct hydrologic feature. These units subdivide the subregions and accounting units into 2,267 areas for the Nation. They have been defined so that most subbasins are larger than 700 square miles (1,813 square kilometers) in area. In special circumstances, areas smaller than 700 square miles are identified.

All boundaries of units within the United States are hydrologic (hydrographic) in nature. At the international boundaries of the United States with Mexico and Canada, region and subregion boundaries end or coincide with the boundary. The boundaries of accounting units and subbasins are hydrologic, and can be extended into Mexico and Canada. With the exception of areas near the international boundary, each unit nests within, or coincides with, its next largest unit. Seaber, Kapinos, and Knapp (1987) provide additional technical criteria for delineating hydrologic units.

Each hydrologic unit has been assigned a name corresponding to the principal hydrologic feature(s) within the unit. In the absence of such features, the assigned name may reflect a cultural or political feature within the unit. All regions and subregions are uniquely named; however, the accounting units are named uniquely only within each region, and the subbasins are named uniquely only within each accounting unit. Duplication of some names at the subbasin level is unavoidable because a large number of streams share the same names.

Shown below is an example of the units in the hierarchy (see Figure 1F):

> region — New England region: the drainage within the United States that ultimately discharges into: (a) the Bay of Fundy, (b) the Atlantic Ocean within and between the States of Maine and Connecticut, (c) Long Island Sound north of the New York-Connecticut state line, and (d) the Riviere St. Francois, a tributary of the St. Lawrence River.
> subregion — Connecticut: the Connecticut River basin.
> accounting unit — Lower Connecticut: the Connecticut River basin below Vernon Dam.
> subbasin — Chicopee.

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[16] Efforts are under way to add levels of subdivision, especially fifth- and sixth-level units.

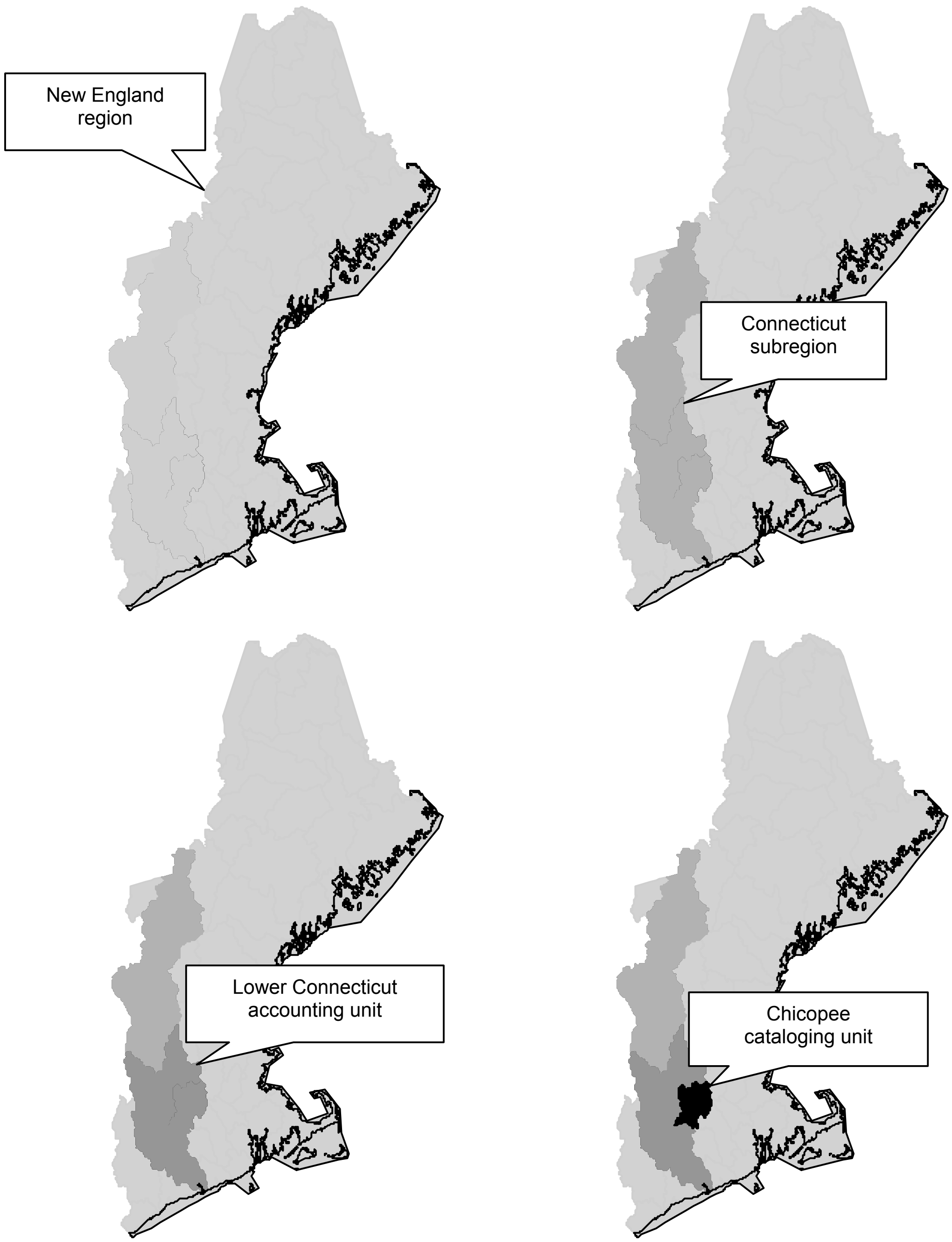

Figure 1F. Hydrologic units in the New England region.
(Data from Allord, 1992).

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An 8-digit hydrologic unit code uniquely identifies each of the four levels of classification within four 2-digit fields. The first 2 digits identify regions, the first 4 digits identify subregions, the first 6 digits identify accounting units, and the full 8 digits identify subbasins. For example, the hydrologic unit codes for the example provided above are as follows:

> 01 — the region (New England)
> 0108 — the subregion (Connecticut)
> 010802 — the accounting unit (Lower Connecticut)
> 01080204 — the subbasin (Chicopee)

Zeroes in the two-digit accounting unit field indicate that the accounting unit and the subregion are the same. Zeroes in the two-digit subbasin field indicate that the subbasin and the accounting unit are the same.

Additional information is available in the online document "Hydrologic unit maps" (USGS, 1998) at http://water.usgs.gov/lookup/get?huc.

Hydrologic unit boundaries have also been incorporated as a map layer in the National Atlas of the United States and are available online at http://www.nationalatlas.gov/hucsm.htm.

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Appendix G. Peculiarities

The NHD contains certain *peculiarities*, which generally reflect inconsistencies and deficiencies in the source data used to create the NHD. The items in this category tend to be irritating, but they do not undermine the usefulness of the NHD and can be resolved on a case by case basis. In some cases, such as quad edge effects, mismatches are likely to be encountered frequently. However, developers of the NHD decided it would be more valuable to make the NHD available as soon as possible rather than investing the time and money that would have been required to identify and correct every quad edge mismatch in the raw data. The purpose of this list is to alert users to the existence of these peculiarities so that they can be anticipated and dealt with as they occur. The following summary describes the most significant of these and any steps, already taken or planned, to resolve them.

Quad Edge Effects

Features in the NHD still stop and start at USGS 1:100,000-scale quadrangle edges. Reaches, however, are continuous across quad edges. By delineating features based on the 1:100,000-scale quadrangle, the NHD maintains the lineage of each feature. By making the reaches continuous across quad edges, the NHD maintains the ability to navigate through the hydrologic network and the ability to create routes and event data without artificial breaks at the quad edges.

Because the NHD is designed to manage the data hydrologically, discrepancies at quad edges become more obvious. Some features stop abruptly, and some features cross quad edges but are classified differently on both sides. This reflects the different sources and dates used to make the 1:100,000-scale maps and associated DLGs from which the NHD was created.

DLG-3 coding inconsistencies

The feature types and characteristics in the NHD reflect the coding of the original DLGs. If a feature was miscoded in the DLG, it likely will be misclassified in the NHD. In some cases, the DLG did not provide enough information to create a correct NHD feature. The following are a few “systematic” coding problems we would like to point out.

Inland oceans

The DLG code 050 0116 is defined as “bay, estuary, gulf, ocean, or sea,”. This code was intended to describe saltwater areas, but in some cases it was used for “named” bays within freshwater areas. The DLG code 050 0116 was always converted to the NHD feature sea/ocean even when applied to an inland “bay”. Therefore, some landlocked (i.e.inland) sea/ocean features were created.

Disguised aqueducts

Conduits like penstocks, aqueducts, tunnels, and pipelines were coded in various ways in the DLGs. In the NHD, the intent is to classify these features by their form. Due to coding inconsistencies or inadequate information, the DLG did not always provide enough information to carry out the NHD intent. For example, in the NHD an open artificial channel would be classified as a canal/ditch, but a closed conduit would be classified as a pipeline. If the feature is “underground,” it would have a “relationship to surface” of underground, but if it is inside a tunnel, then both canal/ditch and tunnel would have been created in the NHD. The same real-world feature also could be classified differently if it appeared on different 1:100,000-scale quads (see previous quad-edge effects discussion)

Coastal features - foreshore versus sand

Several symbols were used on the topographic and topographic/bathymetric maps to identify sand, sand dunes, tidal flats, and foreshore areas. Often these symbols were confused when applying DLG codes. As a result, foreshore features sometimes stop abruptly (see previous quad-edge effects discussion).

Stream/rivers controlled by dams that become a series of slackwater pools

When a stream/river is impounded or has the flow controlled for navigation, it often is difficult to classify the feature based on the information shown on the topographic map. Does it behave like a stream/river or more like a lake/pond? Most often, if a feature was named on the map as a ‘lake’, it was coded in DLG as a lake. But this was done inconsistently. It becomes more obvious in the NHD because reaches are delineated differently if the feature is a stream/river or a lake/pond.

Reservoir versus lake/pond

In the source DLG data, the decision to classify a waterbody as a lake/pond or a reservoir was based on the name of the feature. If the name contained the generic term “reservoir”, it was coded 050 0101 (reservoir). In the NHD, an attempt was made to clarify this distinction based on the form of the feature. However, in some cases there was not enough information in the DLG to make the correct classification. A lake/pond is a standing body of water with a predominately natural shoreline (it may be impounded). A reservoir is a constructed basin. In building the NHD, if the feature was coded as 050 0101(reservoir) or 050 0421(lake/pond) it was classified as a lake/pond unless the geometry of the feature indicated that it was a constructed basin (it was square). Other DLG codes for sewage disposal pond, filtration pond, and aquaculture ponds were converted to the NHD feature reservoir.

NHD linework doesn’t match the published USGS 1:100,000-scale map

Some of the 1:100,000-scale DLGs were created from BLM editions or from earlier planimetric editions of the1:100,000-scale maps. These maps were replaced with USGS topographic editions, but usually, the DLG was not re-digitized. The date of the source DLG indicates which edition of the map was used for digitizing. If the date of the source DLG is older than the published 1:100,000-scale topographic map, it is likely that the DLG was digitized from a planimetric or BLM edition.

Names

Names for transport reaches came from RF3. Names from RF3 were validated against GNIS. There are reaches that have names in GNIS that do not have names in the NHD and some names in NHD are applied to the wrong path when compared to GNIS. Users are encouraged to supply updates to names to the USGS. GNIS is continually updated (including Board of Geographic Names (BGN) decisions and new names), therefore, names in the NHD are likely to be more current than those on published 1:100,000-scale maps.

CU boundaries and the features that touch and cross them

The NHD is a seamless dataset. However, initial distribution of the NHD data is by subbasins. It is not possible to “clip” a subbasin from the seamless data using existing subbasin boundaries, because the resolution of the CU boundaries does not match the resolution of the reach linework. Generally the CU boundaries are based on 1:250,000-scale linework and the reaches are based on 1:100,000-scale linework. Data are pulled from the seamless NHD database and associated with the appropriate CU using a number of rules.

1. All reaches that have a reach code that includes the CU number
2. All features that are part of the reaches from step 1 (artificial path, 1-D canal/ditch, connector, 1-D stream/river, and pipeline)
3. All non-reached features (including landmarks and 2-D stream/rivers and 2-D canal/ditches) that are within or "touch" the CU boundary.

As a result of these rules, features can extend outside the CU boundaries. The most obvious examples are 2-D stream/rivers. They are included in a CU if they touch the CU boundary. This means they will appear in multiple adjacent subbasins. These duplicated features should not pose a problem unless adjacent subbasins are to be appended. A tool to append subbasins is being developed that will properly delete one of the instances.

Some reaches may appear to cross CU boundaries. The flow direction relationships are used to determine which CU a reach is associated with, not just the CU boundary. In building the NHD, problems with reaches being clipped in RF3 were fixed whenever possible, but a few cases where reaches are associated with the wrong CU still exist.

Squared-off coastal CU boundaries

Along the coast, the NHD used CU boundaries that were extended as straight lines into the ocean to the edge of the 1:100,000-scale quad to ensure that all coastal islands in the DLG were included in the NHD.

Empty Subbasins

There are a number of subbasins that represent a single waterbody with the edge of the water body coinciding with the edge of the subbasin. These subbasins are:
01100007 – Long Island Sound
02040204 – Delaware Bay
02060001 – Upper Chesapeake
02080101 – Lower Chesapeake
04020300 – Lake Superior
04060200 – Lake Michigan
04080300 – Lake Huron
04120200 – Lake Erie
04150200 – Lake Ontario

In addition, the NHD does not have data for:
20090000 - Northwestern Hawaiian Islands
21030001 - Canal Zone. Panama Canal Zone.
21030002 - Navassa. Navassa Island.
21030003 - Roncador-Serrana. Roncador and Serrana Banks.

The waterbodies represented by these subbasins are not represented as waterbody reaches in the NHD. The boundaries of the subbasins that border these 'waterbody subbasins' were extended to encompass the area enclosed by the 'waterbody subbasins'. Any hydrographic features such as islands, including streams and lakes on the islands, that are inside these waterbody subbasins are included in the bordering subbasins.

Coastline reaches that bound stream/rivers

RF3 and DLG sometimes used different sources and rules in tidal areas to determine where a stream ends and the ocean begins. In the NHD, the feature classification comes form the DLG, but the information used to create coastline reaches comes from RF3. As a result, coastline reaches sometimes bound stream/river features.

Waterbody reaches

Waterbody reaches were created automatically by associating a lake/pond (and only lake/ponds) in the NHD with a 'lake' identified in RF3. Because of discrepancies in coding and coordinates among the various sources, not all lake/ponds in the NHD have been identified as waterbody reaches. Users needing to link information to a lake that does not have an associated reach with an assigned reach code, may create a reach for the lake/pond and provide the updates to the NHD.

In some cases, lake/ponds near the CU boundary may appear not to be associated with a waterbody reach. Because of the rules needed to create subbasins from the seamless NHD database, waterbodies along a CU boundary may appear in both subbasins. The waterbody reaches however, will only appear in the CU identified by the waterbody reach code.

Flow/coordinate direction/measure direction

In the NHD, flow direction is known and recorded for some, but not all, transport reaches. Flow direction is recorded in flow relationships that describe which transport reaches exchange flow. Recording the flow direction for a transport reach also affects the order of the reach's coordinates and the direction of the measures along the reach's route. When flow direction is recorded for a transport reach, the coordinates of the reach are ordered from upstream to downstream and the measures along the routes for the reach run from downstream to upstream. When flow direction is either unknown or not recorded for a transport reach, coordinate order and measure direction are indeterminate. The coordinates of coastal reaches are ordered so that the water is to the right and the land is to the left and the measures along the routes run the opposite direction. For more information on this subject, see the Introducing the NHDinARC technical reference.

Artificial Paths that fall outside of the 2-D features they represent

Artificial paths were created in 2-D stream/rivers, 2-D canal/ditches, and lake/ponds using ARC/INFO grid with a tolerance of approximately 17 meters. Artificial paths may fall outside of the feature they represent, they may fall on top of an edge of the feature they represent, or they may fall *extremely* close to the edge of a feature they represent. Artificial paths were only created in headwater lake/ponds when the direction of flow was available from RF3. Artificial paths do not follow submerged streams, which represent the old stream channel through an impounded lake/pond.