Federal Guidelines, Requirements, and Procedures for the National Watershed Boundary Dataset

Chapter 3 of
Section A, Federal Standards
Book 11, Collection and Delineation of Spatial Data

Techniques and Methods 11–A3

U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of Agriculture
Natural Resources Conservation Service

Hydrologic Unit Levels

Name	Hydrologic unit level	Digits	Average size (square miles)	Approximate number of hydrologic units
Region	1	2	177,560	21 (actual)
Subregion	2	4	16,800	222
Basin	3	6	10,596	370
Subbasin	4	8	700	2,200
Watershed	5	10	227 (40,000-250,000 acres)	22,000
Subwatershed	6	12	40 (10,000-40,000 acres)	160,000

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KEN SALAZAR, Secretary

U.S. Geological Survey
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Contents

Figures

Conversion Factors

Multiply	By	To obtain
	Length	
mile, nautical (nmi)	1.852	kilometer (km)
	Area	
square meter	0.0002471	acre
acre	0.4047	hectare (ha)
acre	4,047	square meter (m^2)
square mile (mi^2)	259.0	hectare (ha)
square mile (mi^2)	2.590	square kilometer (km^2)

Elevation, as used in this report is the height above a specific vertical reference datum.

Federal Guidelines, Requirements, and Procedures for the National Watershed Boundary Dataset

By U.S Geological Survey and U.S. Department of Agriculture, Natural Resources Conservation Service

Abstract

The Watershed Boundary Dataset (WBD) is a comprehensive aggregated collection of hydrologic unit data consistent with the national criteria for delineation and resolution. This document establishes interagency guidelines for creating the WBD as seamless and hierarchical hydrologic unit data, based on topographic and hydrologic features across the United States. This document provides guidelines, requirements, and procedures for expanding and revising the previous U.S. Geological Survey (USGS)-Natural Resources Conservation Service (NRCS) national data published in 1994. Expansion is accomplished by creating two additional levels of detailed hydrologic unit boundaries nested within the 1:250,000-scale hydrologic units, and revision occurs through increasing the data resolution to 1:24,000-scale in the conterminous United States, 1:25,000 scale in the Caribbean, and 1:63,360 scale in Alaska. The guideline contains details for compiling the two additional levels, Watersheds (5th-level, 10-digit hydrologic units) and Subwatersheds (6th-level, 12-digit hydrologic units), to be incorporated into the WBD. The guidelines are designed to enable local, regional, and national partners to consistently and accurately delineate watersheds. Such consistency improves watershed management through efficient sharing of information and resources and by ensuring that digital geographic data are usable with other related Geographic Information System (GIS) data.

Terminology, definitions, and procedural information are provided to ensure uniformity in hydrologic unit boundaries, names, and numeric codes. Detailed requirements and specifications for data are included. The document also includes discussion of objectives, communications required to revise the 1:250,000-scale source data, as well as final review and data-quality criteria. Instances of unusual landforms or artificial features that affect the hydrologic units are described with metadata requirements. Up-to-date availability of Watersheds (5th-level hydrologic units) and Subwatersheds (6th-level hydrologic units) is listed at *http://www.ncgc.nrcs.usda.gov/products/datasets/watershed/*

This publication has been updated and clarified from the previous NRCS guidance document "Federal Standard for Delineation of Hydrologic Unit Boundaries, Version 2.0, October 1, 2004," through contributions of the WBD Technical Support Team, as requested by the Subcommittee on Spatial Water Data. The USGS online publication is available on the Web at *http://pubs.usgs.gov/tm/tm11a3/*

1. Introduction

1.1 Purpose

This document establishes interagency guidelines, requirements, and procedures to create a national, consistent, seamless, and hierarchical hydrologic unit dataset based on topographic and hydrologic features across the United States. This Watershed Boundary Dataset (WBD) at 1:24,000 scale in the conterminous United States, 1:25,000 scale in the Caribbean, and 1:63,360 scale in Alaska, consists of digital geographic data that include two additional levels of detailed hydrologic unit boundaries nested within existing or modified 1:250,000-scale hydrologic units. This document serves as interagency guidance for developing digital geographic data for Watersheds (5th-level, 10-digit hydrologic units) and Subwatersheds (6th-level, 12-digit hydrologic units) to be incorporated into the WBD. The guidelines are designed to provide a consistent framework for local, regional, and national needs in States, Tribal Lands, Pacific Islands, Puerto Rico, and the U.S. Virgin Islands to accurately delineate watersheds.

This document sets forth terminology, definitions, and procedural information to ensure the uniform development of hydrologic unit boundaries and numeric codes by the agencies, tribes, and other organizations that develop, manage, archive, exchange, and analyze data by hydrologic features. The document will enable a variety of users from different agencies and programs to contribute to coordinated watershed management, to efficiently share information and resources, and to ensure the digital geographic data are usable with other related Geographic Information System (GIS) data.

Use of these criteria and techniques for hydrologic unit selection and boundary delineation will permit use of the standardized hydrologic units by a diverse group serving multiagency programs. Some examples of these programs include watershed management, water-quality initiatives, watershed modeling, resource inventory and assessment, and Total Maximum Daily Load development. The usefulness of hydrologic units in a variety of sizes based on natural surface-water flow and topography cannot be underestimated for potentially invaluable analytical and statistical purposes and applications. Instances of unusual landforms or artificial features that affect the hydrologic units are recorded in attributes and associated metadata but in no way should detract from the intent of these data to reflect surface-water flow.

When the WBD is completed for the Nation, the distribution of GIS layers and associated maps created by use of uniform guidelines and procedures will improve quality, consistency, and accessibility to hydrologic unit data nationwide and become the framework for continued updates. Up-to-date availability of Watersheds (5th-level, 10-digit hydrologic units) and Subwatersheds (6th-level, 12-digit hydrologic units) is listed at *http://datagateway.nrcs.usda.gov/*

1.2 Background

A standardized system for organizing and collecting hydrologic data was developed in the mid 1970s by the U.S. Geological Survey (USGS) under the sponsorship of the Water Resources Council. This system divided and subdivided the country into successively smaller hydrologic units based on surface features; established associated codes, names, and boundaries for the units; and classified them into four levels: Regions, Subregions, Accounting Units (currently referred to as “Basins”), and Cataloging Units (currently referred to as “Subbasins”). The hierarchical hydrologic unit code consists of 2-digit numbers for each of the 4 nested hydrologic unit levels. These 4 levels aggregated form the 8-digit hydrologic unit code. The underlying hydrologic concept is a topographically defined set of drainage areas organized in a nested hierarchy by size and number of divisions per nested level.

The standardized 8-digit USGS Hydrologic Units (1st, 2d, 3d, and 4th levels) are broadly used; however, the geographic area of units is too large to adequately serve many water-resource investigations or resource-analysis and management needs. For example, the focus of many water-resource issues is pollutant loading and land-surface processes and the cumulative effects of pollution over space and time. Management of these issues requires working with areas smaller than those defined by the 8-digit hydrologic units. Examples of programs requiring smaller hydrologic units include state river-basin management plans; the U.S. Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS) conservation and watershed programs; USDA Forest Service land-management-planning and watershed-management programs; various programs in the U.S. Environmental Protection Agency (USEPA), Office of Water; and programs in the USGS.

The NRCS is responsible for working with landowners to protect, improve, and sustain natural resources on private lands. The NRCS completed mapping of Watersheds (5th-level hydrologic units) in the early 1980s on small-scale state base maps for use in natural-resource planning. In the mid-1990s, the NRCS, along with state-agency conservation partners, began a national initiative to delineate and digitize 5th-level Watersheds and 6th-level Subwatersheds using methods and procedures that result in data that meet *national map accuracy standards*. To promote a standardized criterion for hydrologic unit determination and delineation, the NRCS developed National Instruction 170-304 in 1992, which served as the agency’s policy for delineating and digitizing Watersheds and Subwatersheds. The NRCS updated the policy in 1995, incorporating changes from internal and external reviews. The NRCS has made considerable contributions to the development of nationally standardized geographic data of Watershed and Subwatershed boundaries.

The U.S. Department of Agriculture, Forest Service (USDA-FS) and the Bureau of Land Management (BLM) are the primary land-management agencies of Federal lands in the United States. Both agencies are delineating and digitizing Watersheds (5th-level, 10-digit hydrologic units), and Subwatersheds (6th-level, 12-digit hydrologic units) on public lands. The delineation is primarily on public lands in the Western States; however, often all land ownerships are delineated within a Subbasin (4th-level, 8-digit hydrologic unit). Earlier delineations of hydrologic units of federally administered public lands served administrative purposes but were often developed without full coordination between Federal and state agencies.

The USGS and member agencies of the Federal Geographic Data Committee (FGDC), Subcommittee on Spatial Water Data (SSWD), have coordinated and conducted a series of regional workshops to develop a nationally consistent hydrologic unit coverage. Member agencies of the SSWD have assisted NRCS and USGS in reviewing and certifying hydrologic units. Similarly, member agencies and others have assisted in researching techniques to employ digital elevation data for producing hydrologic unit delineations that function as concept lines to adjust to 1:24,000 contour lines where needed.

The BLM and USDA-FS are responsible for managing Federal lands, and many states have programs within their governments that are responsible for managing state-owned land. As keepers of the land, states have partnered with Federal agencies within their state to develop a WBD that meets map accuracy requirements and reflects local knowledge of surface-water resources.

State agencies are often the intermediary between local and Federal programs for land management. A representative example is North Dakota. The North Dakota Department of Health administers the nonpoint-source pollution control program. This watershed-based program provides USEPA grant monies to local organizations for projects that reduce nonpoint-source pollution. The North Dakota Game and Fish Department uses the 6th-level 12-digit hydrologic unit codes for their “Save our Lakes” program. The Private Lands Section of the Wildlife Division uses the 6th-level codes for land-use inventories for their program.

The NRCS, USDA-FS, and BLM have worked directly with the USGS, along with other Federal and state agencies, tribes, and the Subcommittee on Spatial Water Data of the FGDC to establish these “Federal Guidelines, Requirements, and Procedures for the National Watershed Boundary Dataset,” 2009. This document builds upon the original NRCS National Instruction 170–304 and establishes the principles and procedures that Federal agencies should follow to delineate further subdivisions of the USGS Subbasins (4th-level, 8-digit hydrologic units). These guidelines are not agency specific; they have been agreed upon by all member agencies of the Subcommittee on Spatial Water Data.

This USGS Techniques and Methods publication has been updated and clarified from the previous guidance document “Federal Standard for Delineation of Hydrologic Unit Boundaries, Version 2.0, October 1, 2004,” through contributions of the WBD national Technical Support Team, as requested by the Subcommittee on Spatial Water Data. The Technical Support Team has first hand knowledge of the use of this document by working with a variety of WBD creators from different agencies and programs and conducting regional workshops to contribute to coordinated watershed management. This new publication would not have been possible without the previous work of the USDA, NRCS, and numerous prior contributors and reviewers.

2. Coordination

2.1 Federal Geographic Data Committee (FGDC) Subcommittee on Spatial Water Data

The Subcommittee on Spatial Water Data was chartered and sponsored by the Advisory Committee on Water Information (ACWI) and the FGDC. The Spatial Water Data Subcommittee of the FGDC coordinates spatial water data and information activities among all levels of government and the private sector. Spatial water data include information about streams, hydrologic units, lakes, ground water, coastal areas, precipitation, and other hydrologic information related to water resources.

Federal and state agencies involved in development and use of hydrologic units for water-resource management responsibilities are encouraged to participate as members of the Subcommittee on Spatial Water Data.

The Subcommittee on Spatial Water Data assists the ACWI and FGDC by facilitating the exchange and transfer of water data; establishing and implementing standards for quality, content, and transfer of water data; and coordinating requirements and collection of geographic data to minimize duplication of efforts.

2.2 National Steering Committee and Technical Support Team

To facilitate development of nationally consistent data, two groups were established in the late 1990s. The first is the Federal Steering Committee, led by the NRCS and the USGS. The second is the WBD Technical Support Team. The groups engage in program management and long-term planning, integrate and coordinate with other national projects, and facilitate intrastate and interstate cooperation. The teams regularly clarify guidance, provide oversight and training to states, review interim state geographic data, suggest solutions for complex hydrographic landscapes, and review final data for certification. The Steering Committee oversees final review and acceptance of digital geographic data into the national framework by the Technical Support Team, grants certification, and thus approves the data for public access via the Web.

The USGS Water Resources Discipline facilitates the WBD effort by maintaining the Guidelines and by providing delineation support and review to all states. The USDA-NRCS-National Cartography and Geospatial Center reviews, integrates, and merges the individual state certified datasets into a seamless national layer and processes the data for delivery on the *Geospatial Data Gateway*.

2.3 Intrastate and Interstate Coordination

The subdivision of previously delineated hydrologic units into Watersheds (5th-level, 10-digit hydrologic units) and Subwatersheds (6th-level, 12-digit hydrologic units) is an opportunity to develop consistent and commonly used nationwide digital geospatial data for interagency sharing and to foster Federal, state, and locally consistent uses of hydrologic units. States are encouraged to form an interagency hydrologic unit coordinating group composed of Federal, state, local, and watershed agencies with an investment in developing watershed data, specifically including state agencies identified as responsible for watershed data by state statute. Each participating organization would have the responsibility to seek consensus appropriate to all interests and to obtain mutual technical approval. Inviting adjoining states or regional entities to participate in the coordinating group would be advantageous. The intent of the coordinating group would be to promote the development, use, and maintenance of the WBD and to explore opportunities to obtain financial support. The coordinating group should consider identifying a point of contact to coordinate with the USGS/NRCS national Technical Support Team.

All states within a Subbasin (4th-level, 8-digit hydrologic unit) would need to coordinate their delineation work to make the digital geographic data match across state borders. This coordination would cover the locations of outlet points, the sizes of the Watersheds (5th-level, 10-digit hydrologic units) and Subwatersheds (6th-level, 12-digit hydrologic units), and the coding sequence within each level of the hydrologic unit hierarchy, as well as other attribute fields. Mapping and edge-matching hydrologic boundaries that cross county and state boundaries would need to be coordinated to ensure a nationally consistent dataset.

The interaction between these groups and data originators is shown in figure 1.

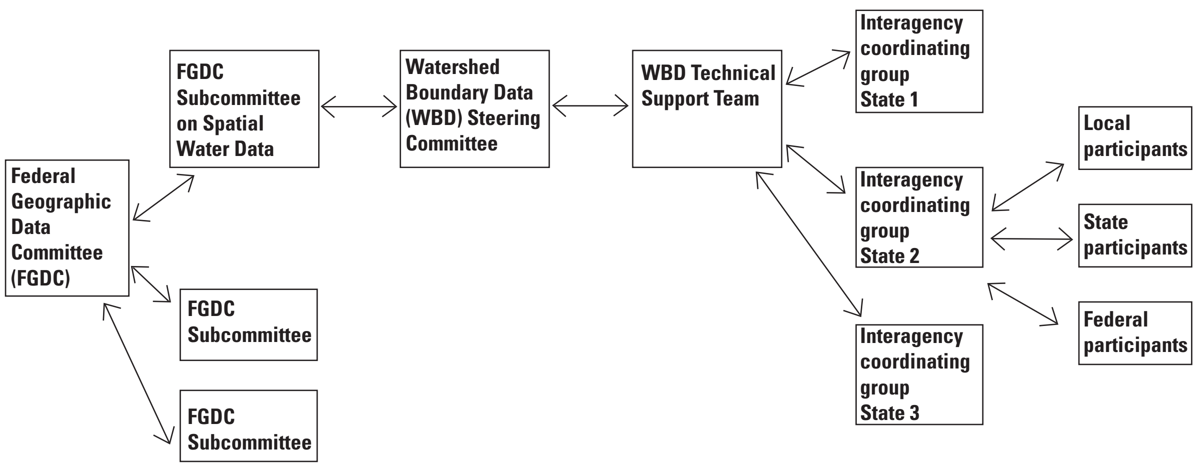


Figure 1. Watershed Boundary Dataset coordination participants and relationships are diagrammed above.

3. Criteria and Considerations for Delineating Hydrologic Units

3.1 General Criteria

This section describes criteria for determining and delineating Watershed (5th-level, 10-digit) and Subwatershed (6th-level, 12-digit) hydrologic units. The 2- through 8-digit hydrologic units will be consistent with the new hydrologic units to create one dataset of 2- through 12-digit Hydrologic Unit Codes and boundaries at scales of 1:24,000 in the conterminous United States, 1:25,000 in the Caribbean, or 1:63,360 in Alaska. Selecting and delineating Watersheds and Subwatersheds requires good hydrologic judgment and must be based solely upon hydrologic principles to ensure a homogeneous, national, seamless digital data layer. When the new hydrologic units are verified and aggregated into the 2- through 8- digit data, the accuracy of the previous 1:250,000-scale hydrologic unit delineation work will be increased to 1:24,000 scale.

The diversity of hydrologic conditions nationwide, the complexity of surface hydrology, and the number of factors involved in the delineation process preclude an all-encompassing guideline. Variations will generally be limited to unusual hydrologic or landform features and dissimilar hydrologic or morphologic drainage-area characteristics. The intent of defining hydrologic units is to establish a baseline that covers all areas. At a minimum, the hydrologic units must be delineated and georeferenced to USGS 1:24,000-, 1:25,000-, or 1:63,360-scale topographic maps, which meet National Standards for Spatial Data Accuracy (NSSDA) (fig. 2). Digital Orthophoto Quarter Quadrangles (DOQQs) or higher resolution imagery, contours of elevation, stream locations, and other relevant data are useful in improving the accuracy or currentness of the hydrologic unit boundaries.

The delineation must be as simple as is practical and avoid creating hydrologic units that favor a particular agency, program, administrative area, or special project. Drainage boundaries generated for special purposes that do not follow these guidelines will not be certified for the national Watershed Boundary Dataset.

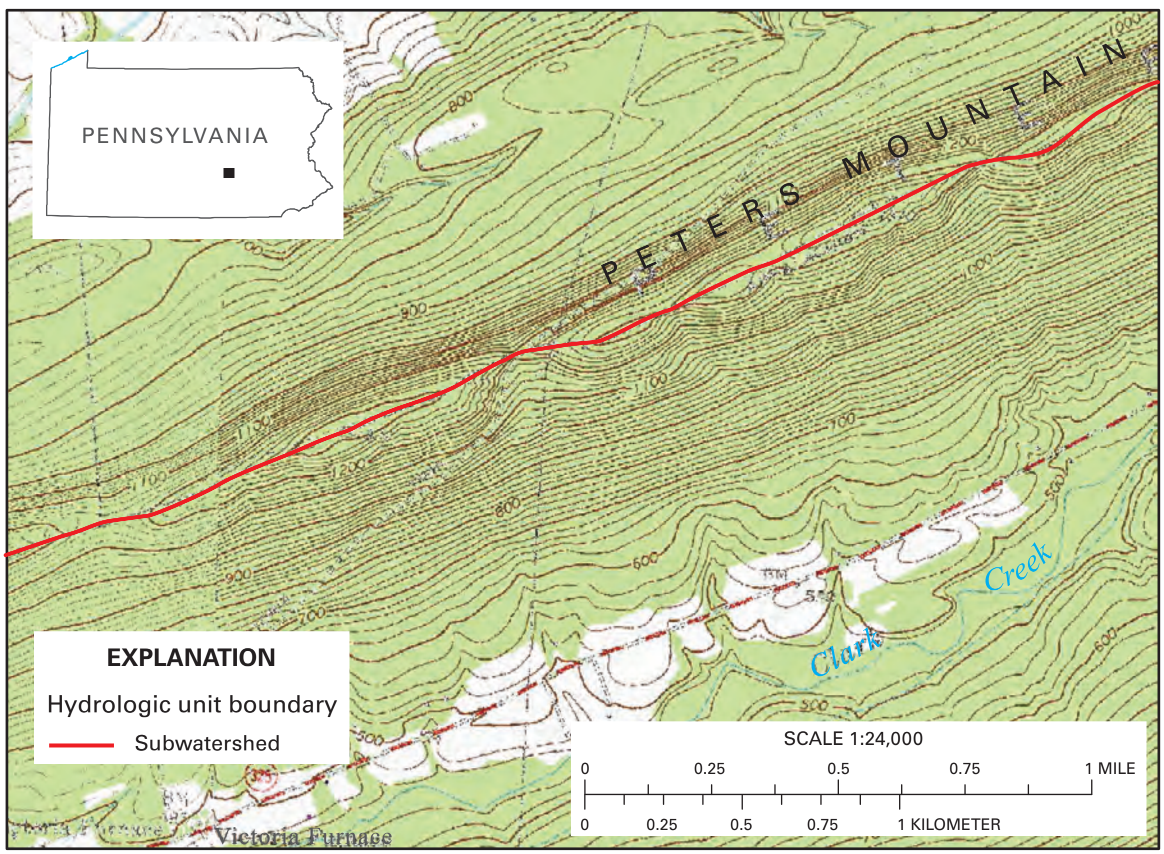


Figure 2. This Subwatershed boundary meets the National Standards for Spatial Data Accuracy and the Watershed Boundary Dataset requirements by its georeference to the minimum 1:24,000 scale topographic base map. The Appalachian Trail south of Enders, in Dauphin County, Pa., is shown.

3.2 Hydrologic Boundaries

Figure 3 illustrates the United States hydrologic unit boundaries, the six nested levels of the hydrologic unit hierarchy, and the aggregated sequence of hydrologic unit codes (from a 2-digit to a 12-digit number). The large geographic area of Subbasins (4th-level, 8-digit hydrologic units) is the basis for subdividing Watersheds (5th-level, 10-digit hydrologic units), and Watershed boundaries are the basis for further subdividing Subwatersheds (6th-level, 12-digit hydrologic units). By delineating Watersheds and Subwatersheds at 1:24,000 scale in the conterminous United States, 1:25,000 scale in the Caribbean, or 1:63,360 scale in Alaska, line precision and accuracy will propagate throughout the dataset including Region boundaries.

Subbasin boundaries should be changed or adjusted when the existing mapping does not conform to hydrologic and topographic reality. If changes or revisions to Subbasin boundaries are needed in addition to resolution improvements required for 1:24,000-scale data (section 4.4), before making the change, inform the WBD in-state coordinator (interagency hydrologic unit group point of contact) of the major change to prompt review by the WBD national Technical Support Team.

Watersheds and Subwatersheds, like other hydrologic units, are defined along natural hydrologic breaks based on land surface and surface-water flow. Boundaries delimit the land-area of the Watersheds and Subwatersheds. A hydrologic unit has a single flow outlet except in frontal, lake, braided-stream, or playa (closed basin) hydrologic units (section 3.5). Hydrologic units with their outlet at a delta or braided stream should be treated similar to frontal hydrologic units. Give priority to delineating Watersheds and Subwatersheds that will be "classic" units having only one outlet (section 3.5.1).Because Watersheds and Subwatersheds are subdivisions of a higher level of hydrologic unit, they must share common boundaries with the existing hydrologic units defined in higher levels of the hydrologic unit hierarchy.

Previous versions of Watershed and Subwatershed boundaries may have used administrative boundaries as hydrologic unit boundaries. Now and in the future, hydrologic unit boundaries must be defined solely by examination of topography and hydrologic features. Avoid use of administrative or political boundaries such as county, state, or national forest boundaries as criteria for defining a hydrologic unit boundary unless the administrative boundary is coincident with a topographic feature that appropriately defines the hydrologic unit. Existing hydrologic unit data that include boundaries delineated solely by use of administrative or political boundaries will not be certified as meeting these guidelines until the hydrologic units are revised on the basis of topography, surface-water flow, and hydrologic features.

Terminate hydrologic unit delineations at the international boundary of the United States (section 5.4). For units including offshore waters, use the National Oceanic and Atmospheric Administration (NOAA) Three Nautical Mile Line (section 3.5.6) as the offshore limit. If delineation agreements are reached with Canada or Mexico existing hydrologic units may be revised.

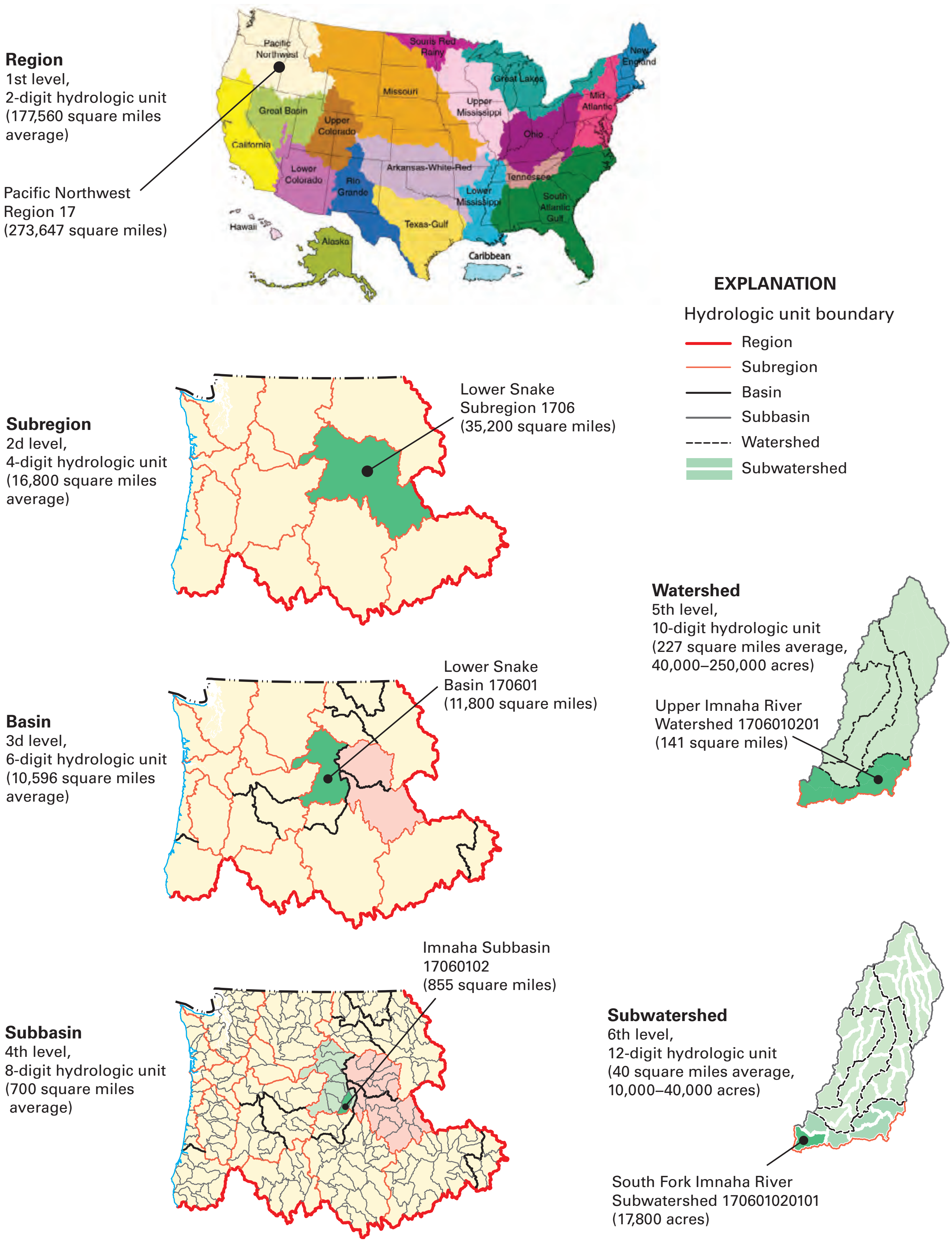


Figure 3. Hierarchy and areas for the six nested levels of hydrologic units are shown in the above example. As they are successively subdivided, the numbering scheme of the units increases by two-digits per level.

Hydrologically based boundary delineations include land areas on both sides of a stream flowing toward a single downstream outlet, except in the case of open-water hydrologic units (section 3.5.6). Boundaries should not follow or run parallel to streams as delineated hypothetically in figure 4A, except where physical features such as levees, berms, incised channels, and similar structures prevent water from flowing directly to the outlet. Avoid delineating boundaries down the middle of a stream. Figure 4B illustrates correct delineation. Boundaries will cross the stream perpendicular to flow at the hydrologic unit outlet (fig. 5). Where that outlet also defines the wide tributary outlet, the boundary should connect to the downstream bank of the stream (fig. 5). Information from stream gages, locations of major highway crossings, and National Hydrography Dataset (NHD) reach endpoints may be considered to help identify dividing points for hydrologic units and some braided-stream networks when no other hydrologic features are available. In the case of a long, narrow hydrologic unit that is typical of a parallel or trellis drainage pattern, the hydrologic unit boundary should cross the stream at a significant confluence to divide the hydrologic unit into suitably sized Watersheds (5th-level, 10-digit hydrologic units) or Subwatersheds (6th-level, 12-digit hydrologic units) (section 3.4). Tributary catchment area may be useful for determining the relative significance of tributaries within an area being subdivided. The hydrologic unit boundary may use smaller tributaries as the delineation point to divide the hydrologic unit into suitably sized Watersheds (5th-level, 10-digit hydrologic units) or Subwatersheds (6th-level, 12-digit hydrologic units). Delineating the boundary just below a confluence accommodates nesting of smaller units within the hydrologic unit for future site-specific planning, assessment, monitoring, or inventory activities.

In addition to the primary criteria, there are general criteria for the number of hydrologic units subdivided from a higher-level unit, the size of hydrologic units, and the treatment of noncontributing and remnant areas.

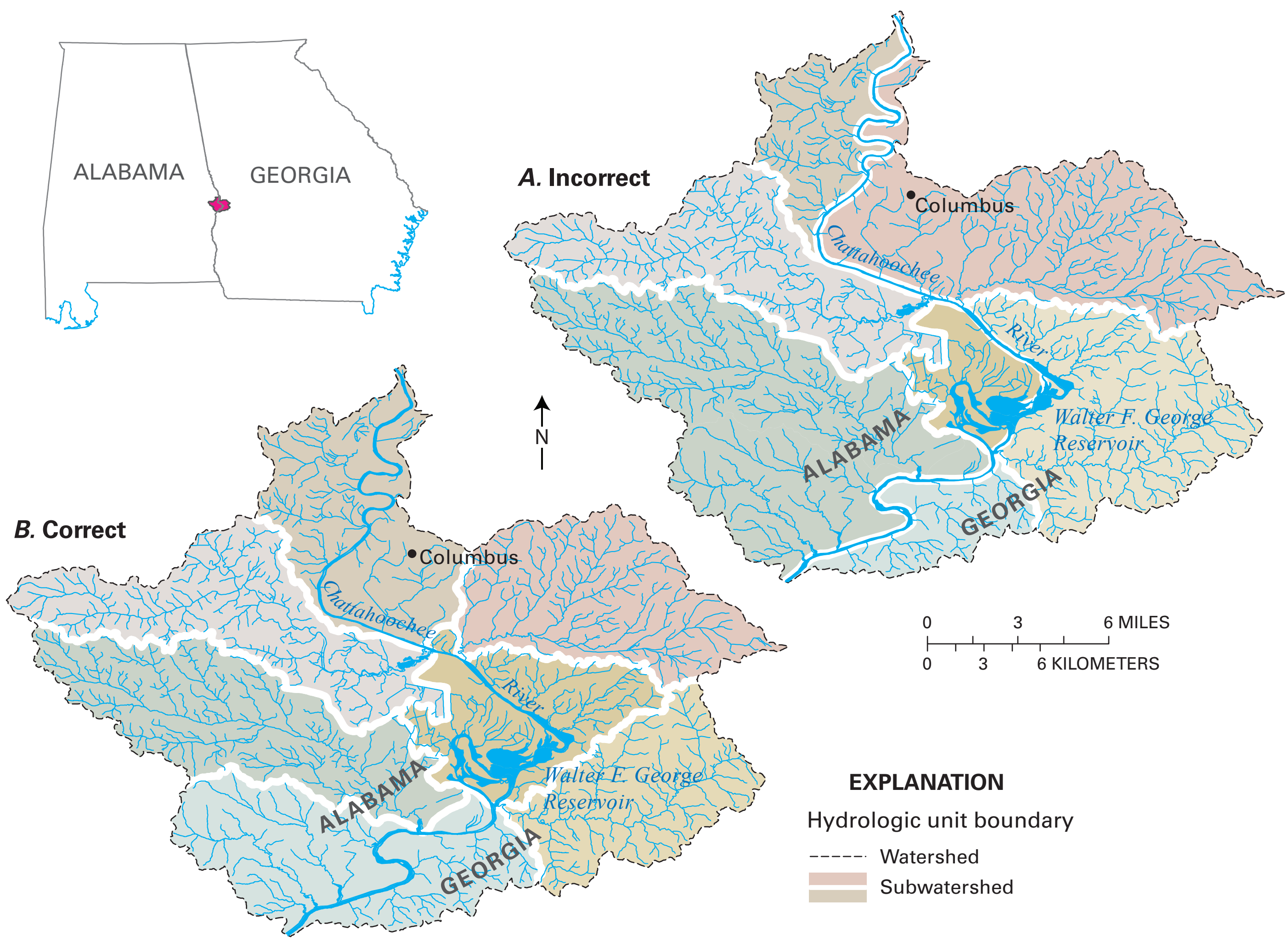


Figure 4. Delineation of hydrologic features must be based on land surface, surface-water flow, and hydrographic features. ***A.*** Incorrect—Subwatershed boundaries follow the river and administrative boundaries. ***B.*** Correct— Subwatershed boundaries cross the Chattahoochee River and end at the bank of the receiving stream for tributaries. The area includes the Walter F. George Reservoir south of Columbus, Ga.

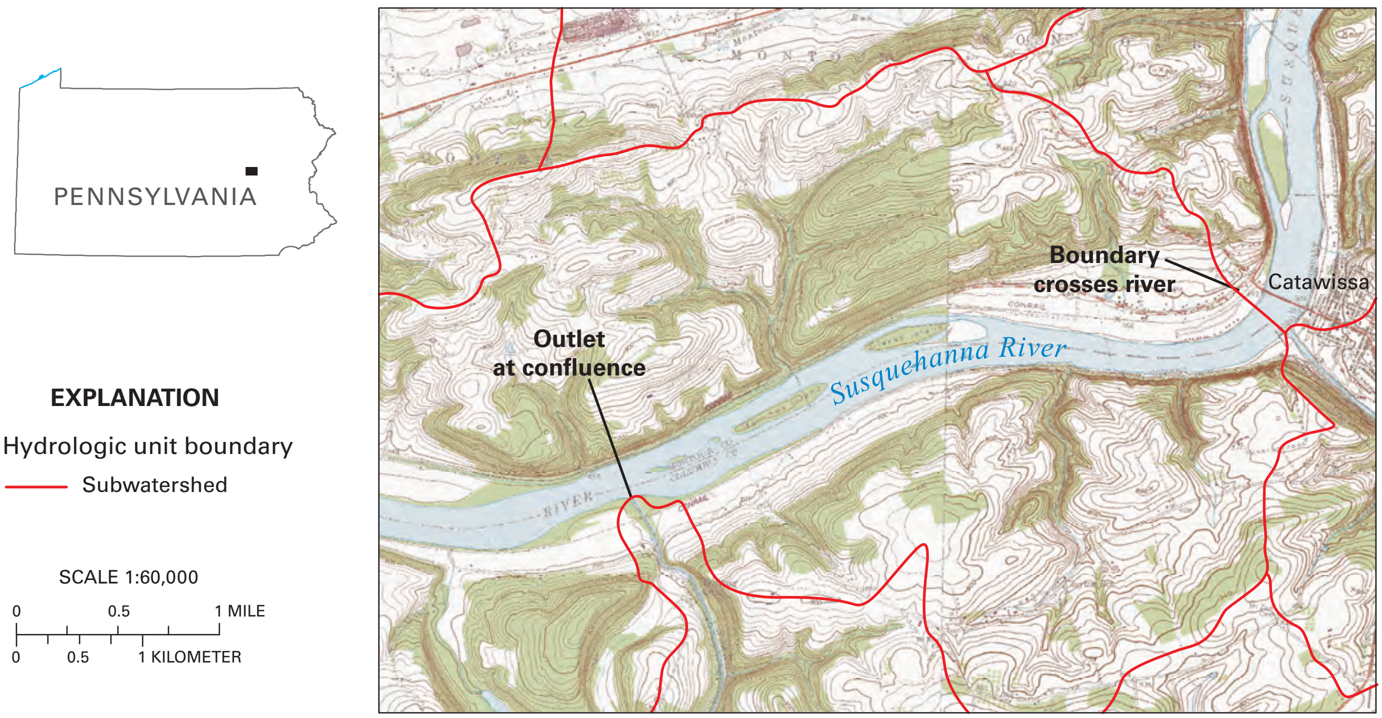


Figure 5. The two tributary outlets shown above are delineated correctly at the bank of the receiving stream. The boundary correctly crosses the Susquehanna River perpendicular to the river just downstream from the tributary confluence. The area is south of Bloomsburg, in Columbia County, Pa.

3.3 Number of Subdivided Hydrologic Units

As a general rule, subdivide each hydrologic unit into 5 to 15 units. For example, 5 to 15 Watersheds (5th-level, 10-digit hydrologic units) will be nested in each Subbasin (4th-level, 8-digit hydrologic unit). This system accommodates geomorphic or other relevant basin characteristics and creates a fairly uniform size distribution of same-level hydrologic units within a broad physiographic area. This system results in a smooth transition between sizes of same-level hydrologic units as topography changes between physiographic areas and maintains consistent delineations across state borders.

There are exceptions to using the 5 to 15 rule, just as there are existing Subregions that contain fewer than 5 Basins (3rd-level, 6-digit hydrologic units), and Basins that contain fewer than 5 Subbasins (4th-level, 8-digit hydrologic units). The number of Watersheds (5th-level, 10-digit hydrologic units) nested within Subbasins or the number of Subwatersheds (6th-level, 12-digit hydrologic units) nested within some Watersheds may occasionally be reduced or expanded to accommodate special areas. In some places, it is not possible to delineate 5th- or 6th-level hydrologic units owing to the lack of hydrologic features or insufficient topography. For offshore waters, subdivisions within the 3 nautical mile limit are acceptable but not required to meet the 5 to 15 rule.

3.4 Size of Hydrologic Units

The hydrologic units of any given level should be about the same size within a physiographic area for comparability and coordinating use and applications of hydrologic units. There should not be hydrologic units that are several orders of magnitude different in size from the rest of the hydrologic units for a given level.

Nationally, the typical size for a Watershed is 40,000 to 250,000 acres. Use this acreage range as a guide in subdividing Subbasins (4th-level, 8-digit hydrologic units). Each Watershed (5th-level, 10-digit hydrologic unit) must be completely contained within one 8-digit Subbasin. Statewide data should have no more than 10 percent of the polygons outside the size requirement range.

The typical size for a Subwatershed (6th-level, 12-digit hydrologic unit) is 10,000 to 40,000 acres. In unique areas, the Subwatersheds may be greater than 40,000 acres or less than 10,000 acres but never less than 3,000 acres. Statewide data should have no more than 10 percent of the hydrologic units outside the size requirement range of greater than 40,000 acres or less than 10,000 acres.

In coastal areas where radial or centripetal drainage predominates, such as Hawaii, individual streams with outlets to the ocean, or remnants, may be less than 3,000 acres each. Their acreage can be combined into a single hydrologic unit to total greater than 10,000 acres. In open-water coastal areas subdivision to meet size criteria is not required.

3.5 Geomorphic Considerations for Hydrologic Units

This section explains the most common geomorphic circumstances and those that require additional considerations for developing hydrologic units.

3.5.1 Classic Hydrologic Units

The classic hydrologic unit is a hydrologically defined surface-water drainage area (fig. 6). All the surface drainage within the classic hydrologic unit boundary converges at a single outlet point. Larger classic hydrologic units may be subdivided into multiple standard hydrologic units that fit within the size criteria of a given level.

Delineate by starting from the designated outlet (a point on a single stream channel that drains the area), and proceed to the highest elevation of land dividing the direction of water flow. This boundary connects back to the designated outlet, where it will cross perpendicular to the stream channel. Correctly selecting the outlet point is critical to delineating all hydrologic units accurately. The classic hydrologic units are subdivisions of higher level hydrologic units based on major tributaries. When choosing between tributaries for hydrologic unit delineation, higher order streams are typically chosen over smaller tributaries. The downstream end of the hydrologic unit will be just upstream from the confluence with the main stem of the higher level hydrologic unit or the main stem of a same-level hydrologic unit when possible.

Hydrologic units may be divided at a lake outlet if the upstream drainage-area size is appropriate for the hydrologic unit level being delineated. The boundaries should be as simple as possible while capturing the topographically defined area that contributes to the outlet.

Identifying classic hydrologic units and delineating them with the recommended number of subdivisions and area sizes will cover much of the area of the higher level hydrologic unit to be subdivided; however, where nonclassic areas such as remnant, noncontributing, and diverted areas exist, they will need to be delineated by use of criteria described in the following sections. These nonclassic areas typically need to be added to adjacent hydrologic units but occasionally may have to exist as small, atypical hydrologic units.

3.5.2 Remnant Areas

Delineating hydrologic units may result in remnant areas around the main stem of larger streams, even when good hydrologic judgment and standard practices described above are used. Remnant areas typically occur as wedge-shaped areas along interfluvial regions between adjacent hydrologic units or as overbank areas along a stream between junctions with tributaries, and they typically need to be included with an adjacent hydrologic unit. These remnant areas are also referred to as “related contributing drainage areas” or “composite” areas.

Coastal remnant areas occur where outlet areas of several mainland or island hydrologic units are individually smaller than the typical size of a given hydrologic unit level. If the combined area of remnants adjacent to each other is in the size range of the hydrologic unit level being defined, they should be combined into a single hydrologic unit. Treatment of coastal remnant areas that are relatively small is described in section 5.2.1.

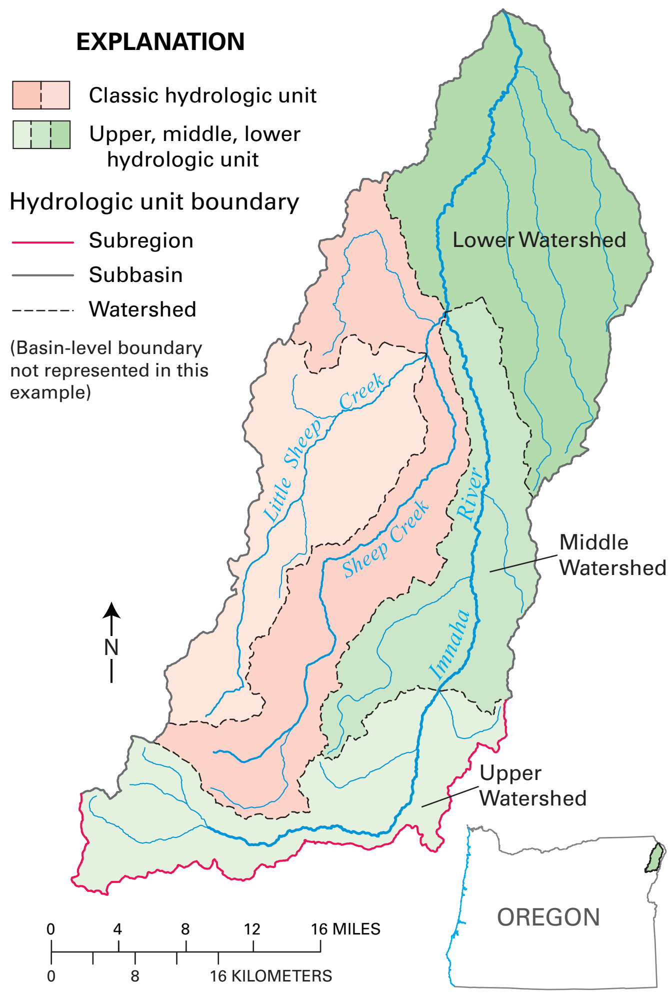


Figure 6. In this example of a hydrologically defined Subbasin (Imnaha Subbasin), the main-stem stream has been split into “Upper,” “Middle,” and “Lower” Watersheds and its tributary Watersheds. The Imnaha River is in Wallowala County, Oreg.

3.5.3 Noncontributing Areas

Drainage areas that do not flow toward the outlet of a hydrologic unit are called noncontributing areas (fig. 7). Such areas may be due to glaciated plains (potholes), closed basins, playas, cirques, depression lakes, dry lakebeds, or similar landforms. A noncontributing area may be designated a hydrologic unit at any level of the hierarchy if within the size range for a given level. The largest noncontributing area in the United States is the Great Basin, which covers parts of Nevada, Utah, Oregon, and California. This closed basin is large enough to be classified as a Region (1st-level, 2-digit hydrologic unit).

Semiconfined basins that contribute surface water to another area in wet years but act as a sink in dry years may be a hydrologic unit or a noncontributing area. These types of special situations require review, coordination, and agreement at the state level. Assistance or consultation with climatologists or NOAA on prevailing precipitation regimes that may have a long-term influence on noncontributing areas should be explored.

If noncontributing areas are small and dispersed relative to the hierarchical level being delineated, or if they are scattered throughout a drainage area, they should be considered as part of the encompassing delineated hydrologic unit. With the diversity of unique and unusual landforms across the country, the criteria for delineating noncontributing areas caused by these unusual land features cannot be fully covered in this section. Because the precise definition of a noncontributing area will likely vary from state to state, document the criteria used to determine noncontributing areas in the metadata file, especially if a significant number of noncontributing areas are defined. Include the total acreage of noncontributing areas within a hydrologic unit as an attribute of the data. Delineate noncontributing areas consistently throughout the state.

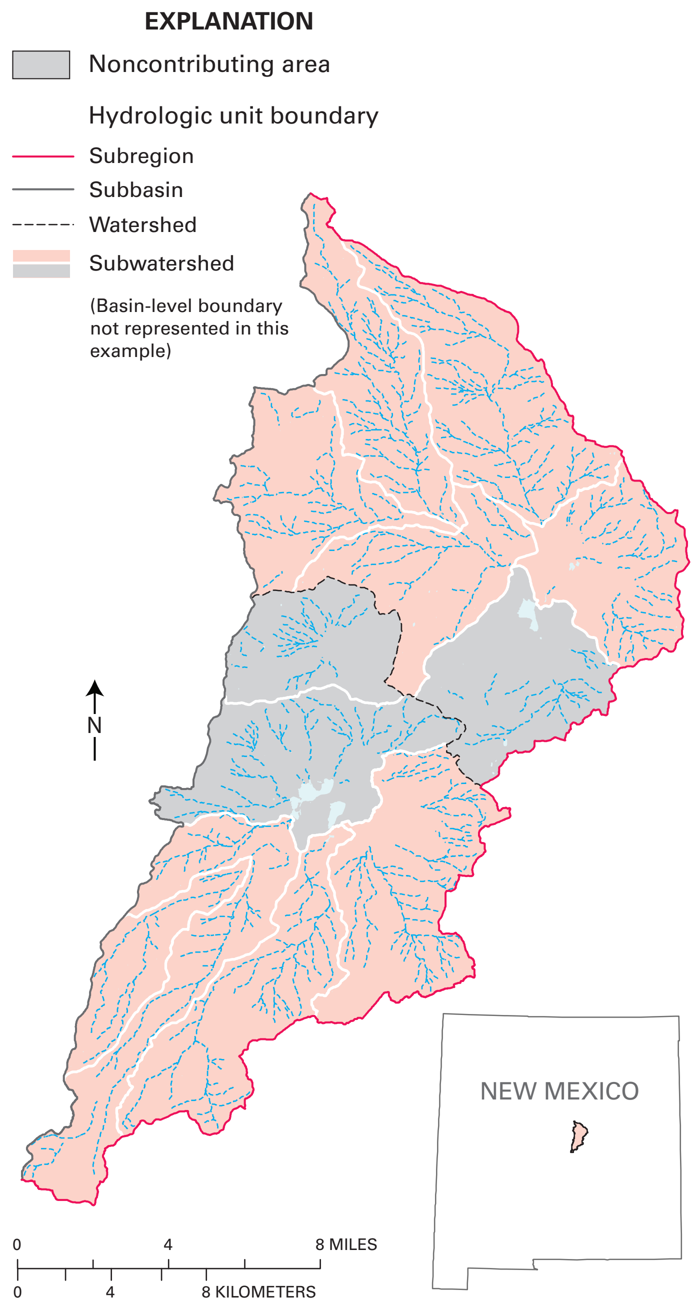


Figure 7. Noncontributing areas, caused by unique and unusual landforms, do not flow to the outlet of the hydrologic unit. Isolated noncontributing areas such as these in Eastern Estancia Subbasin, Torrance County, N.Mex., should be delineated.

3.5.4 Reservoirs and Natural Lakes

Delineating hydrologic unit boundaries is often complicated by the presence of reservoirs or large natural lakes. Reservoirs and lakes obscure the natural drainage system, which makes delineating hydrologic units more difficult. The way the pool area and its underlying drainage pattern affects the delineation of hydrologic units depends on the size of the pool area and the amount of fluctuation in the normal pool area. To delineate hydrologic units that include reservoirs, use depth data or historic maps of legacy channels and ignore the reservoir pool. Let underwater features direct the flow and delineation. The order of priority for delineating reservoirs and lakes follows:

1. If the uninterrupted natural drainage network would form a unit larger than one of the typical size at that level, consider subdividing the hydrologic unit at a dam or natural outlet of the reservoir or lake. This will depend on adjoining hydrologic units and adjacent slope areas.

2. Avoid delineating boundaries to the reservoir's normal, average, or high pool. To be sure all of a reservoir's pool area is accounted for, subdivide the hydrologic units to the legacy channel system underlying the pool area (fig. 8).

3. For natural lakes, delineate tributary areas that flow directly into a lake and are of a size consistent with the hydrologic unit level being delineated as classic hydrologic units with an outlet at the lake edge. Areas that drain into a lake but cannot be delineated at a consistent size should be included as part of the lake hydrologic unit.

4. Permanent, large-scale water bodies, such as lakes and reservoirs with historically documented permanent pools, may require exceptions to these priorities. Some states have completed hydrologic unit delineations without using legacy channels. Where the boundaries are recognized within state law and a legal lake elevation has been established, the delineation should reflect as closely as possible the legal lake elevation. The lake is delineated as a hydrologic unit, and adjacent slope areas not included in classic units are delineated as frontal hydrologic units. These frontal hydrologic units should be subdivided, when necessary, on a hydrographic basis and should be consistent in size. Lakes or reservoirs delineated as hydrologic units should be listed with their legal lake elevation in the detailed overview section of the metadata. An example of an all-water hydrologic unit is Great Salt Lake in Utah.

3.5.5 Diverted Waters

Delineate hydrologic units on the basis of natural surface-water flow and natural topographic land features. Ditches and canals should be used to determine surface-water drainage areas only if the artificial channel has permanently altered the natural flow. Many artificial drainage features in the United States were originally either perennial or intermittent channels that local government and private entities converted into permanent drainage features. Much of the surface drainage in these areas would disappear from local and state drainage maps if permanent, constructed diversions were not considered when delineating hydrologic units. If the present-day canal or ditch was once a legacy stream channel or has perennial flow, then it may be considered for delineating hydrologic units. Avoid delineating small, local ditch systems constructed for seasonal diversion of water or for irrigation of agricultural fields.

When all or part of the flow from one hydrologic unit is continuously discharged into another by constructed transbasin diversions, document the diverted flow as attributes to both the water-losing and water-gaining hydrologic units in the HU_10_MOD and/or HU_12_MOD field (sections 6.2.9 and 6.2.13). Information on the date of the diversion, flow rates, and water rights for both the receiving and losing hydrologic units may be included in the metadata.

A dam, diversion, or stream confluence may be used to divide a hydrologic unit into upper and lower parts. Avoid adjusting the location of hydrologic units because of interconnected flow from one hydrologic unit to another during high flow stages in streams.

Figure 8. To delineate the hydrologic unit boundary within a hydrologic unit that contains a major reservoir, such as the Lake Mead area of Arizona and Nevada, the preferred treatment is to use a topographic map showing pre-inundation contours of underwater features if such a map is available.

3.5.6 Coastal Areas, Including Open-Water, Water, and Frontal Units

The coastal criteria apply to ocean coastal areas, non-ocean coastal areas such as the Great Lakes, and large tidal rivers such as parts of the Mississippi, Columbia, and Potomac Rivers. The coastal guidelines provide a scientific basis to extend gravity-based flow through hydrographically complex coastal areas. Coastal hydrologic units drain either to an outlet (as in inland hydrologic units) or to water hydrologic units.

The delineation of hydrologic unit boundaries is often complicated in coastal areas by the presence of large estuaries, bays, or sounds. Because water levels in coastal water bodies can fluctuate significantly, hydrologic-unit mapping should be based on submerged morphologic features such as shoals, ridges, shore faces, and flow channels (legacy channels). NOAA nautical charts or local marine bathymetric data are available for many coastal areas. Help obtaining bathymetric data is available through your WBD Technical Coordinators. Use the largest scale and most recent charts and maps that provide individual depth-sounding and depth-contour data. Digital elevation model data may be useful for identifying open-water hydrologic units.

When delineating from bathymetric information, use the best available depth data for closure in estuaries, bays, and sounds as agreed upon by state partners. For open-water hydrologic units use the 30-foot depth contour or the NOAA Three Nautical Mile Line. Delineations must transition smoothly between physical features and edge match at state boundaries. Where bathymetry is not available, use the best available coastline data. If the DRG coastline is used and the hydrologic unit does not contain offshore waters it is considered a frontal unit.

For a coastal body of water that is of a size consistent with the hydrologic unit level being delineated, it is appropriate to delineate the waterbody as a separate water hydrologic unit. After delineating the coastal and classic Watersheds (5th-level, 10-digit hydrologic units) and Subwatersheds (6th-level, 12-digit hydrologic units) within the designated size criteria (section 3.4), there may be areas remaining that contain streams that are too small to break out as individual units (section 3.5.2). These remnant areas should be combined into a unit that meets the outlined size criteria for a Watershed or Subwatershed (fig. 9). These composite areas are called frontal units (a unit with more than one outlet).

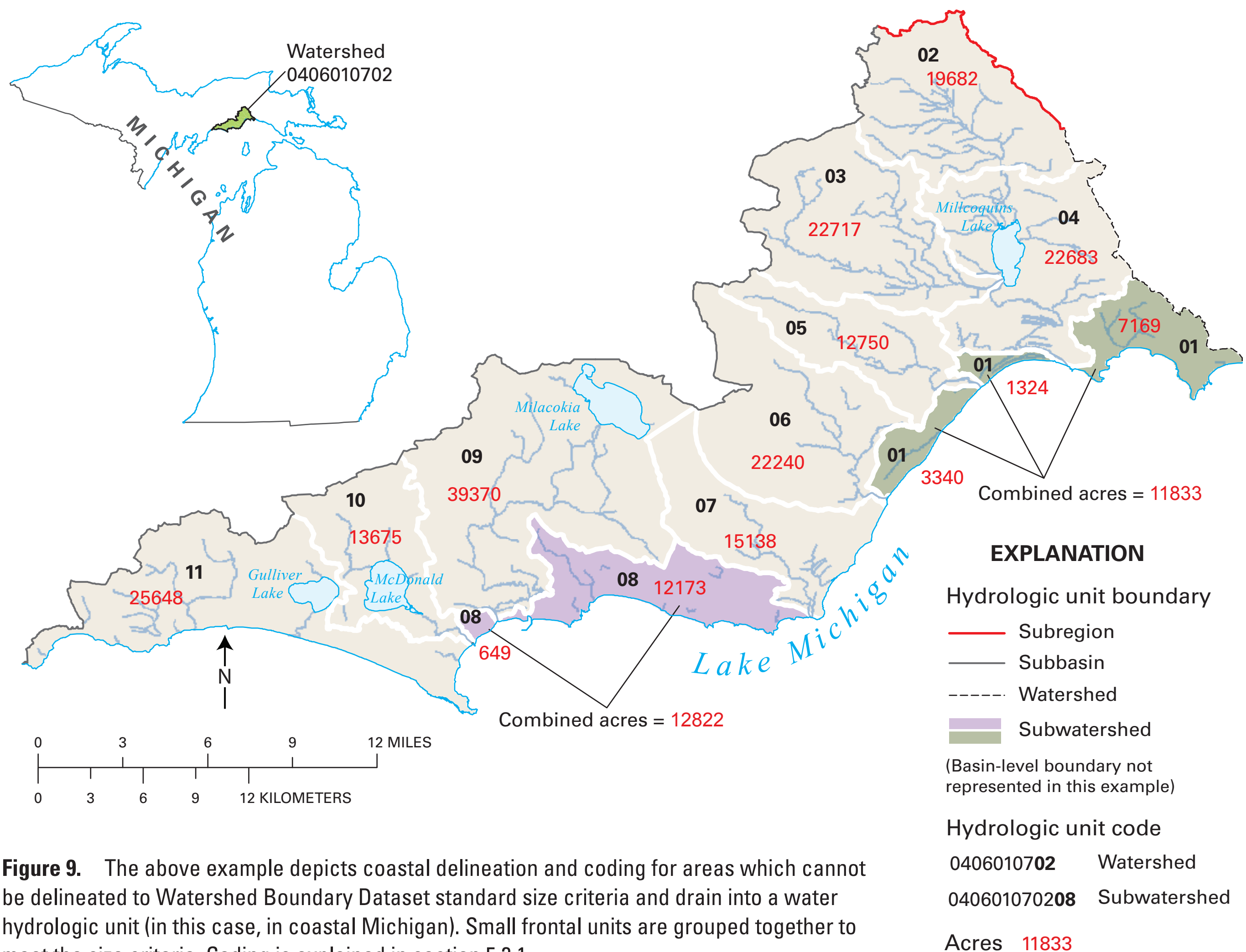


Figure 9. The above example depicts coastal delineation and coding for areas which cannot be delineated to Watershed Boundary Dataset standard size criteria and drain into a water hydrologic unit (in this case, in coastal Michigan). Small frontal units are grouped together to meet the size criteria. Coding is explained in section 5.2.1.

3.5.7 Islands

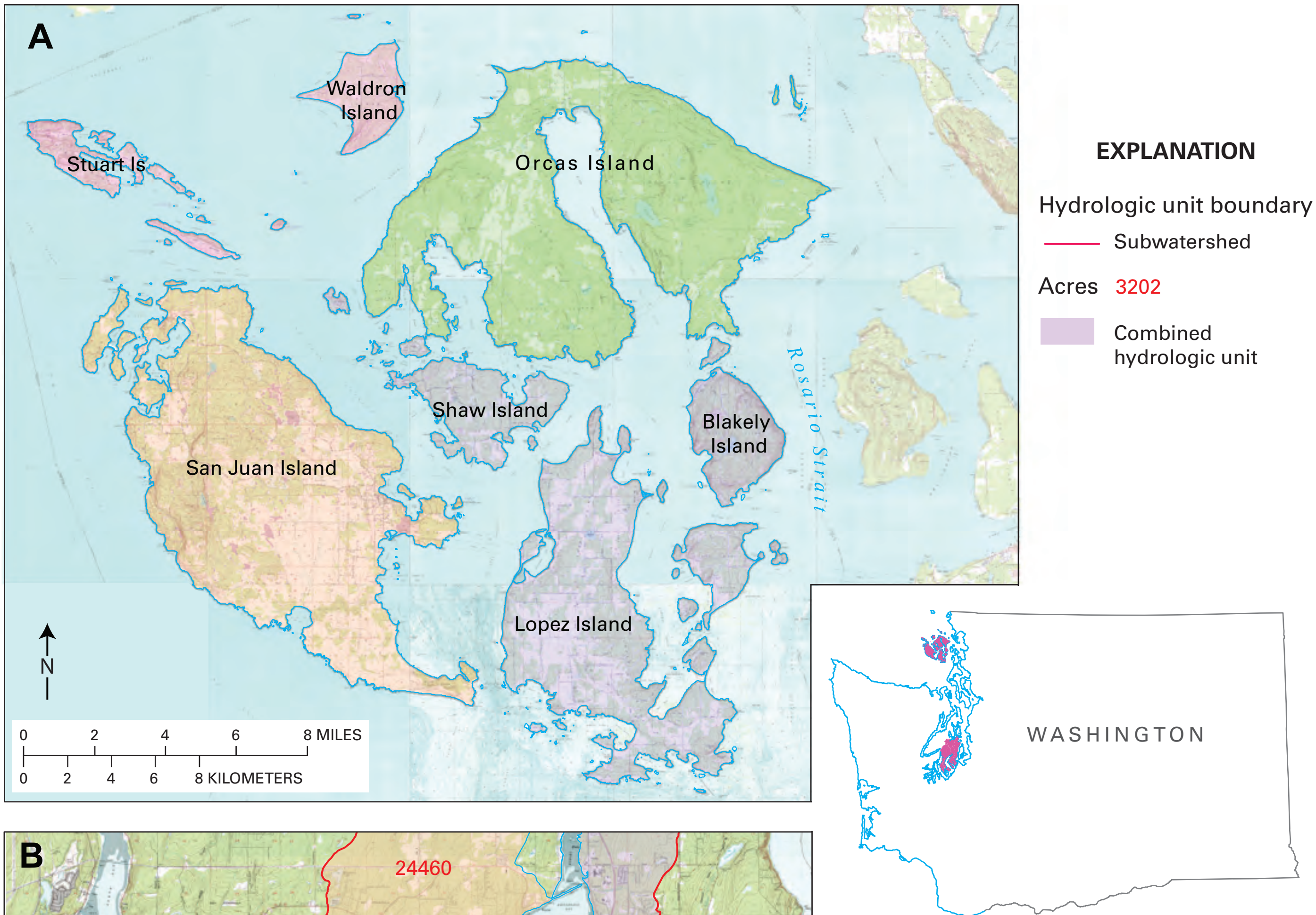
Delineate island hydrologic units on the basis of their size and proximity to each other and to adjacent land. An island large enough to be its own hydrologic unit can be delineated as such and drains into the surrounding water unit or ocean. Subdivide island hydrologic units to be consistent with unit size criteria. An island located between water hydrologic units or between a water hydrologic unit and the ocean is bisected to indicate surface water flows to the adjacent hydrologic units. This technique applies if there is a single barrier island or a string of islands along a shoal or reef that functions as the hydrologic divide. The hydrologic-divide concept can be applied to any formation that provides a hydrologic barrier to flow, such as a peninsula or an isthmus. An island too small to be its own hydrologic unit can be grouped with a nearby land unit or with another island or group of islands in the vicinity, such as a barrier island or those shown in figure 10.

3.5.8 Karst Areas

The delineation of hydrologic unit boundaries in karst areas is difficult because the potential exists to attribute the runoff from one hydrologic unit, or part of a hydrologic unit, to the wrong outlet. This difficulty occurs because the surface drainage pattern in karst areas is typically disrupted by sinkholes and sinking streams, making it difficult to choose a valid hydrologic unit boundary on the basis of topography alone. Karst conduits frequently cross beneath topographically defined hydrologic unit boundaries, and drainage may be routed into or out of a topographically defined hydrologic unit. Because of the presence of karst conduits, ground-water and surface-water interaction is relatively direct and rapid compared to that in nonkarst areas. The conduit networks transport most of the storm-water runoff, and the flow is both fast and turbulent. Each conduit network drains a finite area (karst basin) and discharges to a perennial spring.

Sinkholes, sinking streams, springs, or cave entrances indicate karst hydrology. If sinkhole symbols or other map symbols associated with karst are not expressed on topographic maps in areas with soluble rocks such as limestone, dolomite, gypsum, or salt near the land surface, assume karst hydrology unless evidence indicates otherwise. The WBD is a surface-water dataset; it is not the intent of the WBD to determine or delineate in depth the pattern of underground seepage. Note all hydrologic units containing karst with the modifier “KA” in the relevant hydrologic-unit modifications fields HU_10_MOD and/or HU_12_MOD (section 6.2.9 and 6.2.13).

Additional details describing interpretation or identification of karst within the hydrologic unit should be documented in metadata (section 9.0).



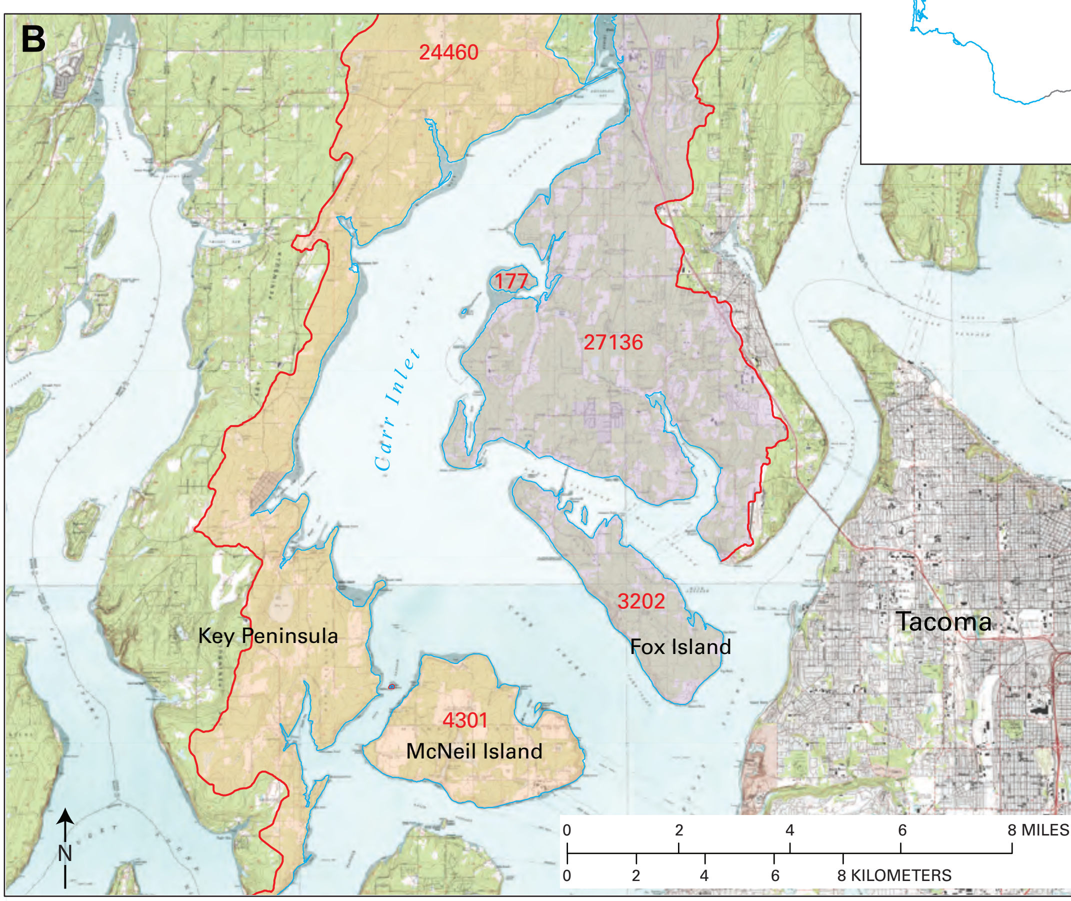


Figure 10. An island that is too small to be its own hydrologic unit can be grouped (A) with another island or group of islands or (B), with a nearby land hydrologic unit as shown in this example of island delineations in the Puget Sound, Wash. McNeil Island is grouped with the east side of Key Peninsula, whereas Fox Island is grouped with the mainland hydrologic unit east of the Carr Inlet.

4. Required Geographic Data Sources and Recommended Techniques for Boundary Delineation

There are three recommended techniques for delineating hydrologic unit boundaries.

The first technique is to interpret the hypsographic and topographic information found on 1:24,000-scale paper or mylar source materials and manually draw boundary lines based on the interpretation of those materials. The manually drawn lines are subsequently digitized using scanning and vectorization or tablet digitizing.

The second technique combines delineation and digitization of hydrologic unit boundaries on a computer display using GIS software. Instead of interpreting the hypsographic and topographic information found on paper or mylar sources as used in the first technique, digital sources are used as interpretive, background images for delineation. The boundary lines are digitized on the computer screen using functionality typically found in GIS software. Digital background sources include1:24,000-scale Digital Raster Graphics (DRG) and orthoimagery and orthophotographs such as Digital Orthophoto Quadrangles (DOQ) or Quarter-Quadrangles (DOQQ).

The third technique is to generate intermediate or “draft” boundary lines using spatial modeling software. Typical GIS software has functions for deriving drainage areas from elevation data, such as the National Elevation Dataset (NED) and supplemental hydrographic and physiographic data. The intermediate boundaries are then verified and refined using the second technique. WBD tools are available from NRCS (*http://www.ncgc.nrcs.usda.gov/products/datasets/watershed/tools.html*) to support delineation using the third technique.

4.1 Map Scale and Map Accuracy

Delineations need to meet 1:24,000-scale map accuracy standards in the conterminous U.S. (1:25,000-scale in the Caribbean or 1:63,360-scale in Alaska), described in the *National Standards for Spatial Data Accuracy* (NSSDA) at a minimum. This can be accomplished by using recommended hardcopy maps, digital geographic data, or combinations. Hardcopy sources include current USGS 1:24,000-scale topographic quadrangles and higher resolution (larger scale) local hardcopy maps. If higher resolution local maps are used to generate the hydrologic unit boundaries, they must be provided to the WBD national Technical Support Team for verification and review. If there is a barrier to providing the source maps, document the source in detail. Digital data sources include the NRCS 1:24,000-scale County Mosaic DRGs, Digital Orthophoto Quarter Quadrangles (DOQQs), and similar high-resolution digital orthophotography showing topography and surface-water features at scales of 1:24,000 in the conterminous United States, 1:25,000 in the Caribbean, 1:63,360 in Alaska, or larger scales. Combinations of these geographic data should be used to delineate accurate, current hydrologic unit boundaries and to interpret areas of complex drainage regimes or geomorphologies.

Digital elevation data at least equivalent in scale to the USGS 30-meter, Level 2 Digital Elevation Models (DEMs) or the National Elevation Dataset (NED) (both 30-meter and 10-meter) are acceptable for the delineation of draft hydrologic unit boundaries. All derivative draft or raster-based delineations will require thorough verification and adjustments to 1:24,000-scale or better topographic data such as the NRCS 1:24,000-scale County Mosaic DRGs. In Alaska and the Caribbean, USGS topographic maps (in digital and hardcopy formats) at 1:63,360-scale or 1:25,000-scale, respectively, may be used when 1:24,000-scale topographic maps are not available.

Subbasins (4th-level, 8-digit hydrologic units) as well as Watersheds (5th-level, 10-digit hydrologic units) and Subwatersheds (6th-level, 12-digit hydrologic units) must be delineated from and georeferenced to a minimum horizontal accuracy of 1:24,000-scale geographic data to meet *NSSDA*. To quantify 1:24,000-scale horizontal accuracy as it applies to the delineation of WBD-compliant hydrologic units, a hydrologic unit boundary must fall within a buffer of 40 feet or 12.2 meters of a well-defined point on a 1:24,000-scale topographic map. Geospatial positioning accuracy standards can be found in *Federal Geographic Data Committee (1998b)*.

4.2 Source Maps

This section describes the types of source maps, in both hardcopy and digital formats, that can be used to delineate hydrologic units. The sources described are not an exhaustive list. Delineation of some hydrologic unit boundaries may require use of larger scale products or newly developed products. Each source map or source data product's scale and series must be recorded in the metadata and in the LINESOURCE field (section 6.3.2).

4.2.1 Base Maps

Use printed USGS 1:24,000-scale topographic quadrangles for hard copy delineations and NRCS 1:24,000-scale County Mosaic DRGs for compiling hydrologic unit boundaries on a computer display. USGS topographic quadrangles can be obtained at *http://www.usgs.gov/pubprod/maps.html*, and NRCS County Mosaic DRGs can be obtained at *http://datagateway.nrcs.usda.gov/*. Blueprints or similar facsimiles of the USGS 1:24,000-scale topographic maps can be distorted and should not be used. In areas where 1:24,000-scale base maps are not available, the USGS 1:25,000-scale, 1:63.360-scale and or USGS 1:100,000-scale maps may be used to generate draft (concept) lines. Other data sources and map products can be used in conjunction with the digital, 1:24,000-scale DRGs or 1:24,000-scale topographic quadrangles to facilitate the interpretation of hydrologic unit boundaries. (See following sections.) Documentation of all supplemental base and source maps, digital and hardcopy should be recorded in the LINESOURCE field (section 6.3.2) as well as in the general metadata (section 9.0).

4.2.2 Hydrologic Unit Maps

Existing smaller scale hydrologic unit maps provide a framework for delineating Watershed (5th-level, 10 digit) and Subwatershed (6th-level, 12 digit) boundaries. USGS State Hydrologic Unit Maps at 1:500,000-scale, National Atlas Hydrologic Unit Boundary data and *online maps* at 1:2,000,000, or the Hydrologic Units of the U.S. data at *1:250,000-scale* are useful to determine the general location of the new or redefined hydrologic units. The publication "Hydrologic Unit Maps" (Seaber, 1987) documents the existing codes and names. The digital publication is available at *http://pubs.er.usgs.gov/usgspubs/wsp/wsp2294*.

Other hydrologic unit maps produced by NRCS, USDA-FS, and state and local entities may be used to determine the general location and level of complexity of Watersheds (5th-level, 10-digit hydrologic units) and Subwatersheds (6th-level, 12-digit hydrologic units). If other hydrologic unit maps are used as sources for compiling Watersheds (5th-level, 10-digit hydrologic units) or Subwatersheds (6th-level, 12-digit hydrologic units), be sure to record the title, scale, and accuracy of the dataset or map series; refer to section 6.3.2.

4.2.3 Reference Maps

The following reference maps may be useful for delineating hydrologic unit boundaries where 1:24,000-scale base maps do not include sufficient detail to determine flow patterns based on topography. These supplemental reference layers or maps are useful for (a) documenting artificial flow delineations based on permanent features on the landscape and (b) determining gravity flow in areas of extreme low relief or complex geomorphologies. In areas of flat terrain, interpolation between contours may be improved by reference to trails, old roads, or firebreaks in forested areas, all of which frequently follow drainage divides. The following types of digital and hardcopy maps may be used:

- county drainage maps
- "as-built" plans, including diversions and ditches
- flow-direction maps
- NOAA nautical charts
- ditch-canal maps
- land-cover maps
- soil-survey maps
- orthophotos or other aerial photographs
- major land-area resource maps
- local highway or street profiles
- local watershed-project maps

Retain as a permanent record all maps, measurement data, and other supplemental reference data/maps used in delineations (section 6.3.2).

4.2.4 Digital Data

NRCS 1:24,000-scale County Mosaic DRGs are the preferred on-screen digital reference layer for initially delineating and digitizing hydrologic unit boundaries. These DRGs are also the preferred layer for clarifying and modifying draft delineations. County Mosaics at 1:24,000 scale are available at *http://datagateway.nrcs.usda.gov*.

The 30-meter and 10-meter National Elevation Dataset (NED) DEMs are the preferred reference layers for using spatial modeling techniques to generate draft hydrologic unit boundaries. These DEMs can also be used with the County Mosaic DRGs and the National Hydrography Dataset (NHD) (described in the following paragraph), as well as with local reference layers, to clarify challenging delineations. More specific guidance regarding spatial modeling techniques to generate hydrologic unit boundaries can be found in Jenson and others (1987). Both 30- and 10-meter NED data can be obtained from *http://ned.usgs.gov/*.

The 1:24,000-scale or better resolution NHD are the preferred hydrographic data layers to use with the NRCS 1:24,000-scale County Mosaic DRGs to determine best placement of hydrologic unit boundaries, to verify the hydrologic unit connectivity, and to aid in the naming of hydrologic units. The NHD are available at *http://nhd.usgs.gov/*.

4.3 Hydrologic Unit Mapping Techniques

Drainage divides are usually determined by bisecting ridges, saddles, and contour lines of equal elevation. Hydrologic unit boundaries follow the middle of the highest ground elevation or the halfway point between contour lines of equal elevation (section 5.1; fig. 2). Where a tributary intersects the bank of a receiving stream, the hydrologic unit boundary should cross the tributary outlet parallel to the receiving stream channel. The hydrologic unit has only one outlet point, except in the case of deltas, braided stream networks, and coastal and lakefront areas (section 3.5). Hydrologic unit boundaries cannot be streams (section 3.2).

Manual, digital, and semiautomated methods can be used to generate hydrologic unit boundaries. Procedures for completing the delineation, mapping, and digitizing differ among these options, but all can produce boundaries that meet the conterminous U.S. 1:24,000-scale, Caribbean 1:25,000-scale, or Alaska 1:63,360-scale NSSDA. Delineating boundaries in areas of complex or flat terrain or complex hydrography requires careful attention to scale and source data for accurate interpretation. Sections 3.3 and 3.4 give the general size criteria for Watersheds and Subwatersheds and the recommended distribution of Watersheds and Subwatersheds within a Subbasin.

4.3.1 Manual Techniques to Delineate Hydrologic Unit Boundaries

When delineating hydrologic units by drawing boundary lines on hardcopy maps, use, at a minimum, USGS 1:24,000-scale topographic map contours, elevations, and drainage patterns to interpret and delineate the hydrologic unit boundaries. Other supplemental geographic data such as county drainage maps, state hydrologic unit maps, and aerial photographs (section 4.2.3) may be used in conjunction with the USGS 1:24,000-scale hardcopy topographic maps to facilitate interpretation of hydrologic units.

The following technique is recommended to manually delineate hydrologic unit boundaries:

1. Where hydrologic units have not been previously compiled on USGS 1:24,000-scale topographic quadrangles, it may be useful to transfer the 1:250,000-scale Subbasin boundaries (4th-level, 8-digit hydrologic units) onto the USGS 1:100,000-scale topographic quadrangles.

2. If the location or position of a Subbasin boundary is found to be questionable or require major reinterpretation, notify the WBD in-state coordinator (interagency hydrologic unit group point of contact), who will then notify the WBD national Technical Support Team.

3. If the Subbasin boundaries were transferred to 1:100,000-scale USGS topographic quadrangles, repeat the same process using 1:24,000-scale USGS topographic quadrangles.

4. Once the Subbasin boundaries are successfully transferred on to 1:24,000-scale topographic quadrangles, begin to subdivide the Watersheds (5th-level, 10-digit hydrologic units) and the Subwatersheds (6th-level, 12-digit hydrologic units).

5. Once all subdivisions of the Subbasins have been compiled on a 1:24,000-scale topographic quadrangle, digitize boundaries and codes directly from the 1:24,000-scale maps.

4.3.2 Digital Techniques to Delineate Hydrologic Unit Boundaries

When delineating and digitizing hydrologic units on the computer screen (for example at 1:24,000-scale), use the NRCS 1:24,000-scale County Mosaic DRG contours, elevations, and drainage patterns at a minimum to interpret and delineate the hydrologic unit boundaries. In special cases–for example, complex or flat topography–the scale of digitizing may decrease depending on the resolution of the base or source data being used. When data layers such as the NED, NHD and DOQQs are used with the 1:24,000-scale DRGs to facilitate interpretation of hydrologic units (section 4.2.4), delineating on the computer display using GIS software may require digitizing 5th-level, 10-digit Watersheds and 6th-level, 12-digit Subwatersheds at a scale of approximately 1:7,500. Before a Subbasin's delineation is complete, the perimeter boundary associated with the 4th-level, 8-digit Subbasin must also be reviewed and updated to meet NSSDA 1:24,000-scale map accuracy standards.

The following technique is recommended to delineate hydrologic unit boundaries on the computer display using GIS software:

1. Develop a reference plot for each Subbasin (4th-level, 8-digit hydrologic unit) showing the 1:250,000-scale hydrologic units and a stream network (preferably the 1:100,000-scale, 1:24,000-scale, or higher resolution NHD) along with other supplemental base information such as shaded relief, DEM data, and/or orthophotos (section 4.2).

2. Use the plots as guides to develop the boundaries, codes, and names of the Watersheds (5th-level, 10-digit hydrologic units) as they are digitized on the computer display. Terminate classic hydrologic units at the outlet of the hydrologic feature.

3. Once the Watershed (5th-level, 10-digit hydrologic units) boundaries have been delineated and units coded for a Subbasin, generate another reference plot showing the digitized and coded Watersheds, along with supplemental base information (section 5.2).

4. Repeat Step 2 to generate the boundaries and codes for the Subwatersheds (6th-level, 12-digit hydrologic unit) within the Subbasin.

4.3.3 Spatial Modeling Techniques to Delineate Hydrologic Unit Boundaries

Image processing, GIS, and hydrologic modeling applications can be used to manipulate DEM data, creating derivative data that represent landform features and drainage-network patterns. DEMs are available in various horizontal and vertical resolutions. Digital elevation data with resolutions at least equivalent to the vertical and horizontal resolutions of either the 30-meter, Level-2 DEMs or NED, (*http://ned.usgs.gov/*) can be used to develop a draft or preliminary delineation of hydrologic units, which will require further refinement to meet NSSDA 1:24,000-scale map accuracy standards. DEMs or NED are combined with other geospatial data such as USGS NHD and hydrography using GIS to simulate drainage networks, stream courses, and direction of flow by applying hydrologic models. Maps generated from digital hydrography data with flow-direction arrows also are helpful in delineating hydrologic units.

Depending upon the spatial modeling technique used, data resolution, data consistency, software applications, and other characteristics, the DEMs and NED will most likely provide a generalized depiction of landforms and drainage networks. This is especially apparent in areas of moderate and low topographic relief or complex hydrography. For this reason, all DEM- and NED-generated boundaries should be independently checked against 1:24,000-scale DRGs, DOQs, 1:24,000-scale NHD, or larger scale data. Adjustments to boundaries and confluences at all levels will be required to ensure 1:24,000-scale accuracy in the conterminous United States, 1:25,000-scale accuracy in the Caribbean, or 1:63,360-scale accuracy in Alaska. A detailed description of the source elevation model must be documented in the metadata.

A similar semiautomated production and review process can be followed for the 30-meter-pixel-size bathymetric DEMs for major estuaries and sounds available nationally from NOAA.

4.4 Updating and Revising Hydrologic Units

Priority should be to resolve Subbasin boundaries (4th-level, 8-digit hydrologic units) with significant hydrologic inaccuracy. Minor related revisions of existing Subbasin boundaries are to be expected to place the boundaries accurately on 1:24,000- 1:25,000- or 1:63,360-scale maps. These are not considered major revisions and do not require review by the WBD national Technical Support Team.

When hydrologic unit boundaries at 1:250,000 or smaller scales are compared to 1:24,000-scale delineations, two categories of inconsistency may be observed. (1) Minor inconsistencies and improvements in detail due to scale differences can be incorporated into the new state data. (2) Substantial differences between the1:24,000-scale and previous smaller scale delineations may prove the smaller-scale boundaries hydrologically inaccurate at the 1:24,000 scale. If substantial differences are identified, refer to guidance that follows.

The Subbasin boundaries (4th-level, 8-digit hydrologic units) have been used and referenced so extensively in water-resource activities nationwide that major changes to them should be made only in cases of major delineation error or significant landform changes due to natural phenomena or human activity. Some examples include the removal of a dam, flow changes caused by earthquakes, construction of new reservoirs, construction of embankments or levees, volcanic eruptions, massive landslides, or hurricane damage. The identification of errors in the original digitized work may also lead to an update for some or all levels within a Subbasin. For example, major revisions include those that place entire stream reaches (not small pieces of headwater reaches) in different Subbasins (4th-level, 8-digit hydrologic units) or those that recode contiguous areas approximating or exceeding the size of Watersheds (6th-level, 12-digit hydrologic units of 10,000 to 40,000 acres).

If the locations of 8-digit boundaries need to be changed to be hydrologically correct, notify the USGS/NRCS national Technical Support Team through the WBD in-state coordinator. Obtain assurance from the Technical Support Team that proposed changes are acceptable before making the revision to Subbasins. When hydrologic unit boundaries have major revisions, update the area measurements, and note significant revisions as “revised” when the new data are released. Keep a record of all changes to the Subbasins in your office.

5. Coding and Naming

5.1 Hydrologic Unit Levels

The six different levels of hydrologic units and their characteristics are shown below and in figure 3.

Name	Hydrologic unit level	Digits	Average size (square miles)	Approximate number of hydrologic units
Region	1	2	177,560	21 (actual)
Subregion	2	4	16,800	222
Basin	3	6	10,596	370
Subbasin	4	8	700	2,200
Watershed	5	10	227 (40,000-250,000 acres)	22,000
Subwatershed	6	12	40 (10,000-40,000 acres)	160,000

5.2 Coding Watersheds and Subwatersheds

This section provides guidance on coding Watersheds (5th-level, 10-digit hydrologic units) and Subwatersheds (6th-level 12-digit hydrologic units) for WBD compliance, as well as their relation to the 1:250,000-scale coding. The 1:250,000-scale dataset does not contain a consistent coding structure. Avoid changing the existing numbering of the 8-digit Subbasin codes unless there is a topographic or hydrologic justification to do so. If there is a legitimate reason to alter a location or code of a Subbasin, the WBD in-state coordinator should notify the WBD national Technical Support Team before making revisions. Assign a new unique numbered code to each Watershed and Subwatershed. Maintain the 2-digit field length for successive hydrologic units. Coordinate the coding within a Subbasin (4th-level, 8-digit hydrologic unit) across state boundaries.

Avoid complicating the coding of hydrologic units by assigning codes based on location within a county or multiple counties or states. Number the hydrologic units sequentially, beginning upstream at the hydrologic unit with the uppermost outlet and proceed downstream. Downstream codes are in ascending order (fig. 11) within each level (lower numbers always flow into higher numbers). All numbers from the lowest to the highest must be used. For example, one can start at the upstream end of the drainage and code the first Watershed as 0908020301, code the next Watershed downstream as 0908020302, and so forth. No numbers are skipped. The main-stem hydrologic unit is assigned the highest number when outlets are adjacent, or break at the same place, as shown in figure 11 (Subwatersheds 170601020104 and 170601020105).

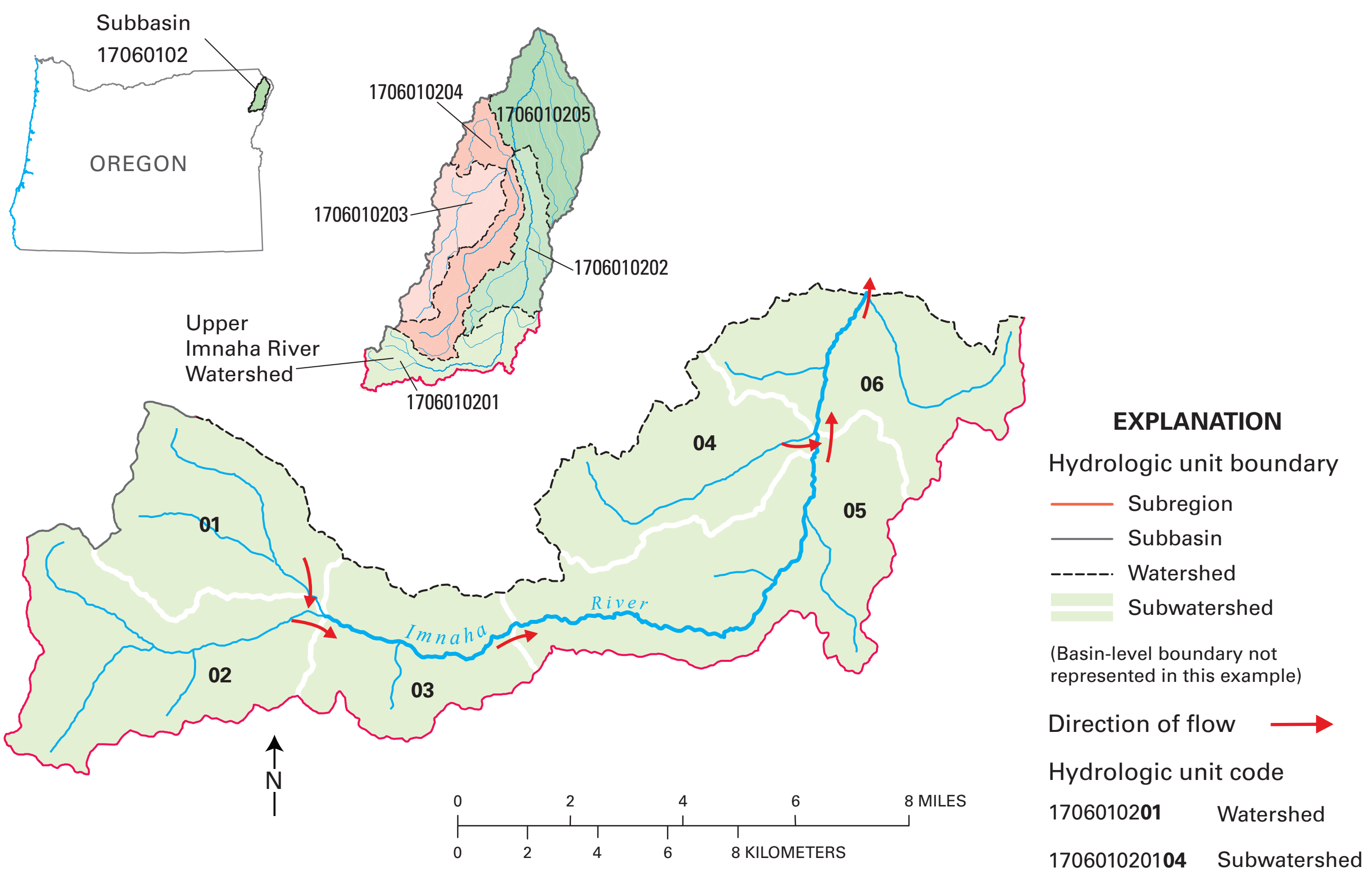


Figure 11. Each hydrologic unit should be coded sequentially based on the location of the outlet, starting with the uppermost stream outlet. The downstream code should always be a higher number than the upstream code for Watersheds and Subwatersheds. The main-stem hydrologic unit should carry the higher code when outlets are adjacent or break at the same place. Subwatershed codes are shown for the Upper Imnaha River Watershed.

If there is no scientific justification to subdivide a hydrologic unit, then code the hydrologic unit 00. For example, if a Watershed (5th-level, 10-digit hydrologic unit) (for example, 1020305118) cannot be subdivided on the basis of hydrologic principles, then the Subwatershed (6th-level, 12-digit hydrologic unit) should be coded with “00” (for example, 102030511800). The “00” represents no subdivision from the next higher level (fig.12).

A sample numbering of hydrologic units:

		Level
First 2 are the Region fields	01	1
Next 2 are the Subregion fields	0108	2
Next 2 are the Basin fields	010802	3
Next 2 are the Subbasin fields	01080204	4
Next 2 are the Watershed fields	0108020401	5
Next 2 are the Subwatershed fields	010802040101	6

5.2.1 Coding Coastal Areas That Contain Frontal Units

This section provides coding rules for frontal hydrologic units. Frontal hydrologic units are areas along coasts where several classic watersheds flowing into the water hydrologic unit are separated by independent remnant areas. Frontal hydrologic units that do not meet the size criteria should be grouped together to make larger units (fig. 9). When aggregating these frontal hydrologic units, group within levels that are flowing into the same hydrologic feature; for example, bay, lake, estuary.

These units will have the same codes and names as the other frontal hydrologic units that make up the overall unit. Code these coastal areas in a clockwise sequence from north or east, depending on the orientation of the hydrologic unit (fig. 9).

5.2.2 Coding Islands

Islands large enough to be subdivided should be coded in the same pattern for classic and frontal-unit coding, in a clockwise sequence from north or east, depending on the orientation of the island.

Island groups containing several islands of the required size for the given level should be coded individually in a clockwise sequence from north or east, depending on the orientation of the islands.

If an island is too small to be its own unit at any given level, it should be grouped with the closest island or land hydrologic unit and given the same code and name as the larger unit (fig. 10).

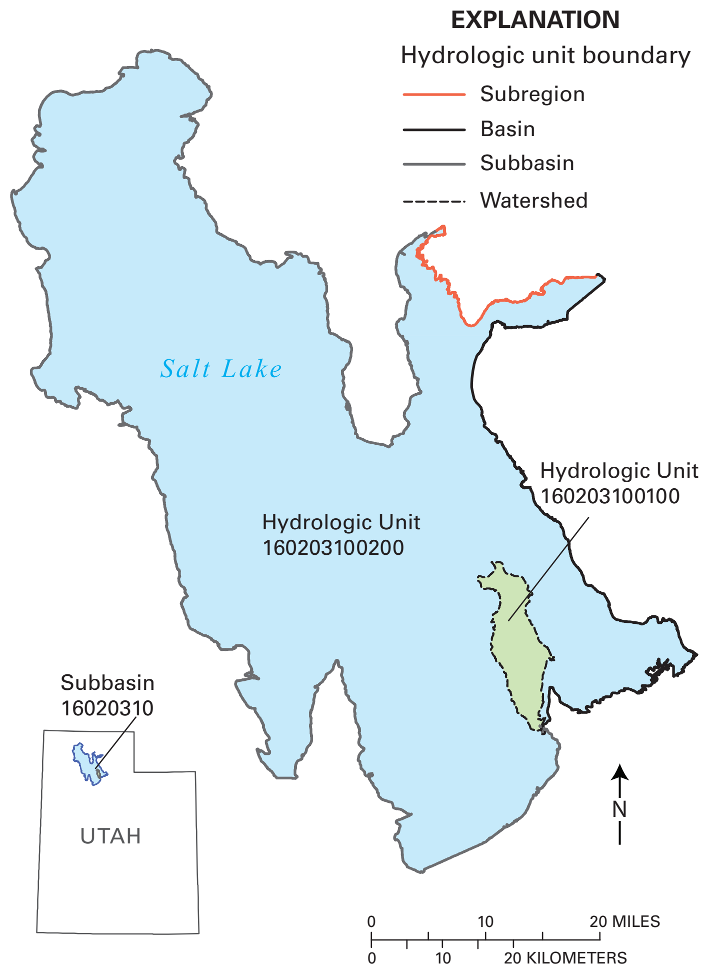


Figure 12. A major lake can be delineated as a separate hydrologic unit. Salt Lake and Antelope Island, Utah, are Watersheds where there is no scientific justification for subdividing the areas into Subwatersheds. The addition of the ‘00’ to the hydrologic unit code indicates that these Watersheds were not subdivided.

5.3 Watershed and Subwatershed Naming Protocol

The numeric hydrologic unit code is the primary unique identifier for each hydrologic unit; however, the numeric identifier alone makes it difficult to relate a hydrologic unit to a geographic location. Therefore, naming the Watersheds and Subwatersheds adds local and geographic identity to the hydrologic unit and is helpful for understanding the geographic location of the hydrologic unit. Hydrologic units are usually named after significant or prominent water features in an area; however, if there are no water features in an area, hydrologic units may be named after prominent physical features.

Identify each Watershed and Subwatershed with a feature name from the area being subdivided. Maintain consistent structure when assigning a name to a unique hydrologic unit. Use the following guidelines for naming Watersheds (5th-level, 10-digit hydrologic units) and Subwatersheds (6th-level, 12-digit hydrologic units). Do not change the names of the 1st-, 2d-, 3d-, and 4th-level hydrologic units

5.3.1 Sources of Watershed and Subwatershed Names

Watersheds and Subwatersheds should be named using feature names officially recognized by the U.S. Board on Geographic Names. Options are contained in the Geographic Names Information System (GNIS) of the USGS at *http://geonames.usgs.gov/*, including names on USGS 1:24,000-, 1:25,000-, or 1:63,360- scale topographic quadrangles, or in the NHD at *http://nhd.usgs.gov*. Avoid naming the hydrologic units after roads, gaging stations, and political or administrative units.

5.3.2 Feature Priority for Watershed and Subwatershed Names

Assign each Watershed and Subwatershed a name from the list of federally recognized names in this order of priority, advancing to the next level if none of that feature type exists or is named:

First–HYDROLOGIC FEATURE (Examples include rivers, lakes, dams, wells, and falls)

Second–GEOLOGIC FEATURE (Examples include canyons, mountains, buttes, and peaks)

Third–TOWN OR CITY (Town of Name, City of Name)

Fourth–OFFICIAL LOCAL NAME (Examples include cemeteries, airports, and schools)

If no water or prominent physical feature name is assigned, the hydrologic unit code is used as a placeholder.

Exceptions may be made to this priority order on the basis of feature significance. For example, a canyon may be more significant than a hydrologic feature, such as an upstream spring. This frequently occurs in arid areas.

5.3.3 Structure for Watershed and Subwatershed Names

Populate the hydrologic unit name attribute field using the following structure:

- Use the name of the major water feature within the hydrologic unit, spelled out in its entirety, usually the water feature at the outlet of the hydrologic unit. Stream names are preferred, but sloughs, lakes, reservoirs, dams, bays, inlets, harbors, coves, falls, wells, and springs may be used when they are the most important feature; for example, "Cresent Lake," "Sequim Bay," and "Grays Harbor."
- The word "Frontal" is reserved for coastal and lake areas that include multiple, nonconvergent streams associated with frontal hydrologic units. Name the hydrologic unit for the major hydrologic feature within the hydrologic unit and use "Frontal" as a prefix to the name of the hydrologic feature that the unit drains into. For example, "Squirrel Creek-Frontal Chesapeake Bay."
- When the same primary water feature exists within equivalent-level hydrologic units or if a main-stem stream is subdivided into more than one hydrologic unit, use this hyphenated naming structure to create unique names. Append the primary water feature name (Imnaha River) onto a secondary water feature such as a large tributary name (Rock Creek). For example, "Rock Creek-Imnaha River," or "Dry Creek-Imnaha River" (fig. 13).

- When a major stream is subdivided into multiple hydrologic units along the main-stem stream, use the words Upper, Middle, and Lower together. For example, "Upper Imnaha River," "Middle Imnaha River," "Lower Imnaha River."
  - Avoid using Upper, Middle, or Lower individually or Middle in combination with either Upper or Lower.
  - Headwaters or Outlet may be used with or without Upper, Middle, or Lower. If a main-stem stream is subdivided into more than five hydrologic units, then avoid this naming convention; use the standard hyphenated name.
  - Upper and Lower or Headwaters and Outlet may be used in pairs when a stream is subdivided into two hydrologic units.
- The words Headwaters and Outlet may be used with the hyphenated naming structure or the Upper, Middle, and Lower naming structure.
- When bathymetry was used to delineate to submerged morphologic features, the resulting coastal water unit may not contain any other named features except the main water body name (for example, Atlantic Ocean). For these units use the "hydrologic unit code-primary water feature" for the name. For example, 030102051706-Atlantic Ocean.
- Islands
  - When islands are large enough to be subdivided, use the standard naming convention for classic and frontal hydrologic units.
  - Islands large enough to be their own unit use the island name.
  - Hydrologic Units that are made up of a group of islands use the name of the major island within that group (fig. 10).

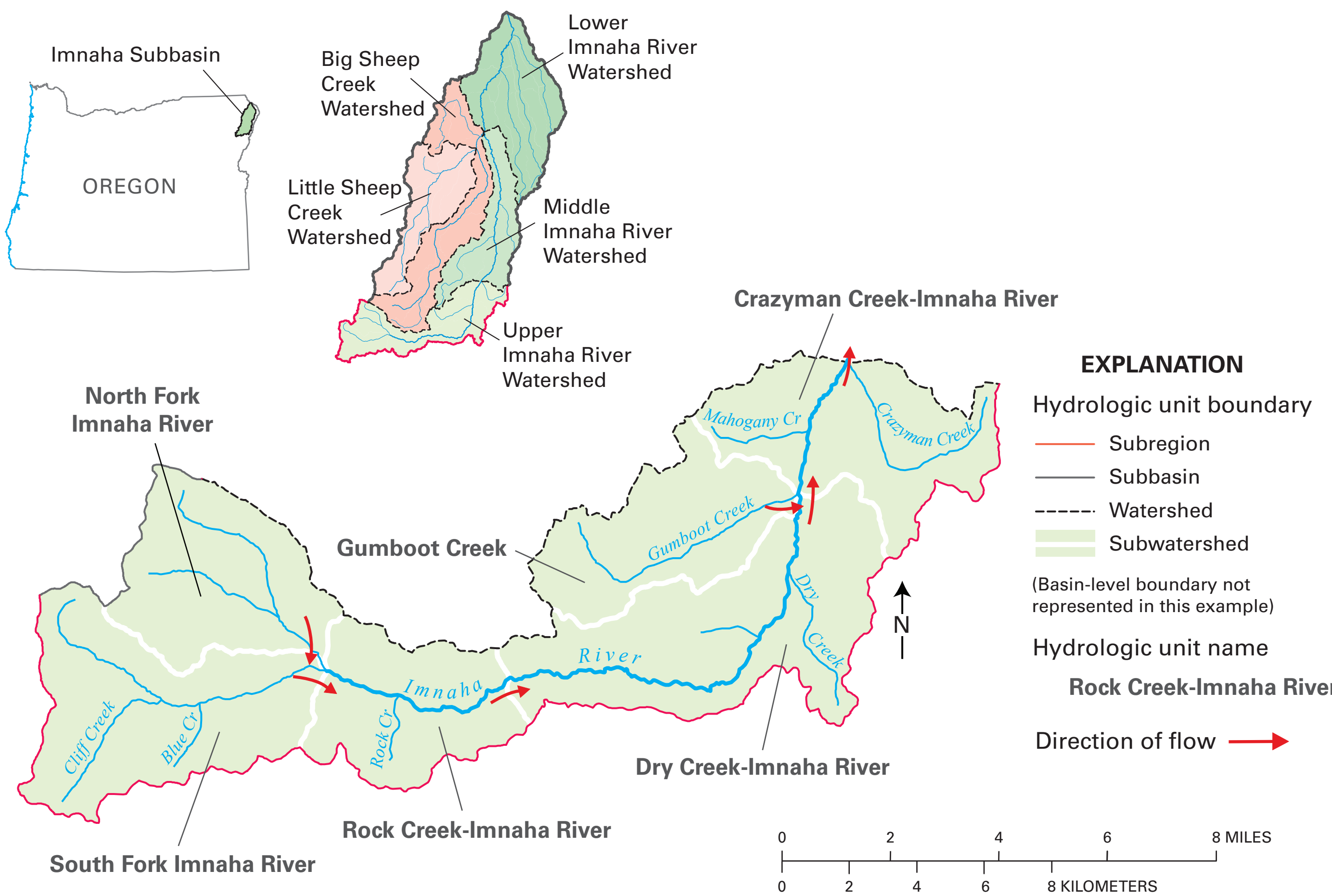


Figure 13. Each hydrologic unit of a subdivided main-stem stream should be named with, first, the largest tributary name, then a hyphen, then the main-stem stream name, for example, Rock Creek-Imnaha River. If a hydrologic unit is not subdivided, then the name of the main stream within that unit can be used. Further naming criteria are given in section 5.3. Subwatershed names for the Upper Imnaha River Watershed in the Imnaha Subbasin are shown.

5.4 International Borders

Avoid delineating or coding across international boundaries. Hydrographic mapping across borders with Canada and Mexico are addressed at the Federal level. When the headwaters of a hydrologic unit fall in a neighboring nation, and sufficient data and base maps are readily available, delineate and attribute using the current WBD guidance. When Watersheds and/or Subwatersheds are bisected by an international boundary, be sure to include the downstream code (HU_10 _DS, HU_12 _DS) shown in section 6.2.7 and 6.2.11. If data are not readily available, estimates may be necessary to maintain a basic level of logical continuity within the coding and delineation structure. Delineations or attributes along international borders may require future adjustment.

6. Geospatial Data Structure

6.1 Specifications for Geospatial Data Structure

The structure of the Watershed Boundary Dataset is based on well known Geographic Information Systems concepts for modeling geographic features as vectors. Lines are used to model the linear features of hydrologic units, whereas polygons are used to model the areal features. For both linear and areal features, associated attribution is stored in tabular format.

Hydrologic unit lines and polygons have well-known spatial relations traditionally referred to as “topology.” Topological relations between hydrologic unit lines and polygons must be consistent and valid to support the national review and certification process and to allow watershed boundary data to be integrated in a nationally consistent, seamless geospatial dataset.

Each hydrologic unit line and polygon has associated attributes stored in tabular format. An attribute, also called a field or column, is defined by name, type, size, and valid values (or range of valid values). A collection of attributes is called a schema. Schemas for hydrologic unit lines and polygons must also be consistent to support the national review and certification process and to allow watershed boundary data to be integrated in a nationally consistent, seamless geospatial dataset.

Several geodatabase tools that may help populate the attribute tables, including a semiautomated method to populate the attribute “GNIS feature identification number,” can be found at *http://www.ncgc.nrcs.usda.gov/products/datasets/watershed.tools.html.*

6.1.1 Hydrologic Unit Geometry

Hydrologic unit boundaries are delineated and digitized as lines. The digital lines are processed using GIS software to form polygons. Recommended techniques are described in Section 4. All typical geometric problems should be resolved, including dangling lines, sliver polygons, and missing or duplicate labels. Note that some of these issues are specific to a particular spatial data format, such as ESRI Coverage format, and do not necessarily apply to other formats such as ESRI Geodatabase format or ESRI Shapefile format.

6.1.2 Valid Topological Relations

Because of the variation in delineation techniques and spatial data formats used, topological relations are defined here in general terms. Not all the topological relations described here apply to all spatial data formats. For example, polygon layers in a spatial data format such as ESRI Geodatabase format always have an associated attribute record and do not require or support the concept of having to attach a label to a polygon in order to store attribution, as is necessary with the ESRI Coverage format. Therefore, independent of a particular data format, valid topological relations are used for several important functions in the Watershed Boundary Dataset:

- Quality control–to prevent polygons from overlapping or to eliminate gaps in the data.
- Data Integration–to support integrating hydrologic units from diverse sources.
- Manage coincident hydrologic units–to determine and resolve how hydrologic units share boundaries.
- Construct polygons from lines–to support development of hydrologic unit polygons from diverse linear delineations.

Hydrologic unit lines should have the following valid topology:

- Dangling lines: Not allowed. A dangling line is a line that has the same polygon on its left and right sides.
- Overlaps and intersects: Not allowed. A hydrologic unit line may not overlap itself or another hydrologic unit line. A hydrologic unit line may not intersect itself or another hydrologic unit line.

Hydrologic unit polygons should have the following valid topology:

- Overlaps and intersects: Not allowed. A polygon must share coincident geometry with adjacent polygons, which dictates that hydrologic unit polygons cannot overlap or intersect with adjacent polygons, nor should there be gaps.

6.2 Database Schema for Attributing Hydrologic Unit Polygons

Each hydrologic unit polygon has associated attributes stored in tabular format. An attribute, also called a field or column, is defined by name, type, size, and valid values (or range of valid values). A collection of attributes is called a schema. There are two categories of schema: logical and physical. The logical schema refers in general terms to the information associated with hydrologic unit polygons. For example, every hydrologic unit polygon has a unique code. The physical schema, on the other hand, defines the specific format of the table used to store attribution. For example, one of the codes for a hydrologic unit polygon has the literal name, "HUC_8", has space for eight characters, and a value is required (cannot be left blank). The physical schema is immutable; that is, attribution must adhere to literal field names, field types, and the order of fields in the table.

The following sections (6.2.1 to 6.2.17) describe the physical schema for hydrologic unit polygons.

6.2.1 8-Digit Hydrologic Unit Code

The 8-digit hydrologic unit code attribute identifies a unique Subbasin (4th-level, 8-digit hydrologic unit). Use the 8-digit codes documented in Seaber (1987) in most circumstances. This code will be the basis for all hydrologic units nested within a Subbasin.

Field Name	HUC_8
Field Type	Character
Field Width	8
Domain	01000000-99999999
Value required?	Yes
Example	01080201

6.2.2 10-Digit Hydrologic Unit Code

The 10-digit hydrologic unit code attribute identifies a unique Watershed (5th-level, 10-digit hydrologic unit). To construct the 10-digit code, add 2 digits to the end of the 8-digit codes documented in Seaber (1987). This code will be the basis for all Subwatershed hydrologic unit codes nested within the Watershed.

Field Name	HUC_10
Field Type	Character
Field Width	10
Domain	0100000000-9999999999
Value required?	Yes
Example	0108020101

6.2.3 12-Digit Hydrologic Unit Code

The 12-digit hydrologic unit code attribute identifies a unique Subwatershed (6th-level, 12-digit hydrologic unit). To construct the 12-digit code, add 2 digits to the end of the 10-digit code of the Watershed it subdivides.

Field Name	HUC_12
Field Type	Character
Field Width	12
Domain	010000000000-999999999999
Value required?	Yes
Example	010802010101

6.2.4 Subwatershed Area (6th-Level, 12-Digit Hydrologic Unit)

The Subwatershed area attribute is the area, in acres, of the Subwatershed. This value is calculated from the intrinsic area value maintained by the GIS software; therefore, acreage values may vary depending on the projection of the data. If the units of the area field are stored in square meters, use the conversion factor 0.0002471. For example, 40,469,446 square meters multiplied by 0.0002471 = 10,000 acres.

Field Name	ACRES
Field Type	Numeric
Field Width	Precision: 12, Scale 0 INFO notation: 8,12,F,0
Domain	0-unlimited
Value required?	Yes
Example	26739

6.2.5 State or Outlying Area

The state or outlying area attribute identifies state(s) or outlying areas that the Subwatershed falls within. Use the two-letter U.S. postal abbreviation. If a hydrologic unit crosses into Canada, use the two-letter postal abbreviation for the Province. If a unit crosses into Mexico, use MX. If using more than one abbreviation, separate by a comma with no space and sort in alphabetical order.

Field Name	STATES
Field Type	Character
Field Width	11
Domain	U.S. States: AL,AK,AR,AZ,CA,CO,CT,DE,FL,GA,HI,IA,ID,IL,IN,KS,KY,LA,MA,MD,ME,MI,MN,MO,MS,MT,NC,ND,NE,NH,NJ,NM,NV,NY,OH,OK,OR,PA,RI,SC,SD,TN,TX,UT,VA,VT,WA,WI,WV,WY Caribbean Outlying Areas: PR,VI Pacific Island Outlying Areas: AS,FM,GU,MH,MP,PW,UM Canadian Provinces: AB,BC,MB,NB,ON,QC,SK,YT Mexico: MX
Value required?	Yes
Example	KS,MO,OK

6.2.6 Noncontributing Area

The noncontributing area attribute represents the area, in acres, of hydrologic units that do not contribute to downstream accumulation of streamflow under normal flow conditions (section 3.5.3). If a noncontributing area is on the boundary between two or more hydrologic units, determine the low point along the noncontributing area boundary and associate the noncontributing area with the hydrologic unit adjacent to the low point on the boundary. The value is the total acreage of the noncontributing areas within a hydrologic unit.

Field Name	NCONTRB_A
Field Type	Numeric
Field Width	Precision: 12, Scale 0
INFO notation:	8,12,F,0
Domain	0-unlimited
Value required?	No
Example	357

6.2.7 10-Digit Hydrologic Unit Code of Downstream Watershed

The 10-digit hydrologic unit code of downstream Watershed attribute is the code for the Watershed (5th-level, 10-digit hydrologic unit) that is downstream from and receives the majority of the flow from the Watershed that contains this Subwatershed.

For special cases when a downstream code cannot be assigned, identify which of these exceptions applies:

- If a hydrologic unit flows into an ocean or the Gulf of Mexico, populate this field with the value "OCEAN."
- If a hydrologic unit drains into either Canada or Mexico, use the appropriate value "CANADA" or "MEXICO."
- If a hydrologic unit is a closed basin, populate this field with the value "CLOSED BASIN," which will be truncated to "CLOSED BAS."

Field Name	HU_10_DS
Field Type	Character
Field Width	10
Domain	OCEAN, CANADA, MEXICO, CLOSED BAS; 0100000000-9999999999
Value required?	No
Example 1	OCEAN
Example 2	1710020504

6.2.8 Watershed Name (5th-Level, 10-Digit Hydrologic Unit)

The Watershed name attribute is a name constructed with reference to feature names officially recognized by the U.S. Board on Geographic Names. Populate this field by following section 5.3, "Watershed and Subwatershed Naming Protocol." The value assigned to the Watershed name should be unique within the Subbasin that contains this Watershed. The Watershed name values for all the Subwatersheds nested within a Watershed are identical.

Field Name	HU_10_NAME
Field Type	Character
Field Width	80
Domain	Official names
Value required?	No
Example	Upper Blue River

6.2.9 Watershed Modifications (5th-Level, 10-Digit Hydrologic Unit)

The Watershed modifications attribute is the two-character, uppercase abbreviation(s) for either (1) the type of modification to natural overland flow that alters the location of a Watershed boundary (5th-level, 10-digit hydrologic unit) or (2) the special conditions GF-ground-water flow, GL-glacier, IF-ice field, OF-overbank flow, KA-karst, NC-noncontributing area, and IT-interbasin transfer. The value of the HU_10_MOD field helps indicate where the modification to the Watershed boundary (5th-level, 10-digit) occurs. If using more than one abbreviation, separate them with a comma in the order of importance.

Previous versions of this guideline did not provide the same number of modification choices—check metadata or contact the WBD in-state coordinator for more information.

AD **Aqueduct** A conduit or artificial channel to transport water that does not allow inflow from the surrounding land (alters natural boundary location).

BC **Barge Canal or Navigation Canal** An artificial waterway built for navigation; for example, by barges (alters natural boundary location).

CD **Channel Diversion** A stream channel within the hydrologic unit has altered to divert surface water from one location to another (alters natural boundary location).

DD **Drainage Ditch** An artificial waterway used to move surface water off the land to a stream or water body (alters natural boundary location).

DM **Dam** A barrier constructed to control the flow or raise the level of water at a hydrologic unit outlet or on the hydrologic unit boundary (alters natural boundary location).

GC **General 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 (alters natural boundary location).

GF **Ground-Water Flow** A special condition where most of the runoff in a hydrologic unit drains underground, usually in locations with sandy soil.

GL **Glacier** A special condition where a hydrologic unit crosses or includes a body or stream of ice moving outward and downslope from an area of accumulation; area of relatively permanent snow or ice on the top or side of a mountain or mountainous area.

ID **Irrigation Ditch** An artificial ditch or canal that supplies land with water for crops (alters natural boundary location).

IF **Ice Field** A special condition where a hydrologic unit crosses, or includes a field of ice, formed in regions of perennial frost.

IT **Interbasin Transfer** A special condition where a water conveyance system within a hydrologic unit is used to divert water from one hydrologic unit to another.

KA **Karst** A special condition where a hydrologic unit is within an area of, or includes an area of, geologic formations of irregular limestone deposits with sinks, underground streams, and caverns.

LE **Levee** An artificial bank to confine a stream channel or limit adjacent areas subject to flooding (alters natural boundary location).

MA **Mining Activity** Heavy topographic modification of a hydrologic unit by surface mining (alters natural boundary location).

NC **Noncontributing Area** A natural formed area that does not contribute surface-water runoff to a hydrologic unit outlet; for example, a playa (special condition).

NM **No Modifications** No modifications are present.

OC **Overflow Channel or Flume** An artificial channel built to control excess high flow from a natural channel (alters natural boundary location).

OF Overbank Flow A natural diversion in which a stream surpasses bankfull stage and the excess flows into a nearby channel draining to a different hydrologic unit (special condition; see example in fig. 14).

OT Other A modification that has not been identified in this list.

PD Pipe Diversion A redirection of surface water by a pipeline from one hydrologic unit to another (alters natural boundary location).

PS Pumping Station A facility along a stream or other waterbody used to move water over a levee or other obstruction (alters natural boundary location).

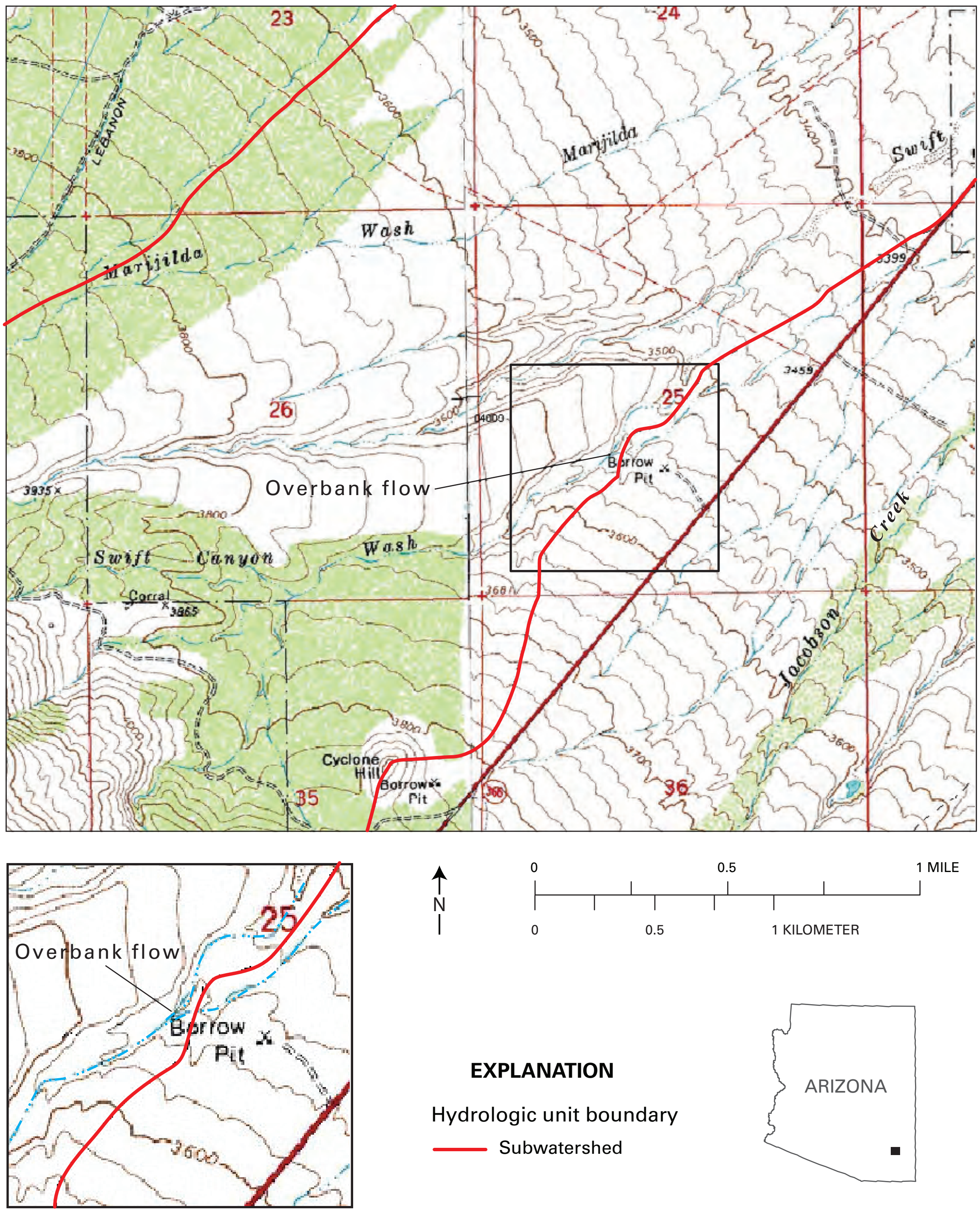


Figure 14. When high flows cause a natural diversion and the excess runs into an adjacent channel draining to a different hydrologic unit, the special condition is named overbank flow. Overbank flow is usually found in areas of alluvial material, such as in this area of Graham County, Ariz.

RS Reservoir A constructed basin formed to contain and store water for future use in an artificial lake (alters natural boundary location).

SC Stormwater Canal or Drainage Canal An open, artificial waterway (many times named on maps) that drains stormwater runoff (alters natural boundary location).

SD Stormwater Ditch An open, artificial waterway (smaller than a canal, usually not named on maps) that drains stormwater runoff (alters natural boundary location).

SI Siphon An artificial diversion (usually named "Siphon" on maps) to move surface water from one stream channel to another (alters natural boundary location).

TF Transportation Feature A land transportation feature; for example, road, railroad, dock, airport, etc. (alters natural boundary location).

UA Urban Area Heavy modification of hydrologic unit topography by development beyond that described above in "Transportation Feature" (alters natural boundary location).

Field Name	HU_10_MOD
Field Type	Character
Field Width	20
Domain	AD,BC,CD,DD,DM,GC,GF,GL,IF,ID,IT, KA,LE,MA,NC,NM,OC,OF,OT,PD,PS,RS, SC,SD,SI,TF,UA
Value required?	Yes
Example	CD,NC,ID

6.2.10 Watershed Type (5th-Level, 10-Digit Hydrologic Unit)

The Watershed type attribute is the single-letter abbreviation for Watershed type from the list provided. Use the single type that most closely describes the Watershed.

S "Standard" hydrologic unit An area with drainage flowing to a single outlet point, excluding noncontributing areas. Some examples include "true," "classic," "composite," and "remnant" hydrologic units (section 3.5.1).

C "Closed Basin" hydrologic unit A drainage area that is 100 percent noncontributing. This means all surface flow is internal; no overland flow leaves the hydrologic unit through the outlet point (section 3.5.3).

F "Frontal" hydrologic unit An area along the coastline of lakes, oceans, bays, etc., that has more than one outlet. These hydrologic units are predominantly land with some water areas at or near the outlet(s) (section 3.5.6).

M "Multiple Outlet" hydrologic unit An area that has more than one natural outlet; for example, an outlet located on a stream with multiple channels. This does not include frontal or water hydrologic units, hydrologic units with artificial interbasin transfers, drainage outlets through karst or ground-water flow, or outlets that cross a stream with an island. This code should be used only in rare instances.

W "Water" hydrologic unit An area that is predominantly water with adjacent land areas; for example, a lake, estuary, or harbor (section 3.5.6).

I "Island" hydrologic unit An area that is one or more islands and adjacent water (section 3.5.7).

U "Unclassified" hydrologic unit An area that cannot be defined or does not fit into one of the other types listed.

Field Name	HU_10_TYPE
Field Type	Character
Field Width	1
Domain	S,C,F,M,W,I,U
Value required?	Yes
Example	S

6.2.11 12-Digit Hydrologic Unit Code of Downstream Subwatershed

The 12-digit hydrologic unit code of downstream Subwatershed attribute is the code for the Subwatershed (6th-level, 12-digit hydrologic unit) that is downstream from and receives the majority of the flow from this Subwatershed.

For special cases when a downstream code cannot be assigned, identify which of these exceptions applies:

- If a hydrologic unit flows into an ocean or the Gulf of Mexico, populate this field with the value "OCEAN."
- If a hydrologic unit drains into either Canada or Mexico, use the appropriate value "CANADA" or "MEXICO."
- If a hydrologic unit is a closed basin, then populate this field with the value "CLOSED BASIN," which will appear "CLOSED BAS."

Field Name	HU_12_DS
Field Type	Character
Field Width	12
Domain	OCEAN, CANADA, MEXICO, CLOSED BASIN; 010000000000-999999999999
Value required?	No
Example 1	OCEAN
Example 2	171002050402

6.2.12 Subwatershed Name (6th-Level, 12-Digit Hydrologic Unit)

The Subwatershed name attribute is a name constructed with reference to feature names officially recognized by the U.S. Board on Geographic Names. Populate this field by following section 5.3, "Watershed and Subwatershed Naming Protocol." The value assigned to the Subwatershed name should be unique within the Subbasin and Watershed that contain this Subwatershed.

Field Name	HU_12_NAME
Field Type	Character
Field Width	80
Domain	Official names
Value required?	No
Example	Drift Creek-Big Bear River

6.2.13 Subwatershed Modifications (6th-Level, 12-Digit Hydrologic Unit)

The Subwatershed modifications attribute is the two-character, uppercase abbreviation(s) for either (1) the type of modification to natural overland flow that alters the location of a Subwatershed boundary (6th-level, 12-digit hydrologic unit) or (2) the special conditions GF-ground-water flow, GL-glacier, IF-ice field, OF-overbank flow, KA-karst, NC-noncontributing area, and IT-interbasin transfer. The value of the HU_12_MOD field helps indicate where the modification to the Subwatershed boundary (6th-level, 12-digit) occurs. If the modification occurs on a boundary that represents both the Watershed and Subwatershed, the same modifications should be reflected in both the HU_12_MOD and HU_10_MOD fields. If using more than one abbreviation, separate them with a comma in the order of importance.

Previous versions of this guideline did not provide the same number of modification choices—check metadata or contact the WBD in-state coordinator for more information.

AD Aqueduct A conduit or artificial channel to transport water that does not allow inflow from the surrounding land (alters natural boundary location).

BC Barge Canal or Navigation Canal An artificial waterway built for navigation; for example, by barges (alters natural boundary location).

CD Channel Diversion A stream channel within the hydrologic unit has altered to divert surface water from one location to another (alters natural boundary location).

DD Drainage Ditch An artificial waterway used to move surface water off the land to a stream or water body (alters natural boundary location).

DM Dam A barrier constructed to control the flow or raise the level of water at a hydrologic unit outlet or on the hydrologic unit boundary (alters natural boundary location).

GC General 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 (alters natural boundary location).

GF Ground-Water Flow A special condition where most of the runoff in a hydrologic unit drains underground, usually in locations with sandy soil.

GL Glacier A special condition where a hydrologic unit crosses or includes a body or stream of ice moving outward and downslope from an area of accumulation; area of relatively permanent snow or ice on the top or side of a mountain or mountainous area.

ID Irrigation Ditch An artificial ditch or canal that supplies land with water for crops (alters natural boundary location).

IF Ice Field A special condition where a hydrologic unit crosses or includes a field of ice, formed in regions of perennial frost.

IT Interbasin Transfer A special condition where a water conveyance system within a hydrologic unit is used to divert water from one hydrologic unit to another.

KA Karst A special condition where a hydrologic unit is within an area of, or includes an area of, geologic formations of irregular limestone deposits with sinks, underground streams, and caverns.

LE Levee An artificial bank to confine a stream channel or limit adjacent areas subject to flooding (alters natural boundary location).

MA Mining Activity Heavy topographic modification of a hydrologic unit by surface mining (alters natural boundary location).

NC Noncontributing Area A natural formed area that does not contribute surface-water runoff to a hydrologic unit outlet; for example, a playa (special condition).

NM No Modifications No modifications are present.

OC Overflow Channel or Flume An artificial channel built to control excess high flow from a natural channel (alters natural boundary location).

OF Overbank Flow A natural diversion in which a stream surpasses bankfull stage and the excess flows into a nearby channel draining to a different hydrologic unit (special condition; see example in fig. 14).

OT Other A modification that has not been identified in this list.

PD Pipe Diversion A redirection of surface water by a pipeline from one hydrologic unit to another (alters natural boundary location).

PS Pumping Station A facility along a stream or other waterbody used to move water over a levee or other obstruction (alters natural boundary location).

RS Reservoir A constructed basin formed to contain and store water for future use in an artificial lake (alters natural boundary location).

SC Stormwater Canal or Drainage Canal An open, artificial waterway (many times named on maps) that drains stormwater runoff (alters natural boundary location).

SD Stormwater Ditch An open, artificial waterway (smaller than a canal, usually not named on maps) that drains stormwater runoff (alters natural boundary location).

SI Siphon An artificial diversion (usually named “Siphon” on maps) to move surface water from one stream channel to another (alters natural boundary location).

TF Transportation Feature A land transportation feature; for example, road, railroad, dock, airport, etc. (alters natural boundary location).

UA Urban Area Heavy modification of hydrologic unit topography by development beyond that described above in “Transportation Feature” (alters natural boundary location).

Field Name	HU_12_MOD
Field Type	Character
Field Width	20
Domain	AD,BC,CD,DD,DM,GC,GF,GL,IF,ID, IT, KA,LE,MA,NC,NM,OC,OF,OT,PD,PS, RS,SC,SD,SI,TF,UA
Value required?	Yes
Example	SD,KA,PD

6.2.14 Subwatershed Type (6th-Level, 12-Digit Hydrologic Unit)

The Subwatershed type attribute is the single-letter abbreviation for Subwatershed type from the list provided. Use the single type that most closely describes the Subwatershed.

S “Standard” hydrologic unit An area with drainage flowing to a single outlet point, excluding noncontributing areas. Some examples include “true,” “classic,” “composite,” and “remnant” hydrologic units (section 3.5.1).

C “Closed Basin” hydrologic unit A drainage area that is 100 percent noncontributing. This means all surface flow is internal; no overland flow leaves the hydrologic unit through the outlet point (section 3.5.3).

F “Frontal” hydrologic unit An area along the coastline of lakes, oceans, bays, etc., that has more than one outlet. These hydrologic units are predominantly land with some water areas at or near the outlet(s) (section 3.5.6).

M “Multiple Outlet” hydrologic unit An area that has more than one natural outlet; for example, an outlet located on a stream with multiple channels. This does not include frontal or water hydrologic units, hydrologic units with artificial interbasin transfers, drainage outlets through karst or groundwater flow, or outlets that cross a stream with an island. This code should be used only in rare instances.

W “Water” hydrologic unit An area that is predominantly water with adjacent land areas; for example, a lake, estuary, or harbor (section 3.5.6).

I “Island” hydrologic unit An area that is one or more islands and adjacent water (section 3.5.7).

U “Unclassified” hydrologic unit An area that cannot be defined or does not fit into one of the other types listed.

Field Name	HU_12_TYPE
Field Type	Character
Field Width	1
Domain	S,C,F,M,W,I,U
Value required?	Yes
Example	C

6.2.15 Watershed GNIS Feature Identification Number (5th-Level, 10-Digit Hydrologic Unit)

The Watershed GNIS Feature Identification Number attribute is the 6- or 7-digit Feature Identification Number from the Geographic Names Information System (GNIS) that correspond to the official names used in the hydrologic unit name. Each officially recognized name in the country has a unique Feature Identification Number. If a hydrologic unit name includes two or more feature names, this field contains two GNIS feature numbers separated by a space.

Field Name	HU_10_GNIS#
Field Type	Character
Field Width	23
Domain	000001-9999999
Value required?	No
Example	102354 238437

6.2.16 Subwatershed GNIS Feature Identification Number (6th-Level, 12-Digit Hydrologic Unit)

The Subwatershed GNIS Feature Identification Number attribute is the 6- or 7-digit Feature Identification Number from the Geographic Names Information System (GNIS) that corresponds to the official names used in the hydrologic unit name. Each officially recognized name in the country has a unique Feature Identification Number. If a hydrologic unit name includes two or more feature names, this field contains two GNIS feature numbers separated by a space.

Field Name	HU_12_GNIS#
Field Type	Character
Field Width	23
Domain	000001-9999999
Value required?	No
Example	102354 238437

6.2.17 Metadata Identification

The Metadata Identification attribute is the code used to track changes made to a specific boundary (line or arc) segment or polygon attribute. When a state has received provisional certification status, all boundary segments and polygon attribute values would be 01. After provisional certification each time changes are made to a boundary segment or polygon attribute, the Meta_ID value is incrementally updated for that feature. The change is documented in the updated FGDC metadata with reference to the Meta_ID.

Construct the 4-character metadata ID starting with the 2-letter U.S. postal abbreviation, in uppercase, followed by a 2-digit sequence number; for example, “OK01,” “ID02.” All state polygons will have a Meta_ID of (state abbreviation01)at the time of provisional certification.

Field Name	META_ID
Field Type	Character
Field Width	4
Domain	AL,AK,AR,AZ,CA,CO,CT,DE,FL, GA,HI,IA,ID,IL,IN,KS,KY,LA,MA,MD, ME,MI,MN,MO,MS,MT,NC,ND,NE,NH, NJ,NM,NV,NY,OH,OK,OR,PA,RI,SC, SD,TN,TX,UT,VA,VT,WA,WI,WV,WY; PR,VI,AS,FM,GU,MH,MP,PW,UM; 01-99
Value required?	Yes
Example	OK01

6.2.18 Polygon Attribute Summary

Attribute	Field name	Field type	Field width	Domain	Is value required?	Example
8-digit hydrologic unit code	HUC_8	Character	8	01000000-99999999	Yes	01080201
10-digit hydrologic unit code	HUC_10	Character	10	0100000000-9999999999	Yes	0108020103
12-digit hydrologic unit code	HUC_12	Character	12	010000000000-999999999999	Yes	010802010310
Subwatershed area	ACRES	Numeric	Precision:12, Scale 0 Info notation: 8,12,F,0	0-unlimited	Yes	26739
State or outlying area	STATES	Character	11	U.S. state or Tribal Lands, Pacific Islands, Puerto Rico, U.S. V.I.	Yes	KS,MO,OK
Noncontributing area	NCONTRIB_A	Numeric	Precision:12, Scale 0 Info notation: 8,12,F,0	0-unlimited	No	357
10-digit hydrologic unit code of downstream Watershed	HU_10_DS	Character	10	OCEAN, CANADA, MEXICO, CLOSED BAS, 0100000000-9999999999	No	1710020504
Watershed name	HU_10_NAME	Character	80	Official names	No	Upper Blue River
Watershed modifications	HU_10_MOD	Character	20	AD,BC,CD,DD,DM,GC,GF,GL, ID,IF,IT,KA,LE,MA,NC,NM, OC,OF,OT,PD,PS,RS,SC, SD,SI,TF, UA	Yes	CD,NC,ID
Watershed type	HU_10_TYPE	Character	1	S,C,F,M,W,I,U	Yes	S
12-digit hydrologic unit code of downstream Subwatershed	HU_12_DS	Character	12	OCEAN, CANADA, MEXICO, CLOSED BASIN, 010000000000-999999999999	No	171002050401
Subwatershed name	HU_12_NAME	Character	80	Official names	No	Drift Creek-Big Bear
Subwatershed modification	HU_12_MOD	Character	20	AD, BC, CD, DD, DM, GC, GF, GL, ID, IF, IT, KA, LE, MA, NC, NM, OC, OF, OT, PD, PS, RS, SC, SD, SI, TF, UA	Yes	CD,NC,ID

6.2.18 Polygon Attribute Summary—Continued

Attribute	Field name	Field type	Field width	Domain	Is value required?	Example
Subwatershed type	HU_12_TYPE	Character	1	S,C,F,M,W,I,U	Yes	S
Watershed GNIS feature identification number	HU_10_GNIS#	Character	23	000001-9999999	No	102354 238437
Subwatershed GNIS feature identification number	HU_12_GNIS#	Character	23	000001-9999999	No	102354 238437
Metadata identification	META_ID	Character	4	AL, AK, AR, AZ, CA, CO, CT, DE, FL, GA, HI, IA, ID, IL, IN, KS, KY, LA, MA, MD, ME, MI, MN, MO, MS, MT, NC, ND, NE, NH, NJ, NM, NV, NY, OH, OK, OR, PA, RI, SC, SD, TN, TX, UT, VA, VT, WA, WI, WV, WY; PR, VI, AS, FM, GU, MH, MP, PW, UM; 01-99	Yes	OK01

6.3 Database Schema for Attributing Hydrologic Unit Lines

Each hydrologic unit line has associated attributes stored in tabular format. An attribute, also called a field or column, is defined by name, type, size, and valid values (or range of valid values). A collection of attributes is called a schema. There are two categories of schema: logical and physical. The logical schema refers in general terms to the information associated with hydrologic unit lines. For example, every hydrologic unit line has a unique code. The physical schema, on the other hand, defines the specific format of the table used to store attribution. For example, one of the codes for a hydrologic unit line has the literal name “HU_Level” with space for one character, which can only be one of the seven characters 0, 1, 2, 3, 4, 5, or 6, and a value is required (field cannot be left blank). The physical schema is immutable; that is, attribution must adhere to literal field names, field types, and the order of fields in the table.

The following sections (6.3.1 to 6.3.3) describe the physical schema for hydrologic unit lines.

6.3.1 Hydrologic Unit Level

The hydrologic unit level attribute indicates the relative position of each boundary (line, or arc) segment within the hydrologic unit hierarchy. Populate this field with the highest hydrologic unit level (smallest number) for each line, or arc, as indicated by the record. A level is represented by numbers 0 through 6, with 0 at the top and 6 at the bottom of the hierarchy. For example, if a line segment is the boundary of a Region, then the value is 1 (Region). If a line segment is the boundary of a Subbasin, then the value is 4 (Subbasin) even though it is also a Watershed and Subwatershed boundary. If a line segment ends at an international border and there is no information to complete the hydrologic unit beyond the U.S. boundary, then the value is 0. If a line segment along a coastal area ends at the shoreline because bathymetry was not applied, then the value is 0. Use one of the levels in the list below.

Level	Digit number	Name
0	0	no data (includes coastline)
1	2	Region
2	4	Subregion
3	6	Basin
4	8	Subbasin
5	10	Watershed
6	12	Subwatershed

Field Name HU_level

Field Type Character

Field Width 1

Domain 0-6

Value required? Yes

Example 6

6.3.2 Line Spatial Data Source

The line spatial data source attribute is the abbreviation to identify the map or other geographic data source(s) used to delineate hydrologic unit boundaries. Populate the field using one or more of the standardized codes listed below in uppercase. If using more than one code separate the values with a comma and no space. Other reference and source maps not listed should be noted in the metadata (section 4).

TOPO24 Delineated from hardcopy 1:24,000-scale topographic maps.

TOPO25 Delineated from hardcopy 1:25,000-scale topographic maps for Alaska and the Caribbean outlying areas.

TOPO63 Delineated from hardcopy 1:63,360-scale topographic maps for Alaska and the Caribbean outlying areas.

DRG24 Delineated from 1:24,000-scale Digital Raster Graphics.

DRG25M Delineated from 1:25,000-scale Digital Raster Graphics for Alaska and the Caribbean outlying areas.

DRG63 Delineated from 1:63,360-scale Digital Raster Graphics for Alaska and the Caribbean outlying areas.

DEM10 Derived from 10-meter Digital Elevation Model.

DEM30 Derived from 30-meter Digital Elevation Model.

NED10 Derived from 10-meter National Elevation Dataset Model.

NED30 Derived from 30-meter National Elevation Dataset Model.

EDNA30 Derived from 30-meter Elevation Derivatives for National Applications.

BATH"scale" Interpreted from NOAA 1:24,000-scale or other bathymetric data; for example, BATH24.

TNML Delineated from NOAA nautical charts' Three Nautical Mile Line.

NAIP"year" Delineated from aerial photography produced by the National Agriculture Imagery Program; for example, NAIP2005

NHD24 Interpreted from 1:24,000-scale National Hydrography Dataset.

NHD100 Interpreted from 1:100,000-scale National Hydrography Dataset.

HYPSO“scale” Delineated from 1:24,000-scale or other contour data; for example, HYPSO24.

ORTHO“scale” Interpreted from 1:12,000-scale or other orthoimagery; for example, ORTHO12.

DEDEM10 Drainage-enforced 10-meter Digital Elevation Model.

DEDEM30 Drainage-enforced 30-meter Digital Elevation Model.

GPS Derived from Global Positioning System.

LIDAR Derived from LIDAR (light detection and ranging) data.

IFSAR Derived from IFSAR (interferometric synthetic aperture radar) data.

OTH Other.

UNK Unknown.

Field Name LINESOURCE

Field Type Character

Field Width 20

Domain TOPO24,TOPO25,TOPO63,DRG24, DRG25, DRG63,DEM10DEM30, NED10,NED30,EDNA30,BATH“scale,” TNML, NAIP”year,”NHD24,NHD100 , HYPSO“scale,”ORTHO“scale,” DEDEM10,DEDEM30,GPS,LIDAR, IFSAR,OTH

Value required? Yes

Example DEM30,DRG24,GPS

6.3.3 Metadata Identification

The Metadata Identification attribute is the code used to track changes made to a specific boundary (line or arc) segment or polygon attribute. When a state has received provisional certification status, all boundary segments and polygon attribute values would be 01. After provisional certification each time changes are made to a boundary segment or polygon attribute, the Meta_ID value is incrementally updated for that feature. The change is documented in the updated FGDC metadata with reference to the Meta_ID.

Construct the 4-character metadata ID starting with the 2-letter U.S. postal abbreviation, in uppercase, followed by a 2-digit sequence number; for example, “OK01,” “ID02.” All state polygons will have a Meta_ID of (state abbreviation01) at the time of provisional certification.

Field Name META_ID

Field Type Character

Field Width 4

Domain AL,AK,AR,AZ,CA,CO,CT,DE,FL, GA,HI,IA,ID,IL,IN,KS,KY,LA,MA,MD, ME,MI,MN,MO,MS,MT,NC,ND,NE,NH, NJ,NM,NV,NY,OH,OK,OR,PA,RI,SC, SD,TN,TX,UT,VA,VT,WA,WI,WV,WY; PR,VI,AS,FM,GU,MH,MP,PW,UM; 01-99

Value required? Yes

Example OK01

6.3.4 Line Attribute Summary

Attribute	Field name	Field type	Field width	Domain	Is value required?	Example
Hydrologic unit number	HU_LEVEL	Character	1	0-6	Yes	6
Line spatial data source	LINE SOURCE	Character	20	TOPO24, TOPO25, TOPO63, DRG24, DRG25, DRG63, DEM10, DEM30, NED10, NED30, EDNA30, BATH“scale,” TNML, NAIP”year,” NHD24, NHD100, HYPSO“scale,” ORTHO“scale,” DE-DEM10, DEDEM30, GPS, LIDAR, IFSAR, OTH, UNK	Yes	DEM30, DRG24, GPS
Metadata identification	META_ID	Character	4	AL, AK, AR, AZ, CA, CO, CT, DE, FL, GA, HI, IA, ID, IL, IN, KS, KY, LA, MA, MD, ME, MI, MN, MO, MS, MT, NC, ND, NE, NH, NJ, NM, NV, NY, OH, OK, OR, PA, RI, SC, SD, TN, TX, UT, VA, VT, WA, WI, WV, WY, PR,VI, AS, FM, GU, MH, MP, PW, UM;01-99	Yes	OK01

7. Quality Assurance and Quality Control

7.1 Quality Assurance

Ideally, hydrologic units are delineated and verified through an interagency process. However, it may be necessary for one agency to lead in developing and certifying the hydrologic unit boundaries. Before newly delineated hydrologic unit boundaries are submitted for the WBD, the boundaries must be reviewed for conformance to these guidelines by the originating agency and/or designated members of an interagency hydrologic unit coordinating group within the state. Qualified reviewers typically would be hydrologists or natural-resource and GIS specialists with background and experience in hydrologic unit delineation. The originating agency should invite representatives of the interagency hydrologic unit coordinating group and or regional/local parties to participate in the development and review of delineations before the data are submitted for national certification and released to the public. The data should be thoroughly reviewed by the state representatives before submitting for certification.

It is recommended that reviews and edit checks be done throughout the delineation process. At a minimum, edit checks should be made after the Watersheds and Subwatersheds are delineated, mapped, and digitized.

7.2 Quality Control (Editing Checklist)

Below is a recommended list of quality-control items to be checked during the delineation, coding, documentation, and digitizing process. This is necessary for maintaining a consistent national database of hydrologic units. This is not an exhaustive list, but it covers most items to be verified.

7.2.1 Delineation

- Do the hydrologic unit boundaries match at state boundaries, with coding and size criteria consistent across boundaries? Resolve differences in delineation at state boundaries before the data are submitted for agency certification.
- Does linework meet current NSSDA?
- Are hydrologic units consistently delineated across the state?
- Is each hydrologic unit subdivided into 5 to 15 units? (Section 3.3.)
- Are the areas of 10-digit Watersheds within the recommended range of 40,000–250,000 acres? Are the areas of 12-digit Subwatersheds within the recommended range of 10,000–40,000 acres, with none below 3,000? When a hydrologic unit is divided by a state boundary, check the total area including both states' portion (section 3.4). A combined total of 10 percent of the polygons outside the specified size criteria is allowed.
- Are the hydrologic units correctly delineated on the 1:24,000-scale topographic maps with respect to hydrography and elevation contours? (Section 4.)
- Do hydrologic units that were difficult to delineate have a description of the procedure used? Make notes about how certain boundaries were established or field checked so they can be documented in the field LINESOURCE (section 6.3.2) and in the metadata (section 9.0).
- Were local sources used to resolve the location of questionable boundaries? Make notes where local knowledge supersedes source maps and document this information in the field LINESOURCE (section 6.3.2).

7.2.2 Codes

- Is the coding of hydrologic units consistent within a Subbasin covering more than one state? Check the coding system for correctness, duplication, or missing codes. Each polygon must have a single label (section 5.2).
- Does the coding of hydrologic units within a given level meet the guidelines for starting upstream and progressing downstream? (Section 3.)

7.2.3 Attributes

- Are the attribute fields complete, with valid values? (Sections 6.2–6.3.)
- Do polygons have the required values in these fields? HUC_8, HUC_10, HUC_12, ACRES, STATES, HU_10_MOD, HU_10_TYPE, HU_12_MOD, HU_12_TYPE, META_ID (section 6.2).
- Do lines have the required values in these fields? HU_LEVEL, LINESOURCE, META_ID (section 6.3).
- Is the ACRES field calculated from the AREA data and values without decimal places? (Section 6.2.4.)
- Is the STATE field complete, with the value correctly formatted using the 2-letter postal abbreviation, a comma between multiple states, no spaces between abbreviations, and multiple states in alphabetical order? (Section 6.2.5.)
- Do artificial modifications or special conditions exist? Check and document in the fields HU_10_MOD and/or HU_12_MOD if modifications to the natural boundary location have been made or special conditions exist (sections 6.2.9, 6.2.13).

7.2.4 Data format

- Does the file format conform to the guidelines? Before submitting for national review and certification, verify that the data's map projection is correct. Data units should be decimal degrees, North American 1983 horizontal datum, Geodetic Reference System, 1980 spheroid. The data precision should be double (section 8.3).

8. Preparing Data for Certification

This section presents guidelines and procedures to be followed for successful certification of state contributions to the Watershed Boundary Dataset (WBD). Digital geospatial data and attributes must match adjoining states or Subregions. The following formats are acceptable: ESRI shapefile, ESRI Personal Geodatabase, ESRI File-based Geodatabase, SDTS, or ESRI exchange format. Data should be topologically valid.

8.1 State Certification Process

Agencies involved in the development of the WBD should establish organizational responsibility for reviewing the data before submitting the data to be formally reviewed and certified by the USGS and NRCS National Cartography and Geospatial Center (NCGC).

After the Subwatersheds (6th-level, 12-digit hydrologic units) are completed, the originating office will submit the data to NCGC/USGS for review and certification. A sample certification submittal letter is available in section 11.4. Supporting material such as text documents describing the procedure used to delineate and digitize the Watersheds and Subwatersheds are documented in the LINESOURCE field and metadata. In addition, a summary of decisions for Watersheds and Subwatersheds in complex hydrographic areas and explanatory hardcopy maps will benefit and expedite the review.

NCGC/USGS will make the data and metadata available electronically to the member agencies of the Subcommittee on Spatial Water Data for review and provisional or full certification (fig. 15). The data will be reviewed for the following:

- Adherence to the current "Federal Guidelines, Requirements, and Procedures for the National Watershed Boundary Dataset" interagency guidelines
- Mapping and delineation accuracy and consistency
- Coordination of boundaries and codes that match across state or Subregion boundaries
- Hydrologic unit size, nesting, coding protocol (including format), and completion of required fields in the attribute table
- Compliance of metadata with the most recent FGDC standard

NCGC/USGS will refer review comments from the interagency team to the office that originated the data. After discrepancies are resolved, NCGC/USGS will send a formal certification letter to the state specifying whether the hydrologic unit data are approved provisionally or approved fully and meet the national guidelines. Provisional Certification usually indicates that work such as providing metadata or matching boundaries across state lines still remains. Provisional Certification is not given when obvious corrections need to be made.

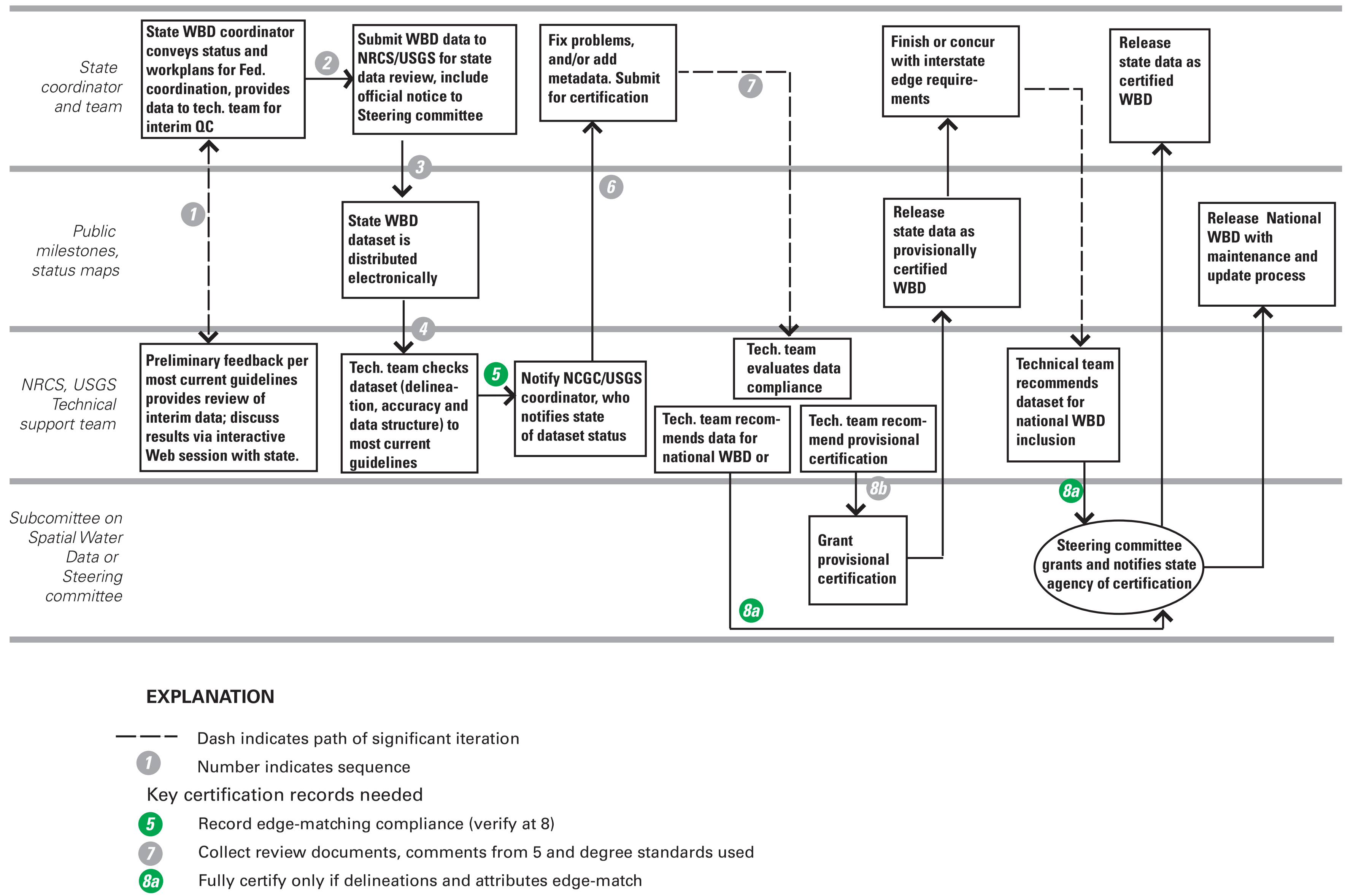


Figure 15. The Watershed Boundary Dataset national certification and review procedure and roles are depicted in the above flowchart.

If the data comply with the “Federal Guidelines, Requirements, and Procedures for the National Watershed Boundary Dataset” and are approved, NCGC/USGS will send a letter to the originating office stating that the WBD meets the national requirements, are fully Certified, and will be added to the national database.

If the data do not conform to the guidelines, the response letter will state the problems with the data, and the national Technical Support Team evaluation and recommendations will continue.

8.2 File Names

The dataset naming convention for certification is 2-letter state postal abbreviation_hu12_monthyear submitted; for example, oh_hu12_0607.

8.3 Map Projection and Horizontal Datum

Data submitted for certification must be in geographic coordinates stored in decimal degrees. The horizontal datum is the North American Datum of 1983 (NAD 83). All projection information must be included in the metadata file. A “read me” file may also accompany the data or instructions included in the state submittal letter; this file may contain other pertinent information that would be useful during QA/QC and standard delineation review.

8.4 Data Delivery Packaging and Compression

Use a packaging structure appropriate for the user’s spatial data format and a compression format appropriate for the user’s operating system. For compression, use ZIP format for Windows operating systems and GZIP format for Unix operating systems. By convention, ZIP format archives use the filename extension .zip, and GZIP format files use the filename extension .gzip. Because procedures vary significantly depending on operating system and the user’s spatial data format, three scenarios are presented for guidance.

Scenario 1: User’s operating system is Unix, and user’s working format is an ESRI Arc/INFO Workstation coverage. The delivery format should be an ESRI Export file. ESRI Export format is a computer-independent file format designed to facilitate the exchange of ESRI Arc/INFO Workstation data. By convention, ESRI Export files have the file name extension “.e00.” For each coverage, use the export command to produce the export file: Arc: EXPORT COVER oh_huc oh_huc.e00 NONE. Use the tar command to add all the .e00 files to a tar archive: tar cvf *.e00 oh.tar. Next, use the gzip utility to compress the tar archive: gzip oh.tar (result is oh.tar.gz).

Scenario 2: User’s operating system is Windows, and user’s working format is an ESRI shapefile. An ESRI shapefile is not a single file, despite the name. Instead an ESRI shapefile is a spatial data format that uses at least three files that share a common base filename but different extensions. For example, an ESRI shapefile named oh_huc is physically implemented as three disk files: oh_huc.shp, oh_huc.dbf, oh_huc.shx. No packaging is necessary for shapefiles. Use a software utility that supports .zip format and add all the shapefile files to a .zip archive.

Scenario 3: User’s operating system is Windows, and user’s working format is an ESRI personal geodatabase. An ESRI personal database stores geospatial information in a single Microsoft (MS) Access database file. By convention, MS Access database files (and by extension ESRI personal geodatabases) have the extension .mdb. The .mdb file functions as a container for geospatial data. For example, an ESRI personal geodatabase named oh_huc is physically implemented as a collection of tables inside a disk file named oh_huc.mdb. No packaging is necessary for personal geodatabase. Use a software utility that supports .zip format and add the .mdb file to a .zip archive.

8.5 Data Transfer Protocol

Post the compressed data to an ftp site as “binary” type. Notify the national contact (refer to section 8) responsible for data certification and archiving. The dataset may also be written to a CD-ROM and mailed to the national contact for certification and archiving. These standards do not cover the distribution of data to users after certification.

9. Metadata

According to an Executive Order 12906 signed by President William J. Clinton on April 11, 1994, all Federal agencies developing geospatial data are required to document newly created data by completing metadata. The most recent FGDC content standards for metadata must be followed. A sample of a completed FGDC-compliant metadata template for hydrologic units is available at *http://www.ncgc.nrcs.usda.gov/products/datasets/watershed/metadata.html*.

10. References

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11. Appendixes

The hydrologic and compliance terms in the following lists are defined with reference to the Watershed Boundary Dataset process. The definitions may not be the only valid ones for these terms. Boldfaced terms within definitions are defined elsewhere in the lists.

11.1 Definitions

11.1.1 Hydrologic Definitions

Basin A subdivision of **Subregion**. A Basin is the 3d-level, 6-digit unit of the **hydrologic unit** hierarchy. Basins were formerly named “accounting units” in USGS terminology.

Classic hydrologic unit A topographically defined area where all the surface drainage converges to a single point.

Composite hydrologic unit A topographically defined area where all the surface drainage converges to a single point, usually along the main stem of a stream between outlets of **classic hydrologic units**. This includes areas or small triangular wedges (**remnant areas**) between adjacent drainage areas that remain after classic hydrologic units are delineated.

Contiguous boundary A **hydrologic unit** boundary shared in whole or in part by an adjacent, different hydrologic unit.

Estuary The region of interaction between streams and near shore ocean waters, where tidal action and streamflow mix freshwater and saltwater.

Frontal hydrologic unit A land and water area where surface flow originates entirely within the **hydrologic unit** and drains to multiple points along a large waterbody such as the ocean or large lake.

Hydrography The scientific description, study, and analysis of the physical conditions, boundaries, measurement of flow, investigation and control of flow, and related characteristics of surface water such as streams, lakes, and oceans.

Hydrologic unit (HU) An identified area of surface drainage within the U.S. system for cataloging drainage areas, which was developed in the mid-1970s under the sponsorship of the Water Resources Council and includes drainage-basin boundaries, codes, and names. The drainage areas are delineated to nest in a multilevel, hierarchical arrangement. The hydrologic unit hierarchical system has four levels and is the theoretical basis for further subdivisions that form the **Watershed Boundary Dataset** 5th and 6th levels. A hydrologic unit can accept surface water directly from upstream drainage areas and indirectly from associated surface areas such as **remnant areas**, **noncontributing areas**, and diversions to form a drainage area with single or multiple outlet points.

Hydrologic unit code (HUC) The numerical identifier of a specific **hydrologic unit** or drainage area consisting of a 2-digit sequence for each specific level within the delineation hierarchy.

Hydrologic unit name A standardized name assigned to a **hydrologic unit** to identify the geographic location of the area. Hydrologic units are typically named after significant or prominent water features in an area; however, in some instances, they may also be named after nonwater features.

Hydrology The science dealing with the properties, distribution, and circulation of water on the surface of the land, in the soil and underlying rocks, and in the atmosphere.

Karst areas Areas of carbonate-rock formations (limestone and dolomite) characterized by sinks, underground streams, and caverns.

Noncontributing area A naturally formed area that does not contribute to downstream accumulation of streamflow under normal flow conditions.

Open-water hydrologic unit An area delineated within an ocean. Land is not a major portion of the **hydrologic unit** but may be included, as in the case of islands.

Region A Region is the 1st-level, 2-digit unit and largest in the **hydrologic unit** hierarchy. The hydrologic unit category name is retained for **Watershed Boundary Dataset**.

Remnant area A topographically defined area that is residual after delineation of **classic hydrologic units**. They include small triangular wedges between adjacent drainage areas. These areas are commonly incorporated into **composite hydrologic units**.

Shoal A natural accumulation of sand, gravel, or other material forming a shallow underwater or exposed embankment.

Sound (a) A relatively narrow sea or stretch of water between two close landmasses and connecting two larger bodies of water. (b) A deeper part of a moving body of water (as bays, estuaries, or straits) through which the main current flows or which affords the best passage through an area otherwise too shallow to navigate.

Standard hydrologic unit An area with drainage flowing to a single outlet point. Examples include **classic**, **composite**, and **remnant hydrologic units**.

Subbasin A subdivision of a **Basin**. A Subbasin is the 4th-level, 8-digit unit of the **hydrologic unit** hierarchy. Subbasins were formerly named “cataloging unit” in USGS terminology. The average size is about 450,000 acres.

Subregion A subdivision of a **Region**. A Subregion is the 2d-level, 4-digit unit of the **hydrologic unit** hierarchy; the hydrologic unit category name is retained for the **Watershed Boundary Dataset**.

Subwatershed A subdivision of a **Watershed**. A Subwatershed is the 6th-level, 12-digit unit and smallest of the **hydrologic unit** hierarchy. Subwatersheds generally range in size from 10,000 to 40,000 acres.

Toe of the shore face A demarcation depth to which seasonal storms, prevailing winds, and resultant waves and currents move shallow sediments to and from the shore. From this geomorphic feature toward the shore, water depth decreases rapidly for a short distance and then slowly for the remaining distance.

True hydrologic unit See **classic hydrologic unit**.

Water hydrologic unit A body of water that can receive flow from adjacent **frontal hydrologic units**, **composite hydrologic units**, and **classic hydrologic units**. Examples include inland lakes and nearshore ocean waters. Generally, these units are not further delineated to the next lower **hydrologic unit** level.

Watershed A subdivision of a **Subbasin**. A Watershed is the 5th-level, 10-digit unit of the **hydrologic unit** hierarchy. Watersheds range in size from 40,000 to 250,000 acres. Also used as a generic term representing a drainage basin or combination of hydrologic units of any size.

11.1.2 Geospatial Data Definitions and Standards

Attribute A defined characteristic of a geographic feature or entity

Contour line A line (as on a map) connecting the points on a land surface that have the same altitude.

Coordinates Pairs of numbers expressing horizontal distances along orthogonal axes; alternatively, triplets of numbers measuring horizontal and vertical distances.

Coordinate System A system where points on the Earth's surface are located with reference to a pair of intersecting lines or grid. For more information, see Dana (1995a) and Snyder (1987).

Compilation The act of composing new or revised materials from existing documents or sources.

Dataset A collection of related data.

Datum A reference surface for a geodetic survey. Refers to a direction, level, or position from which angles, heights, depths, and distances are normally measured. Datum, as applied to a horizontal geodetic survey, is a reference based on the shape of the Earth. For more information, see Dana (1995b).

Delineation. The act of indicating or representing by drawn lines.

Edge matching A digital editing procedure equivalent to joining adjacent features at hardcopy map edges, used to ensure that features crossing political boundaries or adjoining maps connect.

Geographic Information System (GIS) A computer system designed to collect, manage, manipulate, analyze, and display spatially referenced data and associated attributes.

Geospatial Data Information that identifies the geographic location (coordinate system) and characteristics (attributes) of natural or constructed features and boundaries on the Earth. The numeric scale associated with geospatial data refers to the spatial accuracy, the smallest scale of delineation, and the scale of other data that are spatially compatible.

Hypsography The study of the distribution of elevations on the surface of the Earth with reference to a datum, traditionally sea level.

Metadata The description and documentation of the content, quality, condition, and other characteristics of geospatial data.

Polygon A sequence of alternating line segments and angled vertices that form a closed two-dimensional loop, defining the boundary of an area.

Resolution The minimum difference between two independently measured or computed values that can be distinguished by the measurement or analytical method being considered or used.

Topology The spatial relations between geometric entities, including adjacency, containment, and proximity.

Vector data A **coordinate**-based data structure used to represent positional data in spatial units of line, point, and **polygon**.

Vector digitizing The act of tracing a line with a device to capture and store the locations of geographic features by converting their map positions to a series of x-y coordinates.

Watershed Boundary Dataset A National geospatial database of drainage areas consisting of the 1st through 6th hierarchical hydrologic unit levels. The seamless geographic data will be finished by merging the certified versions of watershed data available at 1:24,000 scale across the United States. WBD includes the required **attribute** and **metadata** information. WBD components have been incrementally released through a formal certification process beginning in 1998. The WBD is an ongoing multiagency effort to create hierarchical, and integrated hydrologic units across the Nation. For more information, see *U.S. Department of Agriculture, Natural Resources Conservation Service (2007)*

STANDARDS

Federal Geographic Data Committee (FGDC) The FGDC develops geospatial data standards for implementing the nationwide data publishing effort known as the National Spatial Data Infrastructure (NSDI). For the most recent information, see *http://www.fgdc.gov/standards*.

National Map Accuracy Standards (NMAS) Specifications formerly governing the accuracy of topographic, base, orthophoto, and other maps produced by Federal agencies. For more information, see *U.S. Geological Survey (1999a).*

National Standards for Spatial Data Accuracy (NSSDA) Specifications superseding **NMAS** as the standard for governing the accuracy of topographic, base, orthophoto, and other maps produced by Federal agencies. The **WBD is delineated** and georeferenced to USGS 1:24,000-, 1:25,000-, or 1:63,360- scale **topographic quadrangle** maps that meet the most current NSSDA standard. For more information, see *Federal Geographic Data Committee (1998)*.

11.1.3 Compliance Definitions

Certification Formal acknowledgment that **hydrologic units** have been reviewed and meet the criteria as stated in the "Federal Guidelines, Requirements, and Procedures for the National Watershed Boundary Dataset," 2009, as agreed to by member agencies of the Subcommittee on Spatial Water Data.

Provisionally Certified Acknowledgment that **hydrologic units** for large regional areas or whole states have been reviewed and meet the criteria as stated in "Federal Standards for Delineation of Hydrologic Unit Boundaries; Version 2.0 October 1, 2004," as agreed to by member agencies of the Subcommittee on Spatial Water Data.

Hydrologic unit boundaries and attributes are **edge matched** to the fullest possible extent at that time. States are encouraged to work with neighboring states to resolve boundary issues and resubmit the data to attain final **certification**.

Prior to April 2006 Provisional Certification was known as Certification or Verification.

Full Certification **Hydrologic units** have been reviewed, and meet the National requirement as stated in "Federal Guidelines, Requirements, and Procedures for the National Watershed Boundary Dataset," agreed to by member agencies of the Subcommittee on Spatial Water Data.

11.2 Abbreviations and Acronyms

ACWI Advisory Committee on Water Information
BLM Bureau of Land Management
DEM Digital Elevation Model
DOQ Digital Orthophoto Quadrangle
DOQQ Digital Orthophoto Quarter Quadrangle
DRG Digital Raster Graphic
EDNA Elevation Derivatives for National Applications
ESRI Environmental Systems Research Institute
FGDC Federal Geographic Data Committee
FTP File Transfer Protocol
GIS Geographic Information System
GNIS Geographic Names Information System
HUC Hydrologic unit code
NCGC National Cartography and Geospatial Center
NED National Elevation Dataset
NHD National Hydrography Dataset
NMAS National Map Accuracy Standards
NOAA National Oceanic and Atmospheric Administration
NRCS Natural Resources Conservation Service (U.S. Department of Agriculture)
NSSDA National Standards for Spatial Data Accuracy
QA/QC Quality assurance/quality control
SSWD Subcommittee on Spatial Water Data
STDS Spatial Data Transfer Standard
USDA U.S. Department of Agriculture
USDA-FS U.S. Department of Agriculture, Forest Service
USEPA U.S. Environmental Protection Agency
USGS U.S. Geological Survey
WBD Watershed Boundary Dataset

11.3 Data Type Cross Walk for Data Storage of ESRI Products

SQL standard	Arc GIS	ESRI INFO (coverage)	ESRI ArcView (shape file)	ESRI ArcSDE personal (access)	ESRI ArcSDE file based	ESRI ArcSDE enterprise			
						Oracle	MS SQL (server)	DB2	Informix
Exact numeric	Short integer	I	Number, boolean	Integer	Short integer	Number (4)	Smallint (2)	Smallint (2)	Smallint (2)
Exact numeric	Long integer	B, I	Number	Long integer	Long integer	Number (38)	Int (4)	Integer (4)	Integer (4)
Approximate numeric	Float	F, N	Number	Single	Float	Number (38,8)	Real	Decimal (31,8)	Decimal (32)
Approximate numeric	Double	F, I, N	Number	Double	Double	Number (38,8)	Double	Decimal (31,8)	Decimal (32)
Character string	Text	C	String	Text	Text	Varchar	Varchar (n)	Varchar	Varchar (n)
Date time	Date	D	Date	Date/time	Date	Date	Datetime	Timestamp	Datetime
Bit string	Blob	–	–	OLE object	Blob	Blob	Image	Blob	Blob
Exact numeric	Guid	–	–	Number	Guid	Char (38)	Unique identifier (16)	Character (38)	Char (8)

11.4 Data History Letter for Certification Submittal

To help the review and certification process, consider including these categories of information about the history and development of your dataset in the transmittal letter. Contact the WBD Technical Support Team for questions or assistance.

Date:

Subject: Submittal of the Watershed Boundary Dataset for

To: Director
USDA Natural Resources Conservation Service
National Cartography and Geospatial Center (NCGC)
501 West Felix Street, Building 23
P.O. Box 6567
Fort Worth, Tx 76115-6567

From: [Name]
[Title]
[Agency and address]

I am pleased to inform you that [state] has completed its Watershed Boundary Dataset (WBD) in accordance with the [standards document used]. This dataset, along with its metadata, has been posted at the following ftp site for retrieval:

Describe the timeframe, major cooperators and agencies involved in development, and formal agreements in place. For example,

“The dataset was created by the coordinated effort between multiple agencies. NRCS provided the oversight and did a major portion of the delineations and attribution in [specify] part of the state. Over [timeframe] [other agencies and locations] in [state] as well as [Technical Support Team agent] have, under an agreement between [agencies] and [state], completed the remainder of the state’s boundaries and attributes, and appended the dataset together.”

Describe general production methods and reference or source materials used. For example,

“This dataset was produced digitally on screen in Arcview or Arcmap referencing the Digital Raster Graphics for the method of delineation. As the dataset evolved, and especially in the northeastern portion of the state, the National Hydrography Dataset, along with the Digital Ortho Quarter Quads (DOQQs), provided very useful as a reference for determining breaks in the flood plains. DOQQs were cited frequently along the [specify major features] as well. Every effort has been made to create new boundaries and revise the historical linework to meet the National Standards for Spatial Data Accuracy (NSSDA) for 1:24,000 meter scale.”

Describe edge-matching activities and outcomes. Include desired scenario involving states without current WBD. For example,

“Edge-matching with [list surrounding states] has been completed. [List states without existing WBD delineation]. [Explain desired scenario involving states without current delineation]. It was agreed upon with adjacent states that [your state] would delineate to the [special areas] and the bordering states would include the remainder of the [state] Subbasin boundaries within those states WBDs.”

Itemize other unique areas and circumstances.

Final QA/QC was performed by [Technical Support Team agent] under this latest agreement, as well as [State *inter-agency hydrologic unit group* or lead agency].

If there should be any technical questions during the review process, or edits to be made, please feel free to contact me (information listed below). Or you may contact [Technical Support Team agent] by [phone] or [email]

Sincerely,
[Name]
[Agency and address]
cc: Please fill in list of major people to notify

USGS

USGS and USDA,NRCS—**Federal Guidelines, Requirements, and Procedures for the National Watershed Boundary Dataset**—Techniques and Methods 11–A3