High Resolution NHD*Plus Alpha*:
User Guide
(Data Model HRNHDPlus-Alpha)

NHD*Plus*

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The Alaska Department of Environmental Conservation
and
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This document describes the high resolution NHDPlus produced by the U.S. EPA for Alaska DEC for use in water quality assessment and reporting. The Alaska data was produced with the same software (HRNHDPlusBuildRefresh) that is being used to produce high resolution NHDPlus in the lower 48 states by the USGS. The Alaska data is distributed in the data model produced by the HRNHDPlus Build/Refresh tools and is called HRNHDPlus Alpha throughout this manual.

USGS distributes high resolution NHDPlus in a slightly different data model which is referred to as NHDPlusHR Beta.

This document is tailored to the Alaska high resolution NHDPlus data.

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Introduction to NHDPlus High Resolution in Alaska

High Resolution NHDPlus (HRNHDPlus Alpha) is an integrated suite of application-ready geospatial data products, incorporating many of the best features of the National Hydrography Dataset (NHD) and the 3D Elevation Product (3DEP). HRNHDPlus Alpha, based on the high resolution NHD (1:63,360-scale or better), includes the stream network, feature names, and "value added attributes" (VAA). HRNHDPlus Alpha also includes elevation-derived catchments and other raster layers.

High resolution NHD and the 5-meter 3DEP are regularly updated by USGS and the active stewardship in Alaska. The snapshots of NHD and 3DEP that are used to construct HRNHDPlus Alpha are included with the HRNHDPlus Alpha data. The NHD and 3DEP snapshots included with HRNHDPlus Alpha may not be updated by users with the intent of sending updates back to these national databases. Updates should be directed to the respective national stewardship programs sponsored by USGS and Alaska.

The HRNHDPlus Alpha VAAs provide attributes which greatly improve the capabilities for upstream and downstream navigation, analysis, and modeling. Examples of these enhanced capabilities include using structured queries for rapid retrieval of all NHDFlowline features and catchments upstream of a selected NHDFlowline feature; subsetting the selection of a stream level path (sorted in hydrologic order) for stream profile mapping, analysis, and plotting; and calculating, using hydrologic sequence routing attributes, cumulative catchment attributes. VAA-based routing techniques were used to produce HRNHDPlus Alpha attributes such as cumulative drainage areas.

The HRNHDPlus Alpha elevation-derived catchments are produced using a drainage enforcement technique first applied in New England, named "The New-England Method." This technique involves enforcing the high resolution NHD drainage network onto the 3DEP elevation data through trenching. In most high resolution NHDPlus production, the WBD hydrologic divides are enforced via walls in the elevation. However, in Alaska, it was felt that the 5 meter IFSAR elevation was more accurate than the WBD and therefore no walling was done to the elevation data. The resulting modified digital elevation model (DEM) is used to produce catchments and other hydrologic derivatives that closely agree with NHD and 3DEP.

This document is intended to provide users with an understanding of the format and content of the Alaska HRNHDPlus Alpha and some pointers on how to use the data.

Information about the production process that built this data can be found in the high resolution NHDPlus documentation at nhd.usgs.gov.

HRNHDPlus Alpha Data Structure

The HRNHDPlus Alpha vector feature classes and attribute tables are distributed in file geodatabases (fgdb). Each fgdb contains the data for a single geographic area of Alaska which is composed of one or more HUC12s. Each geographic area is referred to as a Vector Processing Unit or VPU and is named AKnn where nn is a sequential number 01, 02, etc. that was assigned during the production process. The HRNHDPlus Alpha raster data is distributed as a set of .tif files. Each set of .tifs contains the data for one VPU.

The AKnn footprints can be found in the HRNHDPlusGlobalData.gdb in the BoundaryUnit feature class.

Each VPU is distributed as a file geodatabase called HRNHDPlus<vpuid>.gdb and a folder called HRNHDPlusRasters<vpuid> containing the raster .tifs. Where <vpuid> is "AKnn".

> HRNHDPlus<vpuid>.gdb
>> Hydrography feature dataset[1]
>>> NHDFlowline
>>> NHDWaterbody
>>> NHDPoint
>>> NHDLine
>>> NHDArea
>>> NHDHydroAreaEventFC
>>> NHDHydroLineEventFC
>>> NHDHydroPointEventFC
>>
>> NHDPlus feature dataset
>>> NHDPlusBurnAddLine (line feature class)
>>> NHDPlusBurnAddWaterbody (polygon feature class)
>>> NHDPlusBurnLineEvent (line feature class)
>>> NHDPlusBurnWaterbody (polygon feature class)
>>> NHDPlusCatchment (polygon feature class)
>>> NHDPlusLandSea (polygon feature class)
>>> NHDPlusSink (point feature class)
>>> NHDPlusWall (line feature class)
>>
>> WBD feature dataset[1]
>>> NonContributingDrainareArea
>>> NWISBoundary
>>> NWISDrainageArea
>>> WBDHU10
>>> WBDHU12

WBDHU14
WBDHU16
WBDHU2
WBDHU4
WBDHU6
WBDHU8
WBDLine
ExternalCrosswalk[1]
NHDFcode[1]
NHDFeatureToMetadata[1]
NHDFlow[1]
NHDFlowlineVAA[1]
NHDMetadata[1]
NHDPlusDivFracMP
NHDPlusEROMMA (not populated)
NHDPlusEROMQAMA (not populated)
NHDPlusEROMQARPT (not populated)
NHDPlusFlow
NHDPlusFlowlineVAA
NHDPlusIncrLat (not populated)
NHDPlusIncrPrecipMA (not populated)
NHDPlusIncrPrecipMM01 (not populated)
NHDPlusIncrPrecipMM02 (not populated)
NHDPlusIncrPrecipMM03 (not populated)
NHDPlusIncrPrecipMM04 (not populated)
NHDPlusIncrPrecipMM05 (not populated)
NHDPlusIncrPrecipMM06 (not populated)
NHDPlusIncrPrecipMM07 (not populated)
NHDPlusIncrPrecipMM08 (not populated)
NHDPlusIncrPrecipMM09 (not populated)
NHDPlusIncrPrecipMM10 (not populated)
NHDPlusIncrPrecipMM11 (not populated)
NHDPlusIncrPrecipMM12 (not populated)
NHDPlusIncrROMA (not populated)
NHDPlusIncrTempMA (not populated)
NHDPlusIncrTempMM01 (not populated)
NHDPlusIncrTempMM02 (not populated)
NHDPlusIncrTempMM03 (not populated)
NHDPlusIncrTempMM04 (not populated)
NHDPlusIncrTempMM05 (not populated)
NHDPlusIncrTempMM06 (not populated)
NHDPlusIncrTempMM07 (not populated)

NHDPlusIncrTempMM08 (not populated)
NHDPlusIncrTempMM09 (not populated)
NHDPlusIncrTempMM10 (not populated)
NHDPlusIncrTempMM11 (not populated)
NHDPlusIncrTempMM12 (not populated)
NHDPlusMegaDiv
NHDPlusNHDPlusIDGridCode
NHDProcessingParameters[1]
NHDReachCodeMaintenance [1]
NHDReachCrossReference [1]
NHDSourceCitation [1]
NHDStatus [1]
NHDVerticalRelationship [1]

The tables denoted as "not populated" are the NHDPlus stream flow estimates (EROM) and the inputs to EROM which are tables beginning with "NHDPlusIncr". Flow estimation was not built for the Alaska because the necessary input data was not available.

\HRNHDPlusRasters<vpuid>
elev_source.gdb [2]
cat.tif
catseed.tif
elev_cm.tif [2]
fac.tif
fdr.tif
fdroverland.tif
filldepth.tif
hydrodem.tif
shdrelief.jp2
swnet.tif

[1]For complete NHD and WBD documentation, see http://nhd.usgs.gov/
[2]For complete 3DEP documentation, see http://nationalmap.gov/3DEP/

Projection Information

All .tif datasets for Alaska are stored in:
          Projection   ALBERS
          Spheroid   GRS80
          Units   METERS
          Zunits   NO
          Xshift   0.0
          Yshift   0.0
          Parameters
            55 0 0.0 /* 1st standard parallel
            65 0 0.0 /* 2nd standard parallel
          -154 0 0.0 /* central meridian
            50 0 0.0 /* latitude of projection's origin
          0.0 /* false easting (meters)
          0.0 /* false northing (meters)

A Guide for Installing HRNHDPlus Alpha Data

HRNHDPlus Alpha data is distributed in compressed files (compression software) with a ".7z" extension.

After downloading the HRNHDPlus Alpha data, install the data as follows:

1. Make a folder for the HRNHDPlus Alpha data (e.g. \HRNHDPlusData). For the best performance, install the data on a local drive.

2. The compressed data files are named:

   For vector layers and attributes:
         HRNHDPlus<VPUID>_GDB_Alpha.zip

   For raster layers:
         HRNHDPlus<VPUID>_Raster_Alpha.7z

   Each HRNHDPlus Alpha "7z" file should be uncompressed into the folder created in step 1. **When using the un-zip utility be certain to automatically preserve/create the folder structure that is included in the ".7z" files. DO NOT unzip into folders that are named from the 7z file names.**

3. When completely installed, the uncompressed data should look like this:

   \HRNHDPlusData
         HRNHDPlus<vpuid>.gdb (1 gdb per VPU)

         \HRNHDPlusRasters<vpuid> (1 folder per VPU)

         \HRNHDPlusGlobalData (national data)

HRNHDPlus Alpha Global Data

This national data is distributed as a file geodatabase called HRNHDPlusGlobalData.gdb. The .gdb contains the footprints of the VPUs.

HRNHDPlusGlobalData.gdb\BoundaryUnit (feature class)

Description: Contains a polygon boundary for each geographic unit used to build HRNHDPlus Alpha. The unit types are VPU and RPU. The boundaries are constructed from WBD HUC4 polygons available when the production process was performed.

Field Name	Description	Format
DrainageID	Drainage Area identifier	Char(2)
DrainSeqNo	Drainage Sequence Number	Integer
VPUID	Vector Processing Unit unique identifier	Char(8)
VPUName	VPU Name	Char(100)
VPUSeqNo	VPU Sequence Number	Integer
UnitType	Boundary Unit Type - "VPU", "RPU"	Char(3)
RPUID	Raster Processing Unit (same as VPU)	Char(9)
AreaSqKM	Area in square kilometers of the VPU or RPU	Double

HRNHDPlus Alpha VPU Feature Classes

The vector feature classes and attribute tables for each VPU are distributed as file geodatabases named HRNHDPlus<vpuid>.gdb.

HRNHDPlus<vpuid>.gdb\Hydrography (feature dataset)

Description: The Hydrography feature dataset contains the NHD feature classes. Documentation for these feature classes can be found at nhd.usgs.gov.

HRNHDPlus<vpuid>.gdb\WBD (feature dataset)

Description: The WBD feature dataset contains the WBD feature classes. Documentation for these feature classes can be found at nhd.usgs.gov.

HRNHDPlus<vpuid>.gdb\NHDPlus (feature dataset)

Description: The NHDPlus feature dataset contains the NHDPlus feature classes which are described below.

HRNHDPlus<vpuid>.gdb\NHDPlus\NHDPlusCatchment (polygon feature class)

Description: Contains a catchment polygon for either an NHDFlowline feature or an NHDPlusSink feature.

Note: Some polygons may be multipart polygons.

Field Name	Description	Format
NHDPlusID	NHDPlusID of a Catchment which is equal to the NHDPlusID of an NHDFlowline feature or the NHDPlusID of a Sink feature	Double
GridCode	See NHDPlusNHDPlusIDGridCode	Integer
AreaSqKm	Catchment area in square kilometers	Double
SourceFC	Source Feature Class ("NHDFlowline" or "Sink")	Char(20)

HRNHDPlus<vpuid>.gdb\NHDPlus\NHDPlusBurnLineEvent (line feature class)

Description: Lines representing the parts of NHDFlowline features used for hydro-enforcement.

Field Name	Description	Format
NHDPlusID	Unique identifier of an NHDFlowline feature	Double
GridCode	GridCode assigned to the NHDFlowline feature	Integer
ReachCode	See NHDFlowline	Char(14)
FromMeas	Downstream BurnLineEvent Measure (m-value)	Double
ToMeas	Upstream BurnLineEvent Measure (m-value)	Double
BurnLenKm	Length of BurnLineEvent feature	Double
RPUID	Raster Processing Unit ID (same as VPU)	Char(8)
StatusFlag	Reserved for use during HRNHDPlus Alpha Build/Refresh Tools Processing	Char(1)
Catchment	"Y" – line will receive a catchment, "N" - will not receive a catchment	Char(1)
Burn	"Y" – line will be used for hydro-enforcement, "N" - will not be used for hydro-enforcement	Char(1)
VPUID	Vector Processing Unit ID	Char(8)

HRNHDPlus<vpuid>.gdb\NHDPlus\NHDPlusBurnAddLine (Line feature class)

Description: Additional linear features surrounding the VPU that are used for hydro-enforcement.

Field Name	Description	Format
NHDPlusID	Unique identifier of the NHDWaterbody feature or NHDArea feature	Double
GridCode	Unique gridcode assigned to feature	Integer
PurpCode	Purpose Code, See Appendix A	Char(2)
PurpDesc	Purpose Description, See Appendix A	Char(254)
StreamLeve	Stream Level assigned to feature	Integer
HydroSeq	Hydrologic Sequence number assigned to feature	Double
Catchment	"Y" – line will receive a catchment, "N" - will not receive a catchment	
Burn	"Y" – line will be used for hydro-enforcement, "N" - will not be used for hydro-enforcement	Char(1)
VPUID	Vector Processing Unit ID	Char(8)

HRNHDPlus<vpuid>.gdb\NHDPlus\NHDPlusBurnWaterbody (polygon feature class)

Description: NHDWaterbody and NHDArea features used for hydro-enforcement.

Field Name	Description	Format
NHDPlusID	Unique identifier of the NHDWaterbody feature or NHDArea feature	Double
SourceFC	NHD Feature Class – "NHDWaterbody", "NHDArea"	Char(20)
OnOffNet	On/Off network flag – 1 = On network, 0 = Off network	Num(1)
PurpCode	Purpose Code, See Appendix A	Char(2)
PurpDesc	Purpose Description, See Appendix A	Char(254)
Burn	"Y" – line will be used for hydro-enforcement, "N" - will not be used for hydro-enforcement	Char(1)
VPUID	Vector Processing Unit ID	Char(8)

HRNHDPlus<vpuid>.gdb\NHDPlus\NHDPlusBurnAddWaterbody (polygon feature class)

Description: Additional waterbody features surrounding the VPU used for hydro-enforcement.

Field Name	Description	Format
NHDPlusID	Unique identifier of the NHDWaterbody feature or NHDArea feature	Double
OnOffNet	On/Off network flag – 1 = On network, 0 = Off network	Num(1)
PurpCode	Purpose Code, See Appendix A	Char(2)
PurpDesc	Purpose Description, See Appendix A	Char(254)
Fcode	NHD Feature Code	
Burn	"Y" – line will be used for hydro-enforcement, "N" - will not be used for hydro-enforcement	Char(1)
VPUID	Vector Processing Unit ID	Char(8)

HRNHDPlus<vpuid>.gdb\NHDPlus\NHDPlusSink (point feature class)

Description: Point locations of sinks used for hydro-enforcement.

Field Name	Description	Format
NHDPlusID	Unique identifier for Sink point	Double
GridCode	GridCode assigned to the Sink point	Integer
PurpCode	Purpose of Sink, See Appendix A	Char(2)
PurpDesc	Description of Sink, See Appendix A	Char(254)
FeatureID	The NHDPlusID of a feature in another feature class.	Double
SourceFC	The feature class of the feature referenced in FeatureID. Values are "NHDFlowline", "BurnWaterbody", "WBD_Subwatershed", "BurnAddWaterbody", and "Null".	Char(20)
RPUID	Raster Processing Unit Identifier (same as VPUID)	Char(8)
StatusFlag	Reserved for use during HRNHDPlus Alpha Build/Refresh Tools Processing	Char(1)
Catchment	"Y" – line will receive a catchment, "N" or Null - will not receive a catchment	Char(1)
Burn	"Y" – line will be used for hydro-enforcement, "N" or Null - will not be used for hydro-enforcement	Char(1)
VPUID	Vector Processing Unit Identifier	Char(8)

HRNHDPlus<vpuid>.gdb\NHDPlus\NHDPlusWall (line feature class)

Description: Lines used as walls in hydro-enforcement. Note that in HRNHDPlus Alpha, none of the wall features were used during hydro-enforcement.

Field Name	Description	Format
NHDPlusID	Unique identifier for wall line	Double
WallSource	"WBDLine"	Char(8)
Burn	"Y" – line will be used for hydro-enforcement, "N" or Null - will not be used for hydro-enforcement	Char(1)
VPUID	Vector Processing Unit Identifier	Char(8)

HRNHDPlus<vpuid>.gdb\NHDPlus\NHDPlusLandSea (polygon feature class)

Description: Polygons used for hydro-enforcement along the NHD coastline.

Field Name	Description	Format
NHDPlusID	Unique identifier for land/sea polygon	Double
Land	A numeric code to identify land/sea/estuary areas. 1 = Land, -2 = Sea, -1 = Estuary	Short Integer
VPUID	Vector Processing Unit Identifier	Char(8)

HRNHDPlus Alpha VPU Tables

In addition to the 3 feature datasets holding the spatial data, the HRNHDPlus gdb contains tables. Ones that begin with NHD are standard NHD tables whose documentation can be found at nhd.usgs.gov. The tables that begin with NHDPlus are generated by the NHDPlus production process and are documented below.

HRNHDPlus<vpuid>.gdb\NHDPlusDivFracMP (table)

Description: Contains specifications about the fraction of a cumulative attribute to be routed through each path in a divergence. The NHDPlusIDs in this table represent NHDFlowline surface water features that, based on the NHDPlusFlow table, form a network divergence (i.e. a flow split). All the paths in a given divergence are identified in this table by a unique NodeNumber.

All divergences are represented in this table. If DivFracMP values are specified, they are used in the divergence routing method of all NHDPlus accumulated attributes, such as drainage area. Divergences where no information is known about the fractional split have DivFracMP.DivFrac = -9998 for all paths in the divergence. In this case, the Divergence Routing method uses the PlusFlowlineVAA.Divergence field and routes a fraction of 1 to the main path (i.e. Divergence = 1) and a fraction of 0 to all other paths (i.e. Divergence = 2). The impact of using DivFracMP in the Divergence Routing method is discussed in section "Understanding and Using HRNHDPlus".

When not set to -9998, the sum of the DivFrac values for all paths in a divergence (i.e. all records with the same NodeNumber) must equal 1.

Field Name	Description	Format
NodeNumber	See PlusFlowlineVAA.FromNode	Double
NHDPlusID	NHDPlusID of an NHDFlowline feature which is a path in a divergence	Double
DivFrac	Fraction used for routing cumulative attributes down the flowlines paths in a divergence. Values between 0 and 1	Double
StatusFlag	Reserved for use during HRNHDPlus Alpha Build/Refresh Processing	Char(1)

HRNHDPlus<vpuid>.gdb\NHDPlusMegaDiv (table)

Description: Table containing the NHDPlusFlow records for divergences that have more than two outflow paths.

Field Name	Description	Format
FromNHDPID	NHDPlus identifier of the upstream NHDFlowline feature	Double
ToNHDPID	NHDPlus identifier of the downstream NHDFlowline feature	Double

HRNHDPlus<vpuid>.gdb\NHDPlusFlowlineVAA (table)

Description: Value Added Attributes (VAAs) for each NHDFlowline feature that appears in the PlusFlow table (i.e. every NHDFlowline with NHDFlowline.FlowDir = "With Digitized"). The HRNHDPlus Alpha Build/Refresh process populates the PlusFlowlineVAA table. The PlusFlowlineVAA table differs from the NHDFlowlineVAA table. NHDFlowlineVAA is an official table in the NHD schema, contains any VAA values that are stored in the NHD central database and is not populated by the HRNHDPlus Alpha Build/Refresh process.

Additional documentation on VAAs can be found in the section titled "HRNHDPlus Alpha Build/Refresh Process Description" under Steps C, F, Q, and R.

Field Name	Description	Format
NHDPlusID	Unique identifier of an NHDFlowline feature	Double
FDate	See NHDFlowline	Date
StreamLeve	Stream level	Integer
StreamOrde	Modified Strahler Stream Order[1]	Integer
StreamCalc	Stream Calculator	Integer
FromNode	Unique identifier for the point at the top of the NHDFlowline feature	Double
ToNode	Unique identifier for the point at the end of the NHDFlowline feature	Double
HydroSeq	Hydrologic sequence number; places flowlines in hydrologic order; processing NHDFlowline features in ascending order, encounters the features from downstream to upstream; processing the NHDFlowline features in descending order, encounters the features from upstream to downstream	Double
LevelPathI	Level Path Identifier - Hydrologic sequence number of most downstream NHDFlowline feature in the level path	Double

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[1] http://en.wikipedia.org/wiki/Strahler_number

PathLength	Distance to the terminal NHDFlowline feature downstream along the main path	Double
TerminalPat	Terminal Path Identifier - Hydrologic sequence number of terminal NHDFlowline feature	Double
ArbolateSu	Arbolate Sum - Kilometers of stream upstream of the bottom of the NHDFlowline feature	Double
Divergence	0 – feature is not part of a divergence 1 – feature is the main path of a divergence 2 – feature is a minor path of a divergence	Integer
StartFlag	0 – feature is not a headwater flowline 1 – feature is a headwater flowline	Integer
TerminalFl	0 – not a terminal NHDflowline feature 1 – a terminal NHDFlowline feature	Integer
DnLevel	Streamlevel of main stem downstream NHDflowline feature	Integer
ThinnerCod	Not valued; Reserved for future use	
UpLevelPat	Upstream mainstem level path identifier	Double
UpHydroSeq	Upstream mainstem hydrologic sequence number	Double
DnLevelPat	Downstream mainstem level path identifier	Double
DnMinorHyd	Downstream minor hydrologic sequence number	Double
DnDrainCou	Count of NHDFlowline features immediately downstream	Integer
DnHydroSeq	Downstream mainstem hydrologic sequence number	Double
FromMeas	ReachCode route measure (m-value) at bottom of NHDFlowline feature	Double
ToMeas	ReachCode route measure (m-value) at top of NHDFlowline feature	Double
RtnDiv	Returning Divergence Flag; 0 = no upstream divergences return at the top of this NHDFlowline feature 1 = one or more upstream divergences returned to the network at the top of this NHDFlowline feature	Double
VPUIn	Are there VPU inflows? 0(no) or 1(yes)	Integer
VPUOut	Are there VPU Outflows? 0(no) or 1(yes)	Integer
AreaSqKm	Area of Catchment (km^2)	Double
TotDASqKm	Total upstream drainage area (km^2)	Double
DivDASqKm	Divergence-routed drainage area (km^2)	Double
MaxElevRaw	Maximum raw elevation	Double
MinElevRaw	Minimum raw elevation	Double
MaxElevSmo	Maximum smoothed elevation	Double
MinElevSmo	Minimum smoothed elevation	Double
Slope	Flowline slope (cm/cm)	Double
SlopeLenKm	Length used as denominator for slope computation	Double

ElevFixed	Flag indicating that the downstream elevation is fixed (i.e. not smoothed)	Char
HWType	"H" - real headwater, "A" - artificial headwater (i.e. all inflows have Gapdist > 43m	Char
HWNodeSqKm	If headwater flowline, the area that drains to top of the flowline	Double
StatusFlag	Reserved for use during NHDPlus Build/Refresh Process	Char
VPUID	Vector Processing Identifier	Char

HRNHDPlus<vpuid>.gdb\NHDPlusFlow (table)

Description: A table that describes flowing and non-flowing connections between NHDFlowline features. The table contains entries for: (1) pairs of NHDFlowline features that exchange water, (2) headwater NHDFlowline features, (3) terminal NHDFlowline features, (4) surface water NHDFlowline features that connect to coastline NHDFlowline features, and (5) coastline NHDFlowline features that connect to each other.

Note: Native NHD contains a flow table called NHDFlow. NHDFlow contains only geometric connections between NHDFlowline features. NHDPlusFlow, on the other hand, may include non-geometric and geometric connections. Non-geometric connections are used to represent situations such as return flows along an international border and underground connections in karst topography.

Field Name	Description	Format
FromNHDPlusID	Unique identifier for the upstream NHDFlowline feature	Double
ToNHDPlusID	Unique identifier for the downstream NHDFlowline feature	Double
NodeNumber	Node number at the bottom of FromNHDPlusID and the top of ToNHDPlusID	Double
DeltaLevel	Not populated	Integer
Direction	714 – coastal connection (FromNHDPlusID may be a coastline and ToNHDPlusID is always a coastline) 709 – flowing connection 712 – network start (ToNHDPlusID is a headwater) 713 – network end (FromNHDPlusID is a network end)	Integer
GapDistKm	Distance between the downstream end of FromNHDPlusID and the upstream end of ToNHDPlusID	Double
HasGeo	"Y"es FromNHDPlusID touches ToNHDPlusID, "N"o, there is a geometry gap between FromNHDPlusID and ToNHDPlusID	Char(1)
FromVPUID	VPU that holds the FromNHDPlusID flowline	Char(8)
ToVPUID	VPU that holds the ToNHDPlusID flowline	Char(8)
FromPermID	NHD Permanent Identifier for the FromNHDPlusID flowline	Char(40)
ToPermID	NHD Permanent Identifier for the ToNHDPlusID flowline	Char(40)

HRNHDPlus<vpuid>.gdb\NHDPlusNHDPlusIDGridCode (tables)

Description: Crosswalk table between NHDPlusIDs and gridcodes assigned during the raster processing.

Field Name	Description	Format
NHDPlusID	Identifier of an NHDPlusBurnLineEvent or NHDPlusSink Feature	Double
SourceFC	Feature class of the NHDPlusID; 'NHDPlusBurnLineEvent' or "NHDPlusSink"	Char(20)
GridCode	Integer gridcode unique within a VPU	Integer
VPUID	Identifier of VPU	Char(8)

HRNHDPlus Alpha VPU Raster Layers

\HRNHDPlusRasters<vpuid>\cat.tif

Description: Raster catchments. Each catchment has a unique GridCode value with a one-to-one match to NHDPlusID.

Field Name	Description	Format
Value	GridCode of each catchment.	Integer
Count	Number of cells with GridCode value	Integer
NHDPlusID	Identifier of an NHDPlusBurnLineEvent or NHDPlusSink Feature	Double

\HRNHDPlusRasters<vpuid>\catseed.tif

Description: Seed raster used to produce the HRNHDPlus Alpha catchments using the fdr.tif raster with the ArcGIS Watershed tool.

Field Name	Description	Format
Value	GridCode of each catchment seed	Integer
Count	Number of cells with GridCode value	Integer

\HRNHDPlusRasters<vpuid>\elev_cm.tif

Description: Elevation raster projected to raster coordinate system. Elevation values are represented as integer centimeters.

Field Name	Description	Format
Value	Elevation value NAVD88, in centimeters	Integer
Count	Number of cells with elevation value	Integer

\HRNHDPlusRasters<vpuid>\fac.tif

Description: Flow accumulation grid which contains the number of cells within the RPU draining to each cell within the RPU based on the HydroDEM. (Attribute table will only be built if this raster can be stored in integer format (max value < 2.1e9) -- see Esri documentation of Flow Accumulation too.)

Field Name	Description	Format
Value	Number of cells that drain to each cell.	Integer
Count	Number of cells with each Value	Integer

\HRNHDPlusRasters<vpuid>\fdr.tif

Description: Integer flow direction grid which contains the codes that show the direction water would flow from each grid cell within the RPU based on the HydroDEM. The raster is saved as 8-bit unsigned.

Field Name	Description	Format
Value	The value for the grid cell. Can be assigned one of eight possible values: 　0 _ Flow ends (sink) 　1 – Flow is to the East 　2 – Flow is to the Southeast 　4 – Flow is to the South 　8 – Flow is to the Southwest 　16 – Flow is to the West 　32 – Flow is to the Northwest 　64 – Flow is to the North 128 – Flow is to the Northeast	Integer
Count	Number of cells with each Value	Integer

\HRNHDPlusRasters<vpuid>\fdroverland.tif

Description: Overland flow direction raster. This raster is the same as fdr.tif, with cells coincident with flow network or water bodies and flow network (swnet.tif data cells) are set to NoData. The raster is saved as 8-bit unsigned.

Field Name	Description	Format

Value	The value for the grid cell. Can be assigned one of eight possible values:
	  0 _ Flow ends (sink)
	  1 – Flow is to the East
	  2 – Flow is to the Southeast
	  4 – Flow is to the South
	  8 – Flow is to the Southwest
	  16 – Flow is to the West
	  32 – Flow is to the Northwest
	  64 – Flow is to the North
	  128 – Flow is to the Northeast
		Integer

Count	Number of cells with each Value	Integer

\HRNHDPlusRasters<vpuid>\filldepth.tif

Description: Difference raster between hydrodem.tif and the intermediate grid (not included in the final product) that was filled to create it.. This raster is useful for examining the results of hydroconditioning process. The "burned and walled" raster before filling can be re-created by subtracting this grid from hydrodem.tif. The units of this raster are in cm (although some values are very large due to burn and wall values used in the processing).

Field Name	Description	Format
Value	Fill depth value (in cm)	Integer

Count	Number of cells with each Value	Integer

\HRNHDPlusRasters<vpuid>\hydrodem.tif

Description: An integer grid of the hydro-conditioned digital elevation model, with all aspects of the NHDPlus burn components integrated and filled. This grid is used to generate the flow direction grid from which the flow accumulation and catchment grids are generated. The elevations are in centimeters.

Field Name	Description	Format
Value	Elevation value in centimeters	Integer
Count	Number of cells with Value	Integer

\HRNHDPlusRasters<vpuid>\shdrelief.jp2

Description:
Shaded relief raster built from elev_cm.tif. Values are scaled from 0 to 255. For more details, see the Esri documentation for the Hill Shade tool. The raster is saved as 8-bit unsigned.

Field Name	Description	Format
Value	Shaded relief brightness value	Integer
Count	Number of cells with shaded relief Value	Integer

\HRNHDPlusRasters<vpuid>\swnet.tif

Description:
Raster flow network. All cells besides cells on the flow network or on waterbodies are assigned a value of NoData. The raster is saved as 8-bit unsigned.

Field Name	Description	Format

Value	Can be assigned one of two possible values:
	   1 – Network flow cell
	   2 – Waterbody cell
		Integer

Count	Number of cells with Value	Integer

Tips for Using HRNHDPlus Alpha

HRNHDPlus Alpha Unique Feature Identifiers

The unique identifier for all HRNHDPlus Alpha spatial objects is the NHDPlusID. It is a 14-digit number stored in a field defined as Double. **Caution:** Do not export HRNHDPlus Alpha tables to .dbf or feature classes to shapefile. ArcGIS does not translate all the significant digits of the NHDPlusID to the target format. Low order digits are lost, along with the ability to link HRNHDPlus Alpha components to each other.

The HRNHDPlus Alpha network includes complex hydrography (network components), including HRNHDPlus Alpha and Divergences

The HRNHDPlus Alpha network includes complex hydrography (network components), including convergent, divergent and complex flow paths (Figure 3). A convergent junction is the simplest type of junction for downstream routing and accumulating attributes, such as drainage area. Divergent and other types of complex junctions, however, complicate computing cumulative values. These issues and how the cumulative values are computed in HRNHDPlus Alpha are described below.
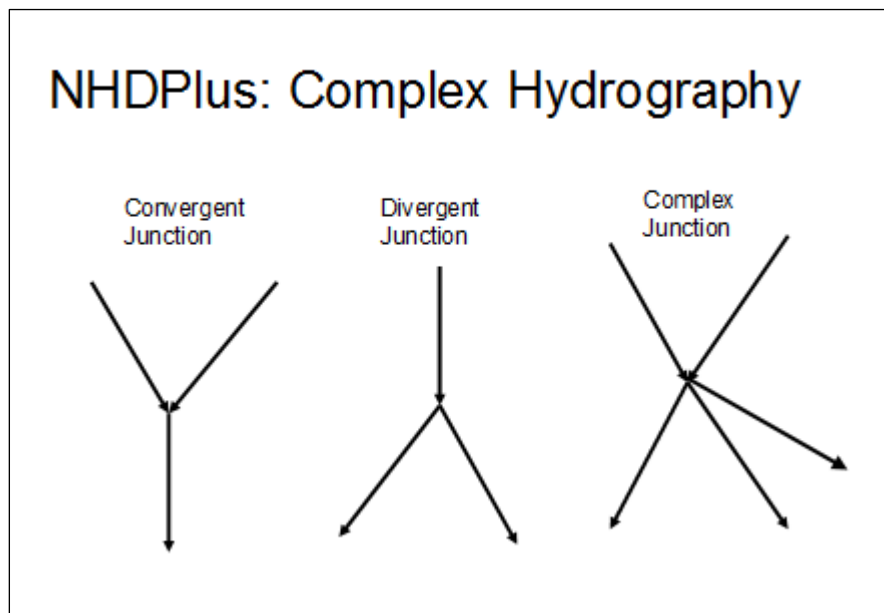
Figure 3: HRNHDPlus Alpha Complex Hydrography

The DIVERGENCE field in the HRNHDPlus<vpuid>.gdb\NHDPlusFlowlineVAA table defines "main" and "minor" paths at divergences. One path is designated as the main path and is given a DIVERGENCE attribute value of "1". All other paths in the divergence are designated as minor paths and are given a DIVERGENCE attribute value of "2", as illustrated in Figure 4.
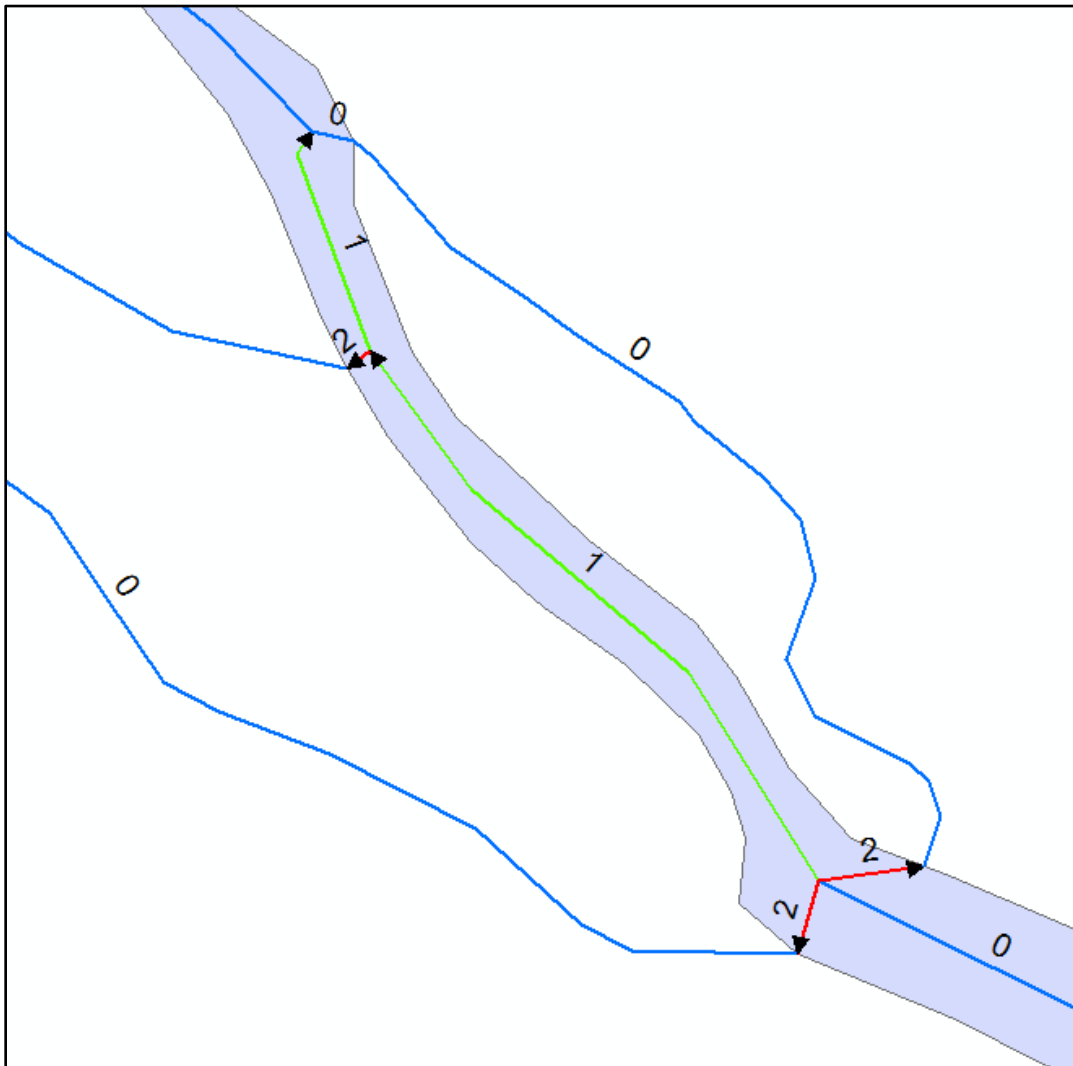

Figure 4: Main and Minor Paths in HRNHDPlus

In many cases, the divergences are "local", as shown in Figure 5, where the divergence returns to the main network at the next downstream confluence. The red flowlines represent the divergences. The blue lines represent flowlines not affected by these divergences because the divergent streams have rejoined the network upstream of the blue lines.
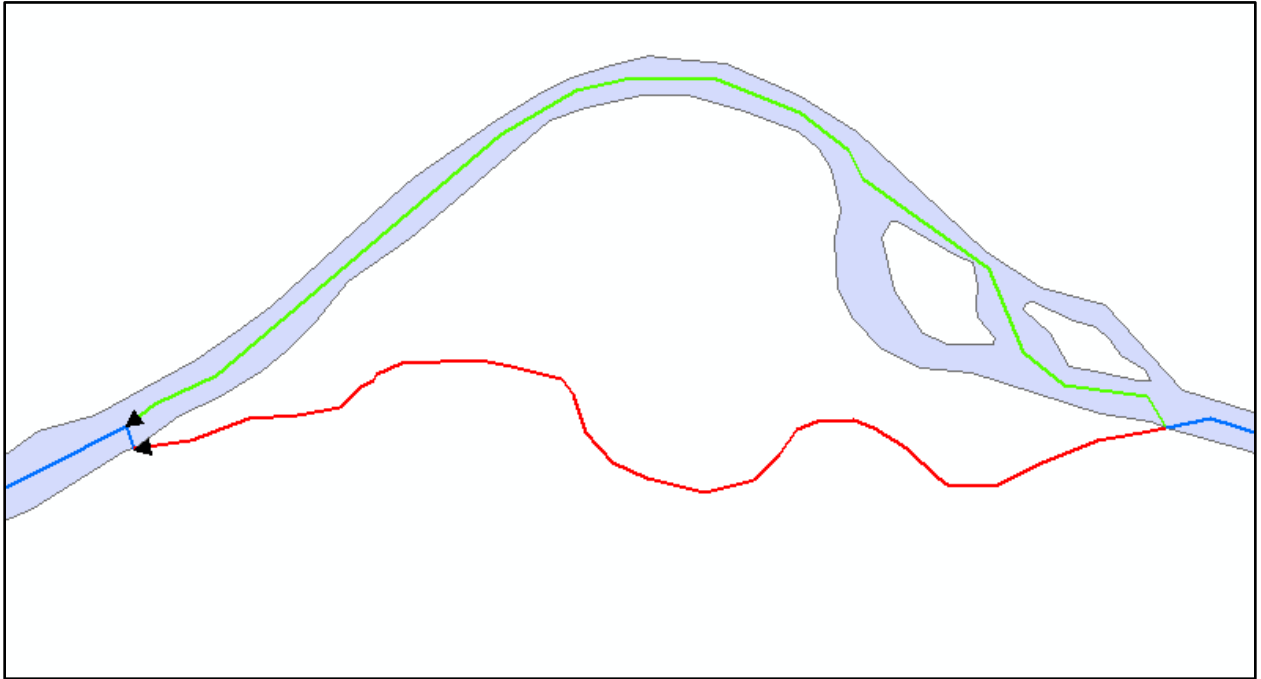
Figure 5: "Local" Divergences

HRNHDPlus Alpha has many complex networks; for example nested divergences, braided streams, coastal drainage patterns, and divergences where the divergent flowlines never re-join the network downstream. As shown in Figure 6: some complex divergences, 1) do not immediately to rejoin the main network and may flow into additional divergences and return to the main network many miles downstream, and 2) can affect multiple flowlines. When routing and accumulating attribute values, cumulative values will be affected by divergences (on the red flowlines) while non-divergent features (the blue flowlines) are not affected.
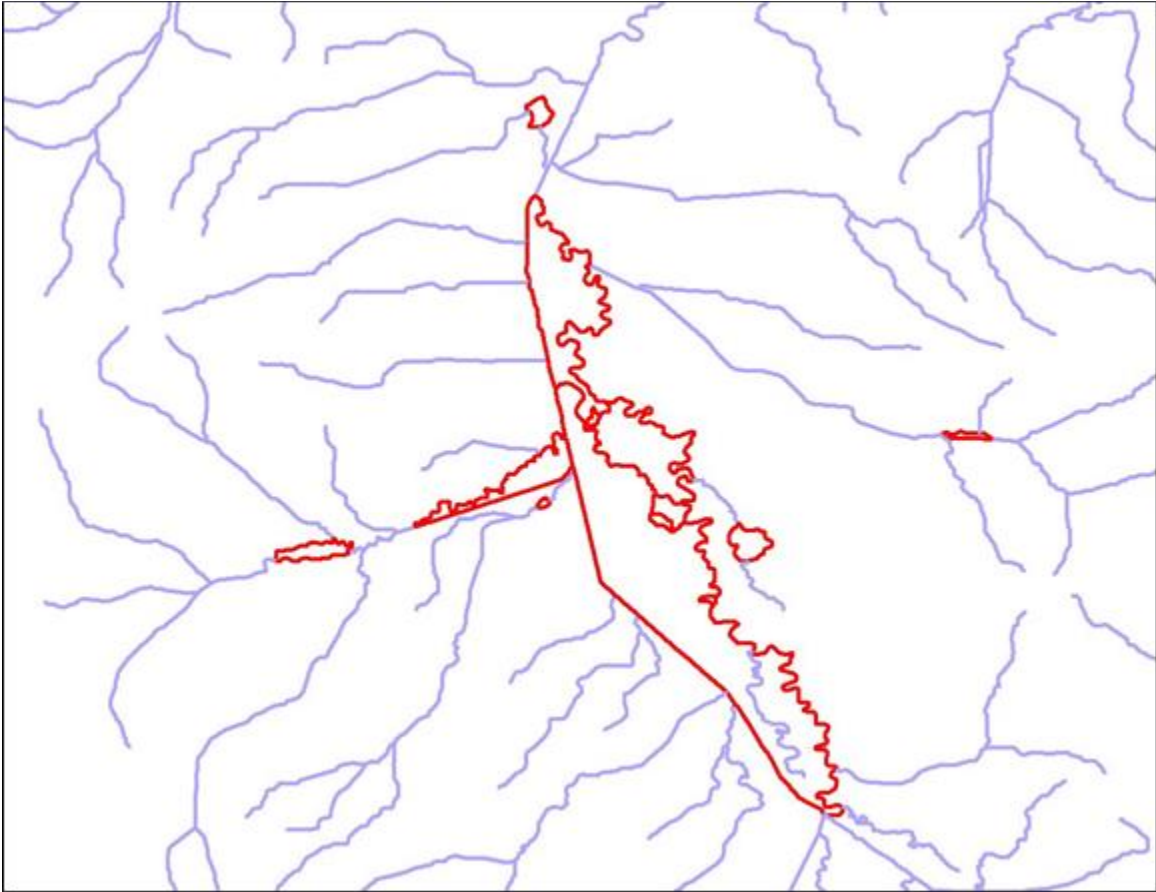
Figure 6: More Complex Divergent Junction Example

Total Upstream Accumulation and Divergence-Routed Accumulation

HRNHDPlus Alpha has implemented two approaches for accumulating attributes downstream along the HRNHDPlus Alpha network. The first approach, Total Upstream Accumulation accumulates the attribute for each NHDFlowline feature along the network which represents the total value of the attribute upstream of the bottom (downstream node) of the NHDFlowline feature. The second approach Divergence-Routed Accumulation apportions the attribute value at each divergence. A portion of the accumulation is routed down each path of the divergence such that the sum of the divergence portions is 100% of the accumulated value at that point in the network. For each NHDFlowline feature along the network, the Divergence-Routed Accumulation values for an attribute will not include amounts routed down minor divergent paths that have not returned to the main network.

For a vast majority of divergences, it is not known how to appropriately apportion to the paths in the divergence. Where there is no knowledge, HRNHDPlus Alpha uses defaults that route 100% down main paths (NHDPlusFlowlineVAA.Divergence=1) and 0% down minor paths (NHDPlusFlowlineVAA.Divergence=2). The HRNHDPlus Alpha table called DivFracMP enables, assigning percentages, other than 100% and 0%, to be routed down the main and minor paths, respectively.

Using the Divergence-Routed Accumulation method minor divergent flowlines and the flowlines downstream of the minor divergences will not include the cumulative values upstream of the divergence (Figure 7), until the divergence rejoins the main path.
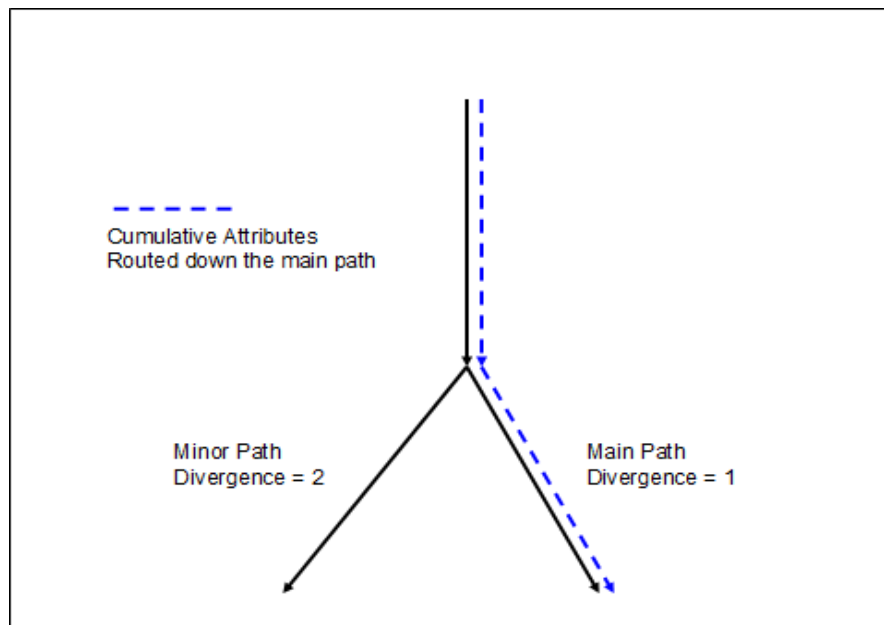

Figure 7: Divergence-Routed Accumulation Method: Attributes are routed down the main path

Building an HRNHDPlus Alpha Attribute Accumulator

There are two types of requirements for attribute accumulation: site specific accumulation or entire network accumulation. Site specific accumulation can be easily completed with upstream navigation followed by aggregation, of any attributes assigned to NHDFlowline features (or their associated catchments) using the navigation results. When implementing an entire network accumulation method, the desired attributes are accumulated for each NHDFlowline feature and saved in an attribute table for future use. Entire network accumulations will need a program or script to complete the accumulation task. Specifications for such a program or script are provided in this section.

The objective of accumulation is to aggregate the incremental values such that, at any particular NHDFlowline feature/catchment in the network, the cumulative attribute value for the area upstream of the feature/catchment is computed. Depending on the attribute being aggregated, different mathematical operations are used. For example, a "drainage area" attribute is additive, while "percent of area in forest" is computed using an area-weighted average.

As previously discussed, two techniques are used for accumulating attributes for every flowline: Total Upstream Accumulation and Divergence-Routed Accumulation (see the previous section entitled "Total Upstream Accumulation and Divergence-Routed Accumulation").

The Divergence-Routed accumulation method starts at the top of the network and moves downstream aggregating the incremental values for features or catchments. As each feature/catchment is processed, the cumulative values are saved. The advantage of this is that values can be computed quickly. The disadvantage of this method is that decisions about routing and accumulation must be made when the flow diverges. The Divergence-Routed Accumulation method is very sensitive to errors in divergence classifications. When the wrong path is designated as the major path, accumulated values will be routed down the wrong path. In addition, NHDFlowline features downstream of divergences that have not returned to the major network path will not receive the full accumulated value from upstream features. This may be appropriate for some attributes and not for others, but the user should be aware of these distinctions.

The Total-Upstream Accumulation Method is similar to the site specific method, discussed above, where the accumulation for each NHDFlowline feature is the aggregation of all the incremental upstream values. The advantages of this method are divergence classifications are less sensitive to error. As the name implies, the accumulated values represent the total accumulation upstream of each NHDFlowline.

The following example contains specifications for a script which performs the Divergence-Routed method. In this example, begin with a file containing NHDFlowline feature/catchment NHDPlusIDs and the incremental value for a single attribute assigned to each NHDFlowline

feature or catchment. For this example, assume the file is called IncrementalAttributeFile and contains fields NHDPlusID and AttrValue.

1. Add a field to the IncrementalAttributeFile for the cumulative value for the attribute. The new field is "CumAttrValue."
2. Join IncrementalAttributeFile with NHDPlusFlowlineVAA using NHDPlusID.
3. Sort the joined file by Hydroseq, in descending order.
4. Outline of the Accumulation procedure/algorithm:
    4.1.   Get next record from the sorted file. If end of file or Hydroseq = 0, quit.
    4.2.   If NHDPlusFlowlineVAA.Startflag = 1 (i.e., this is a headwater and there is nothing upstream) or NHDPlusFlowlineVAA.Divergence = 2 (i.e., nothing is routed down the minor paths of the divergence), then set CumAttrValue = AttrValue and go to step 4.1.
    4.3.   Else, find all the inflows to this current NHDFlowline feature: inflows are records in the joined file where the NHDPlusFlowlineVAA.tonode = NHDPlusFlowlineVAA.fromnode of the current flowline.
    4.4.   Set CumAttrValue = AttrValue + the CumAttrValue for each inflow.
    4.5.   Go to step 4.1.

This procedure routes the accumulation down the main path at each divergence. Alternatively, the accumulation may be apportioned to the different paths in the divergence using the contents of the NHDPlusDivFracMP table or other apportioning method, as long as 100% (neither less nor more) of the accumulation is routed down the paths from any single divergence.

Understanding NHDPlus Slope

NHDPlus slope is unit-less and can be viewed as cm/cm or m/m or km/km. (Cm/cm appears elsewhere in this documentation).

Slope is found in the NHDPlusFlowlineVAA table. Minimum and maximum smoothed elevations for flowlines, are expressed in meters. The length of NHDPlusBurnLineEvent features (BurnLenKM) is in kilometers. Therefore when slope is calculated with these fields the result is slope in meters per kilometer (m/km):

maxelevsmo(m) - minelevsmo(m) / BurnLenKM(km)   =   slope in m/km

To get the unit-less slope provided in NHDPlusFlowlineVAA.Slope the units must be converted as follows:

slope in m/km * 1 km/1000m = slope (unit-less)

NHDPlus slopes are constrained to be greater than or equal to 0.00001.

Finding all the Tributaries to a Stretch of River

First, find the stretch of interest along the main river using one of these methods:

> Method 1: Navigate upstream mainstem on the major river from the desired starting flowline for the desired distance.

> Method 2: Use the attributes in the NHDPlusFlowlineVAA table. Establish the StartPathlength as the Pathlength attribute of the starting NHDFlowline feature. Query all NHDFlowline features with Levelpathid of the major river's LevelPathID where (Pathlength - StartingPathlength) <= desired distance. If the desired stretch of river does not start at the mouth of the river, remove any NHDFlowline features from the query that have Hydroseq < Hydroseq of the starting NHDFlowline feature.

Then, find the tributaries to the stretch:
> Join the NHDPlusFlow.ToNHDPlusID to the list of NHDPlusIDs from Method1 or Method2.
> All the NHDPlusflow.FromNHDPlusID's in the joined records are the NHDPlusIDs of the downstream NHDFlowline features of the tributaries to the desired stretch of the river.

NHDFlowline Features "In" the NHDPlus network and NHDFlowline Features "Not In" the NHDPlus network.

Most, but not all of the NHDFlowline features have a known flow direction. Flow direction information is contained in the attribute "FlowDir" in the NHDFlowline feature class attribute table. FlowDir can have the values 1 (i.e. "With Digitized" which means that flow direction is known) or 0 (i.e. "Uninitialized" which means that the flow direction is unknown). The features having unknown flow direction are primarily: isolated stream segments, canal/ditches, and some channels inside braided networks.

FlowDir should not be confused with the NHDFlowline attribute InNetwork. InNetwork can have the value 1 (i.e. "Yes" the flowline is included in the NHDPlus network) or 0 (i.e. "No" the flowline is not included in the NHDPlus network). The "Plus" part of HRNHDPlus Alpha is constructed only for the InNetwork = 1 flowlines. When using HRNHDPlus Alpha, it is useful to symbolize the NHDFlowline feature class using the InNetwork attribute. This helps clarify which features are considered to be in the HRNHDPlus Alpha surface water network and which features are not.

Main Flowline Network vs. Isolated Networks

The majority of the NHDPlus surface water network features eventually drain to an ocean. These features comprise the NHDPlus "main" flowline network. In addition, NHDPlus contains many isolated networks throughout the U.S. An isolated network appears to terminate into the ground or has no outflow. Many isolated networks either seep into the ground or end due to excess evaporation. These are often called "non-contributing" networks. Some isolated networks are mapping errors. These networks should be connected to the main NHDPlus network. Figure 8: and Figure 9 illustrate isolated networks that are non-contributing and mapping errors, respectively.
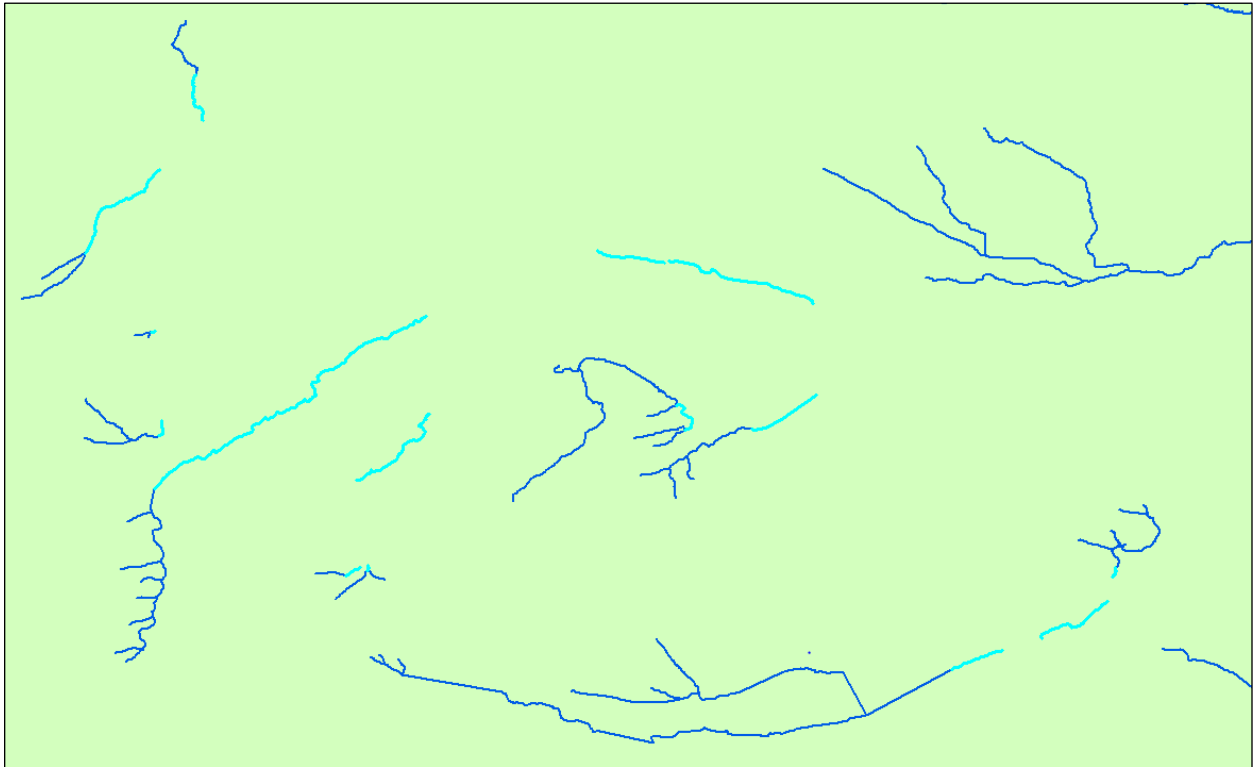
Figure 8: Non-contributing Isolated Networks Teal lines are terminal segments of isolated networks.
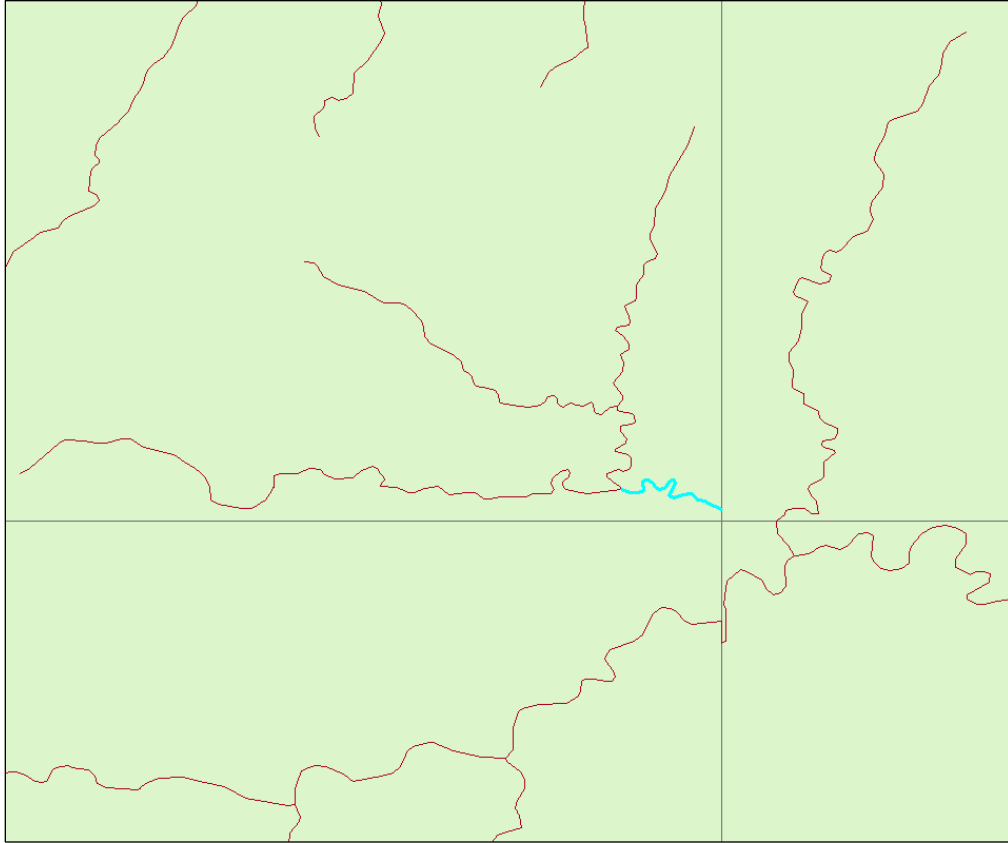
Figure 9: Map error - The cross-hairs are the edges of USGS quad maps.

Isolated networks may be located in any HRNHDPlus Alpha Drainage Area. To find isolated networks, join the NHDPlusFlowlineVAA attribute table to the NHDFlowline feature class using the NHDPlusID field in each. Then select all flowlines with NHDPlusFlowlineVAA.Terminalfl = 1. The flowlines selected are considered by the NHDPlus as terminal flowlines.

NHDFlowline Features With and Without Catchments

In general, catchments are generated for NHDFlowline features that are in the NHDPlus network (InNetwork = 1 or "Yes"). However, in HRNHDPlus Alpha, some networked flowlines were intentionally removed from the set of features used for catchment generation. Examples include pipelines, elevated canals, and other data conditions. The CATCHMENT field in BurnLineEvent identifies the flowlines that were designated as "N" for no catchment.

A common reason for flowlines without catchments is due to the resolution of the 3-DEP elevation data. Catchments were not generated for many very short flowlines, those approximately 7 meters or less in length (7 meters is the diagonal distance across a 5 meter grid cell). When longer flowlines fall within the same grid cells as very short flowline, the grid cells are typically assigned to the longer flowline. And no catchment is delineated for the very short flowline.

In rare circumstances, flowlines longer than 7 meters may not have been assigned a catchment depending on the spatial configuration of a flowline with other surrounding flowlines. For example, flowlines may run parallel with each other within a given grid cell (and may continue this way for additional grid cells that encompass one of the flowline's entire length). In this case, all of the cells used as seeds to delineate the catchments are assigned the longer flowline and no catchments will be delineated for the shorter flowline.

Using the NHDPlus Value Added Attributes (VAAs) for Non-Navigation Tasks

The attributes in the NHDPlusFlowLineVAA table provide several easily used and powerful capabilities. Below are examples which use the NHDPlusFlowlineVAA for non-navigation tasks.

Example 1: Using LevelPathID to Generalize the Stream Network based on Stream Length

The mainstem of each stream is assigned a unique identifier VAA called "LevelPathID". By convention, LevelPathID is equal to the Hydroseq value of the most downstream flowline on that river. LevelPathID can be used in conjunction with NHDFlowline feature LengthKM (in the NHDFlowline table) to build a table of the total lengths for each mainstem of every networked stream/river. Using ArcMap:

Join NHDPlusFlowlineVAA.NHDPlusID and NHDFlowline.NHDPlusID
Summarize by NHDPlusFlowlineVAA.LevelPathID with sum(NHDFlowline.LengthKM

The output table from the Summarize will contain each LevelPathID and the sum of the lengths of all the flowlines in the level path. Figure 17 highlights the main rivers greater than or equal to 100 Km in length. Note that any length threshold criteria can be used as desired.
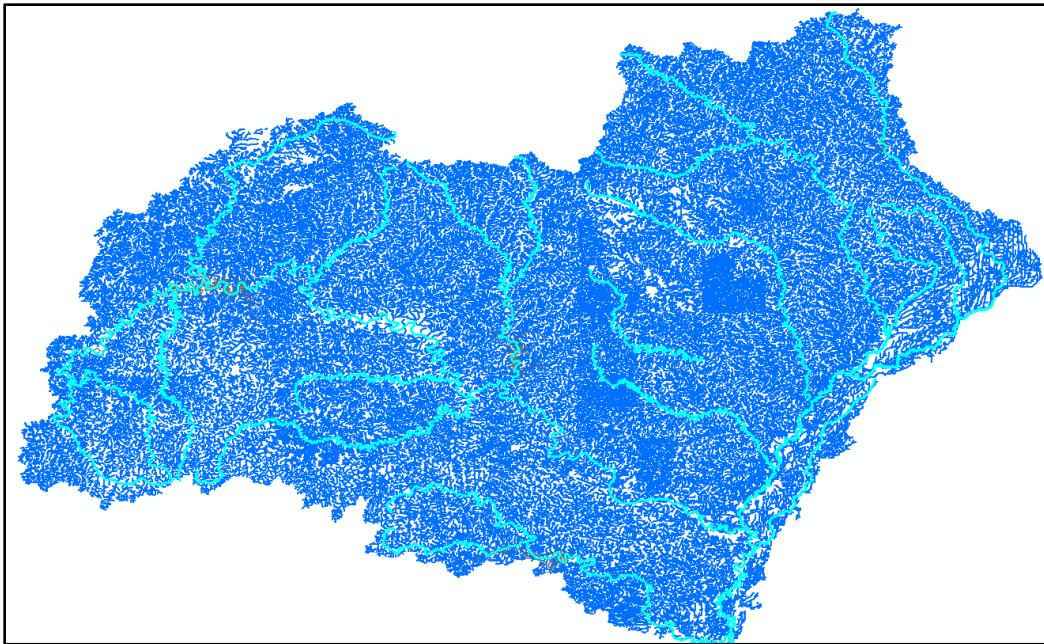

Figure 17: Streams Greater than or Equal to 100 Kilometers in Length

Example 2: Selecting an Individual River or an Individual Terminal River Basin

TerminalPathID is a VAA that contains the same value for the NHDFlowline features in an entire drainage area. By convention, TerminalPathID is set to the Hydroseq VAA of the terminal NHDFlowline feature in the drainage. For example, if the terminal feature of a river has a Hydroseq value of A. This means, the LevelPathID for the river's mainstem is assigned the value A and, if this river ends in a network terminus the TerminalPathID for the river and its drainage area is assigned the value A. Figure 18: shows the selection of LevelPathID = A, which selects the mainstem of the river. Figure 19: shows the selection of TerminalPathID = A which selects the river and its drainage area.
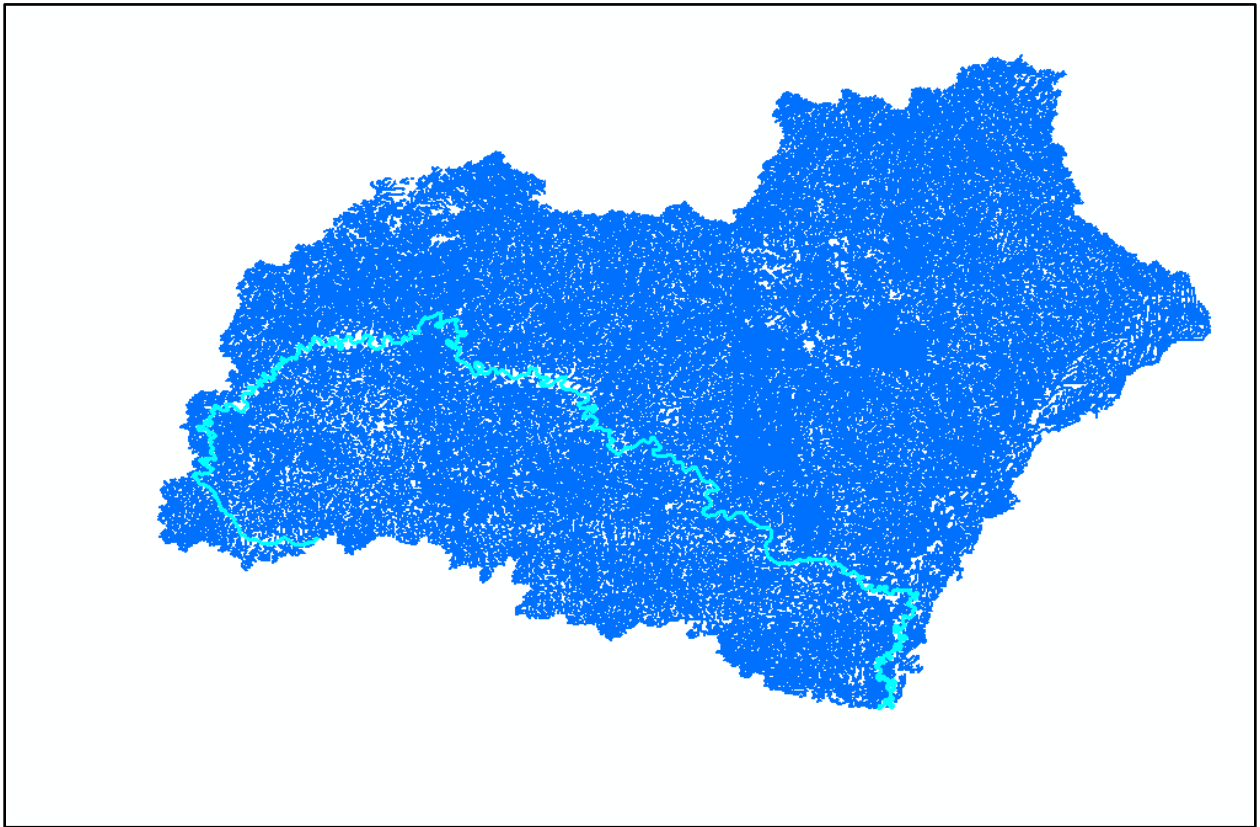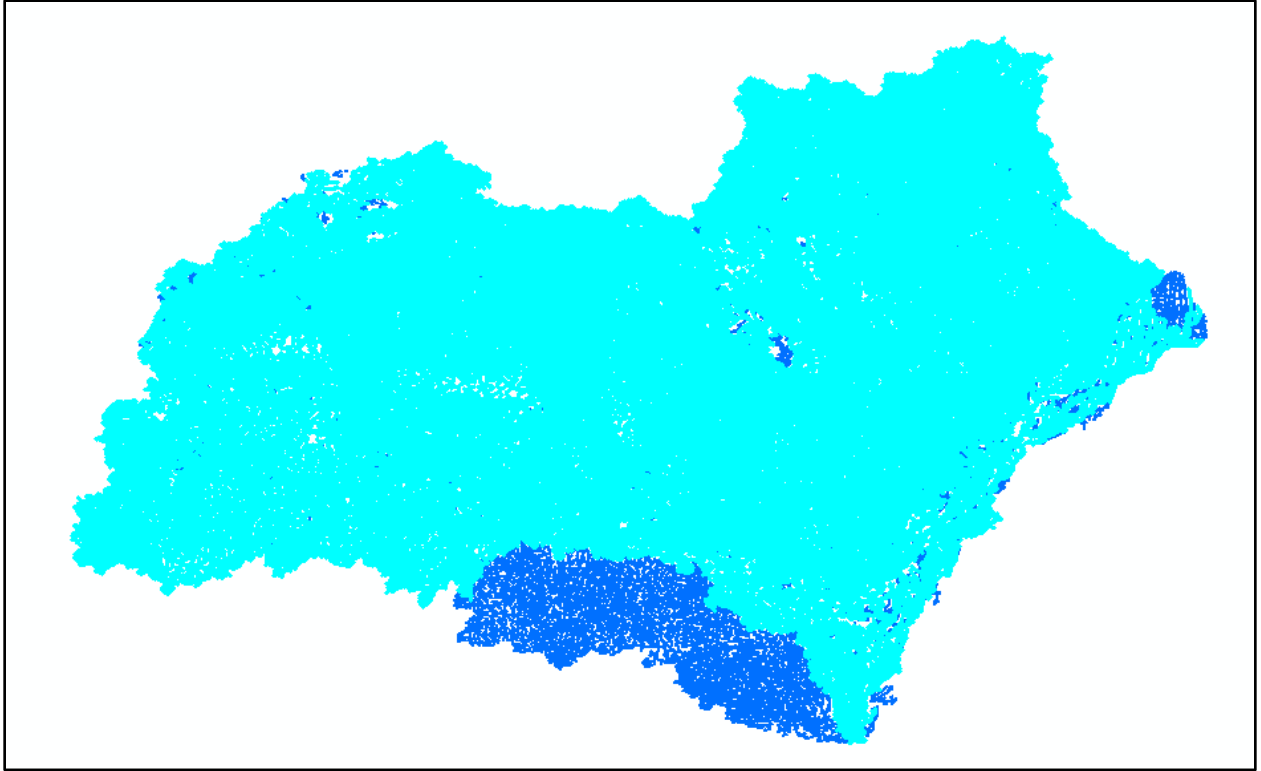

Figure 18: The Mainstem of a river with LevelPathID=A

Figure 19: The river and its drainage area where TerminalPathID = A

Example 3: Profile Plots

Plots of data along a river where the x-axis is the river mile (or river kilometer) are widely used for showing data and modeling results. The HRNHDPlus Alpha VAAs contain the basic information to readily develop profile plots. Previous VAA examples demonstrated how the LevelPathID can be used to identify every flowline on a river. Another VAA, PathLength, is the length from the bottom of the NHDFlowline feature to the end of the network. For instance, every flowline in the Missouri drainage basin has a PathLength value that tells how far away it is from the mouth of the Mississippi River.

Basic profile plotting procedure is to select the NHDFlowline features using the LevelPathID for the river of interest and assign a data value (for example, a modeling result) to the NHDPlusIDs of the selected NHDFlowline features. By including the VAA PathLength in the dataset, the user can plot data using PathLength as the x-axis and data value as the y-axis.

Figure 20 uses the NHDPlusFlowlineVAA.PathLength (distance to network terminus) attribute of the mainstem of a river as the x-axis and NHDPlusFlowlineVAA.MinElevSmooth (minimum smoothed elevation) attribute for the y-axis. This particular profile is interesting because the elevation change near PathLength 180 is dramatic; this is where this river changes from free-flowing to estuarine. The profile displays the data from downstream to upstream the x-axis can be easily reversed.
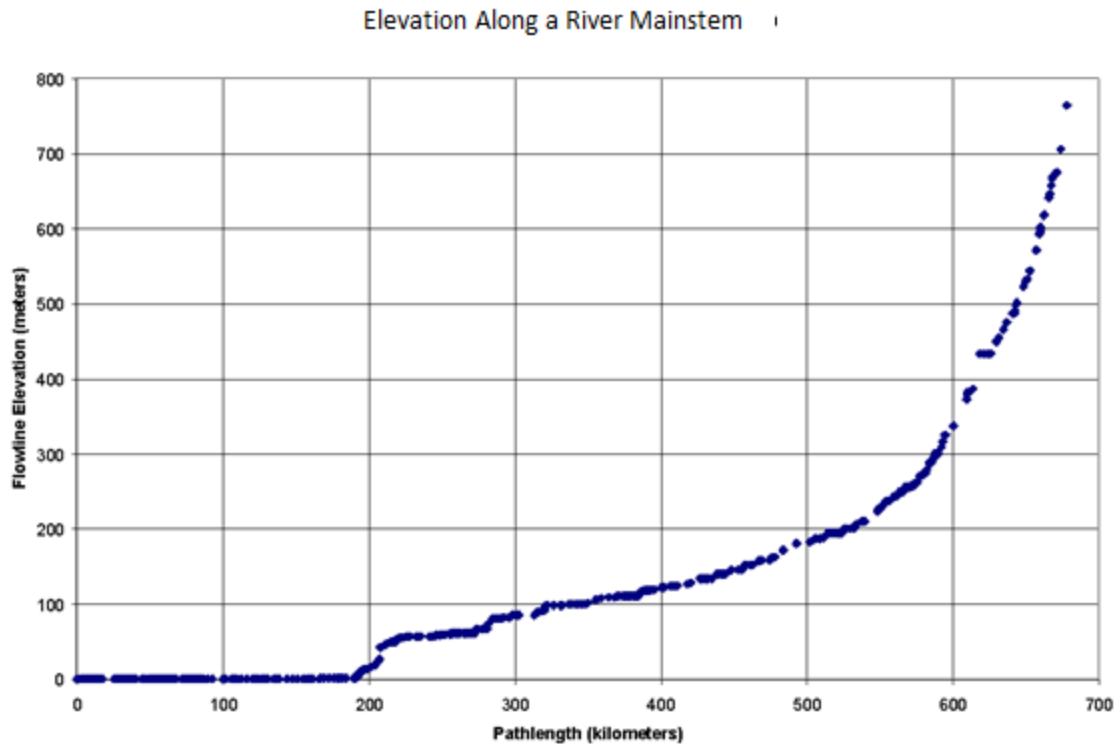
Figure 20: An Elevation Profile Plot of the Mainstem of a River

Example 5: Stream Order

The HRNHDPlus Alpha stream order is based on a modification of the Strahler Method. Stream order is a classic method for ranking streams according to relative size or position in the network.

Mapping or classifying NHDFlowline features on the basis of stream order can assist with ranking features by relative size within the network, selecting out streams of only certain orders, or aggregating data by stream order. Some examples of mapping by stream order are shown below.

Figure 21 shows different colors for each stream order for an area in the Mid-Atlantic Region. This figure illustrates how stream order helps rank streams by relative size. Figure 22 shows the same area but with stream order 1 removed. This is one method to "thin" the network based on hydrologic criteria..
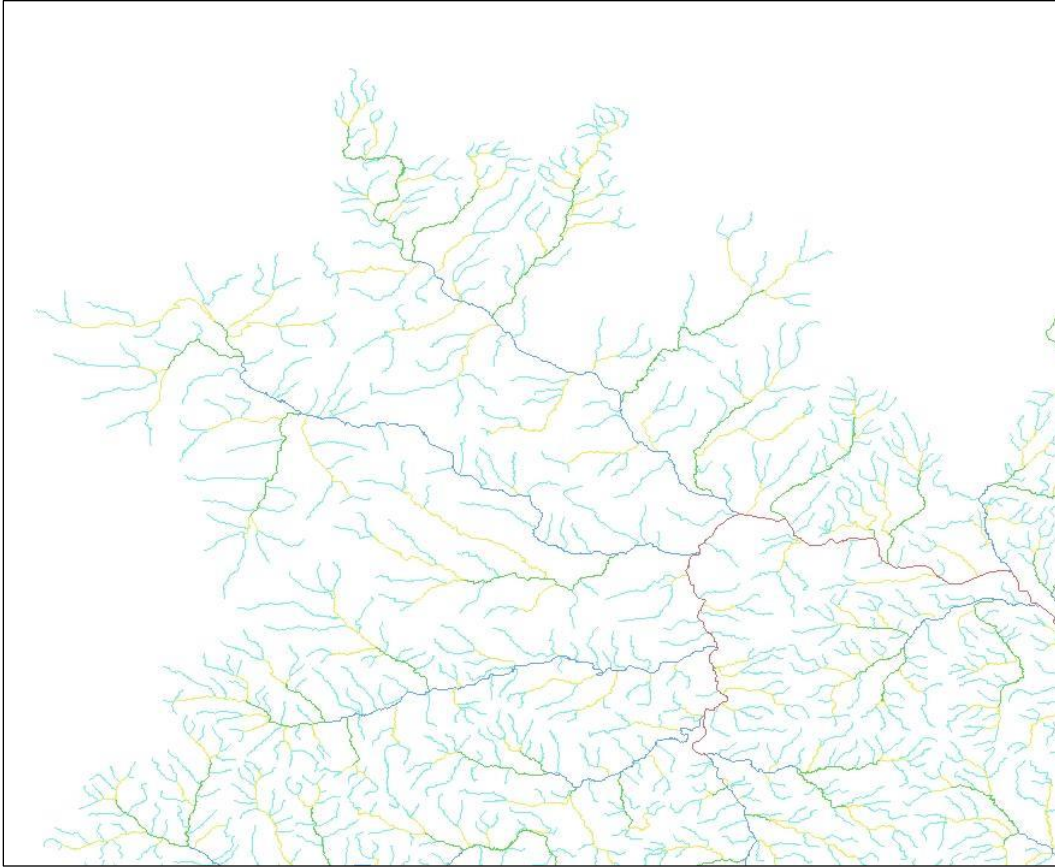
Figure 21:   Stream Orders in Part of the Mid-Atlantic Hydrologic Region
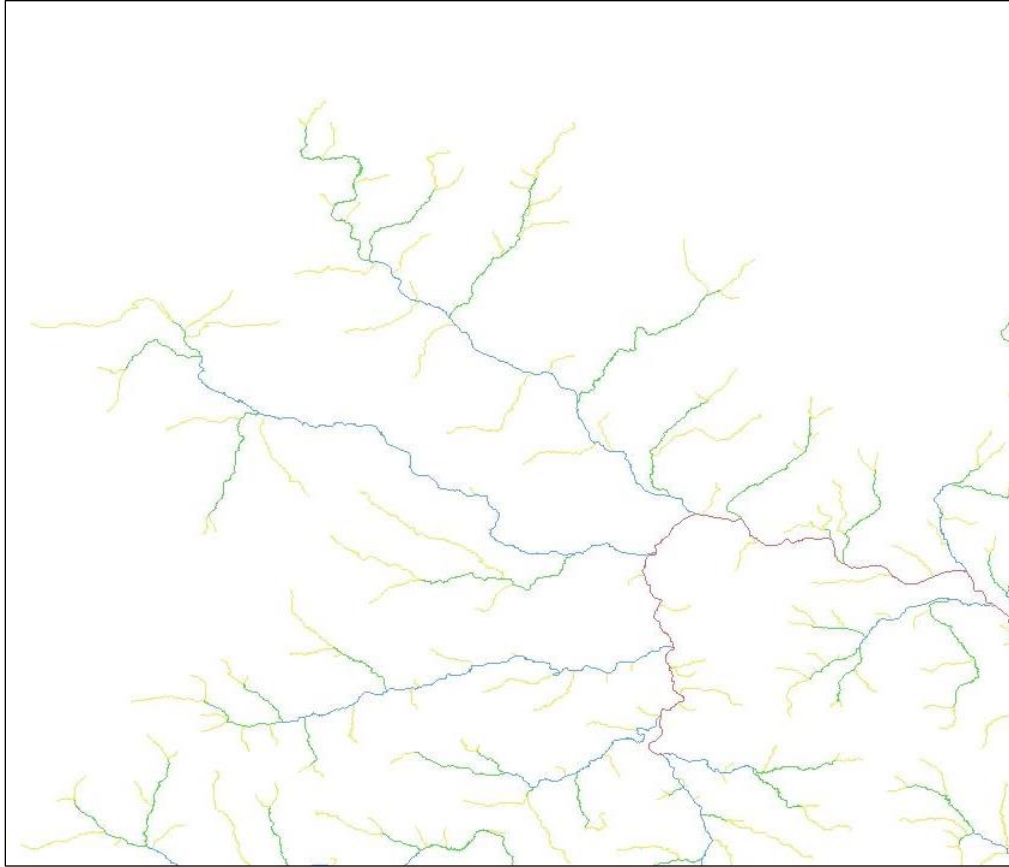
Figure 22: Stream Orders in a Part of the Midatlantic Region with Order 1 Streams Removed

Example 6: Stream Level

The StreamLevel VAA is often misunderstood or misused by users. Users often think of StreamLevel "as the opposite of Stream Order". However, this is not true in any sense. Streamlevel = 1 will apply to the Mississippi mainstem but also to every small or large stream that terminates on the coastline. Therefore, StreamLevel has nothing to do with relative stream size.

The only valid use of StreamLevel is to identify, from the inflows immediately upstream, the mainstem and tributary. The lowest valued stream level is the mainstem and the higher valued stream level(s) is the tributary. Figure 23 illustrates this. The flowlines are labeled with the StreamLevel values. The NHDFlowline features going in the north-south direction are StreamLevel = 2, and the features coming in from the West is StreamLevel=3. Therefore, the North-South features are the mainstem and the feature coming in from the West is the tributary.
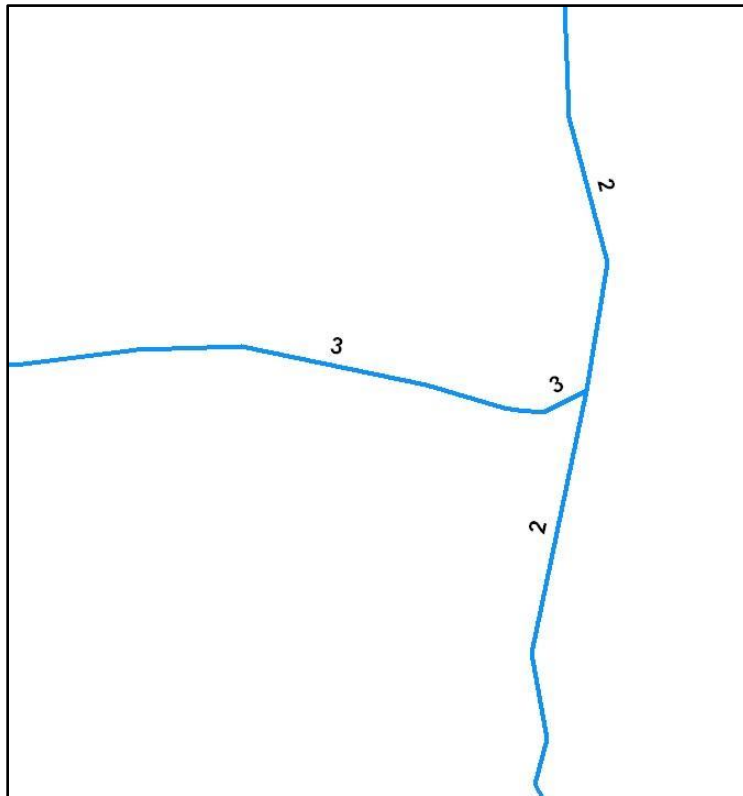

Figure 23: StreamLevel Values at a flowline Junction

Appendix A: Purpose Codes and Descriptions

Table 1.   Purpose Code Domains and Descriptions

PurposeCodeDomain Description: Purpose Code Domain Field type: *String*		Applicable feature classes					
Code	Description	NHDPlus-Burn-LineEvent	NHDPlus-Burn-Waterbody	NHDPlus-Burn-AddLine	NHDPlus-Burn-AddWaterbody	NHDPlusSink	WBDHU12
SE	Network End	X	X	X	X	X	
SN	BurnLineEvent non-spatial connection	X	X	X	X	X	
SP	NHDWaterbody playa		X	X	X	X	
SC	NHDWaterbody closed lake		X	X	X	X	
SH	HUC12 polygon min point or centroid					X	X

SK	Karst sinkhole					X	
SD	Togographic depression					X	
SO	Other sink					X	
AC	Coastline from adjacent VPU			X			
AF	Added feature from adjacent VPU (non-upstream)			X	X		
AU	Added feature from adjacent VPU (upstream)			X	X		
AI	Inflow connecting feature from upstream VPU			X	X		
AO	Outflow flowlines to elevation clip boundary			X	X		
UF	Unused feature (FCode or by feature)			X	X		
DO	Digitized outlow path			X			
DC	Digitized connector flowline			X			

OC	NHDWaterbody sea, bay, estuary		X				
WB	NHDWaterbody (other)		X				