Downloading and Exploring NHDPlus Data

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October 2009

Purpose

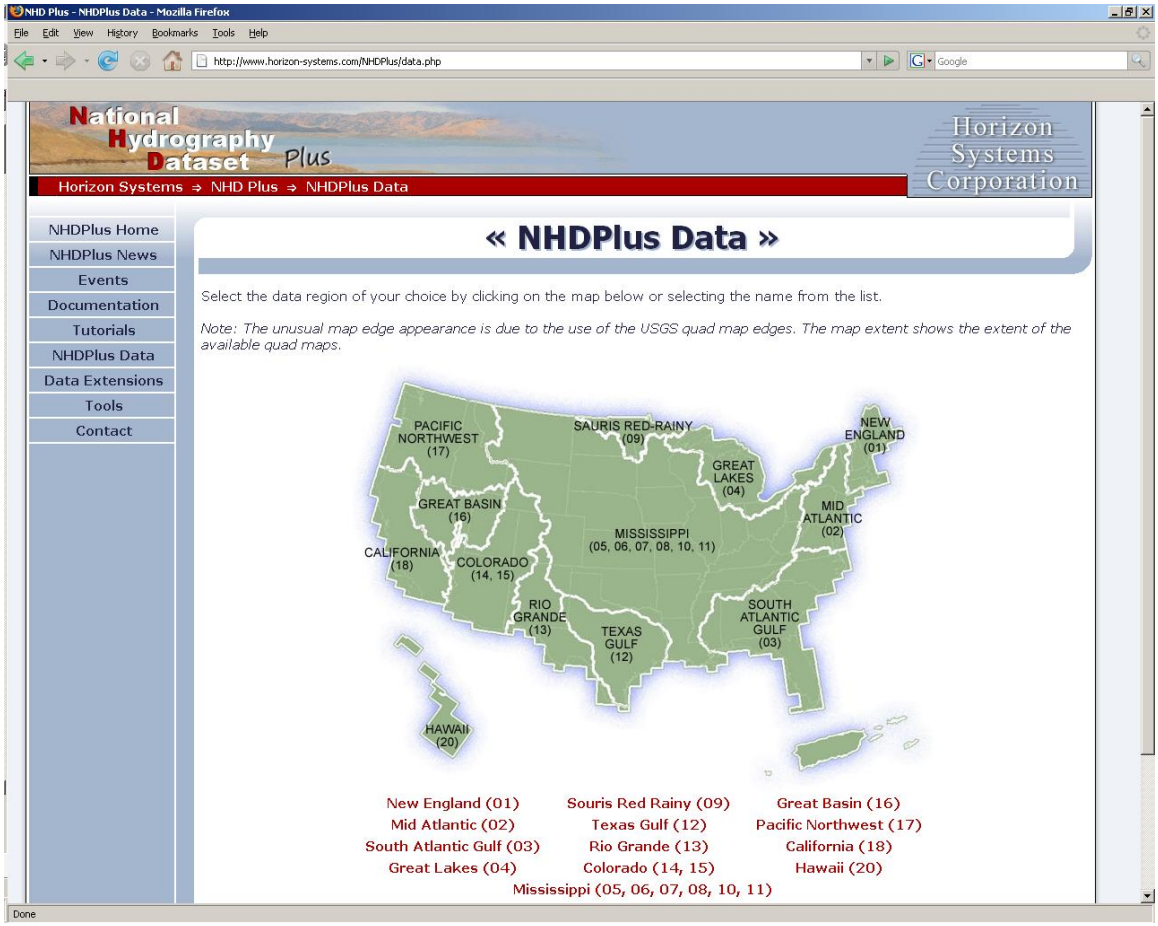
The purpose of this exercise to demonstrate the steps involved in downloading and exploring NHDPlus data from Horizon Systems Corporation.

Brief Description about NHDPlus

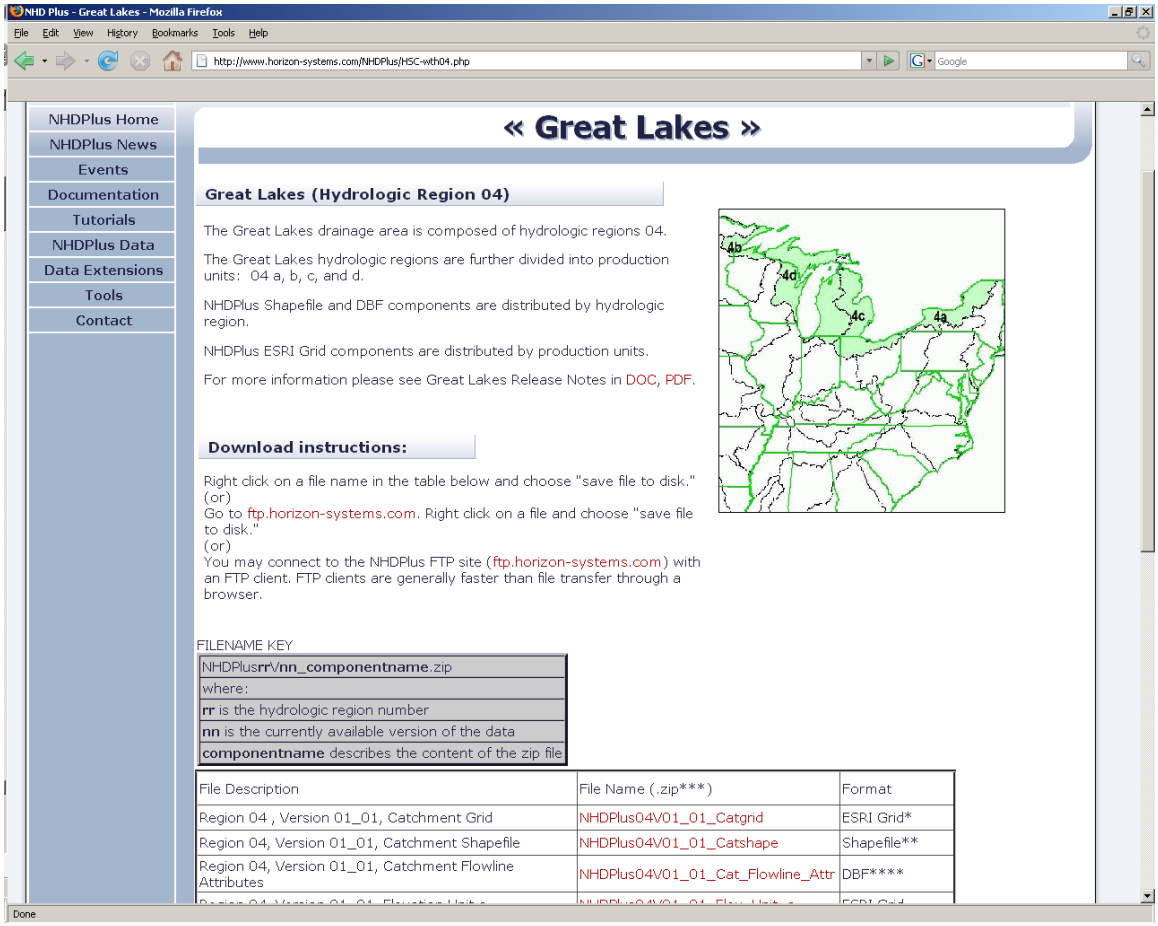
According to NHDPlus Users Guide, "*NHDPlus is an integrated suite of application-ready geospatial data products, incorporating many of the best features of the National Hydrography Dataset (NHD), the National Elevation Dataset (NED), and the National Watershed Boundary Dataset (WBD).*" *NHDPlus is based on medium resolution (1:100,000) NHD NHDPlus includes a stream network based on the medium resolution NHD (1:100,000 scale), improved networking, feature naming, and "value-added attributes" (VAA).*" The VAAs include attributes such as mean annual flow, mean annual velocity, slope, elevation, and other connectivity information for each reach that greatly enhance capabilities for upstream and downstream navigation, analysis, and modeling. More information about NHDPlus can be found at http://www.horizon-systems.com/NHDPlus/index.php.

Downloading NHDPlus Data

As of 2007, NHDPlus is hosted by Horizon Systems, which is a member of the NHDPlus team headed by U.S. EPA. NHDPlus can be downloaded from Horizon System's website http://www.horizon-systems.com/NHDPlus/index.php. To download the data, **click** on NHDPlusData tab on the left menu. NHDPlus data are developed and distributed according to hydrologic regions within the U.S. so you will see a map of U.S. with hydrologic regions as shown below:



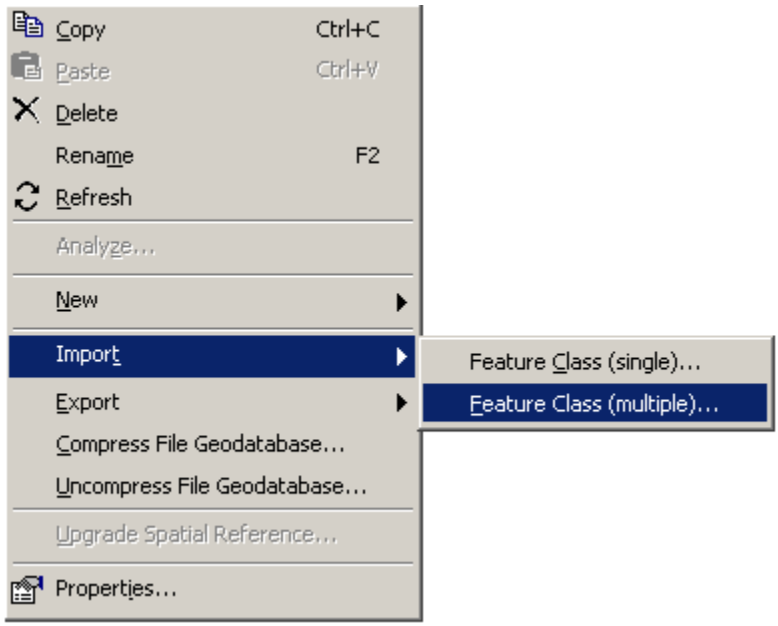
In this exercise, we are interested in developing a NHDPlus database for St. Joseph River Watershed in northern Indiana, which is a part of Great Lakes region (region 04). Note that you have to download data for an entire region where your area of interest is located and then extract relevant features from the regional dataset. **Click** on *GREAT LAKE (04)* area, and then you will see an inventory of data available for this region along with download instructions as shown below:



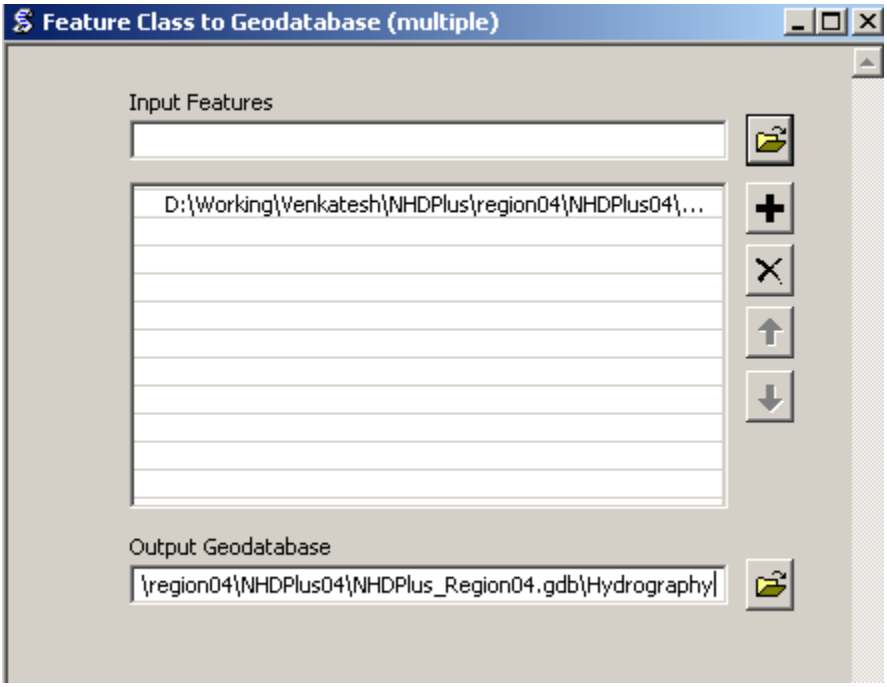
NHDPlus contains raster (grid), vector (shapefile) and tabular data (DBF) for each region. Grid files contain topography, flow direction and flow accumulation grids. Shapefiles contain drainage and hydrography data, and DBF files contain value added attributes, metadata and other miscellaneous information. **Right click** on all hyperlinks related to shapefile and dbf data, and save them on a hard disk (region04 folder) by **pressing** the *Save Link As…* option in the right click menu. All data will be saved as zip files in the selected folder so the first step is to unzip all files. After all files are unzipped, you should have three sub-folders: *Drainage* (containing catchments), *Hydrography* (containing NHD flowlines, points, areas) and *HydrologicUnits* (containing basins, subbasins, watersheds, etc.).

Next, **open ArcCatalog** and **create** an empty file geodatabase named *NHDPlus_region04* in the working folder. **Create** a feature dataset named *Hydrography* within NHDPlus_region04.gdb named, and **define** the coordinate system. You can choose any appropriate coordinate system of your choice, but if you wish to choose UTM, St. Joseph River Watershed lies in UTM Zone 16 so NAD_1983_UTM_Zone_16N will work.

Next, **right click** on *Hydrography* feature dataset, and **select** *Import→Feature Class (Multiple)…* option as shown below:



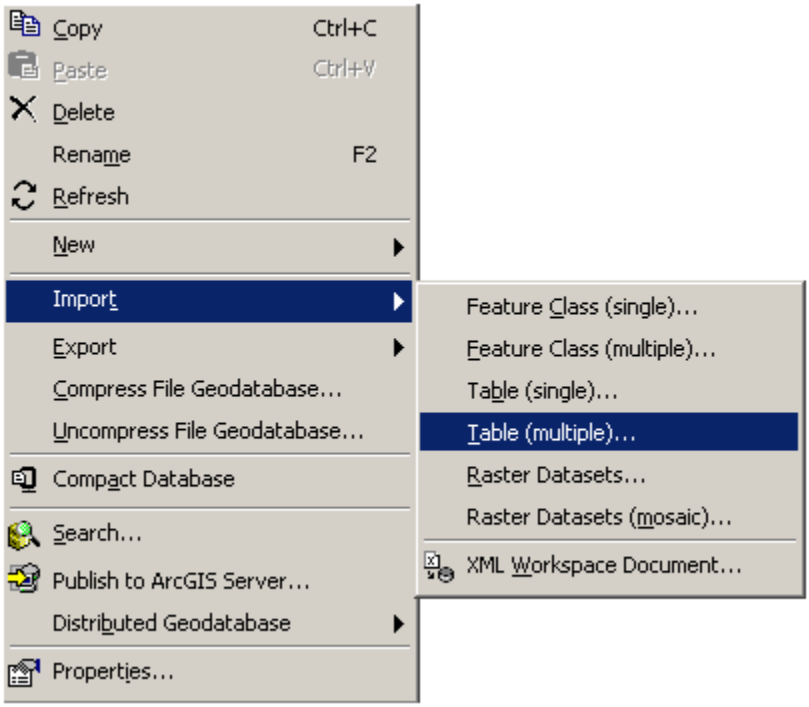
In the *Feature Class to Geodatabase (multiple)* window, **add** all files from Hydrography folder and **press** *OK*.



This process will take some time to load the data. Be patient until all shapefiles are imported into hydrography feature dataset. If you want, you can create separate feature datasets for HydrologicUnits and Drainage, and follow the same process to import corresponding shapefiles from HydrologicUnits and Drainage folders. In this tutorial,

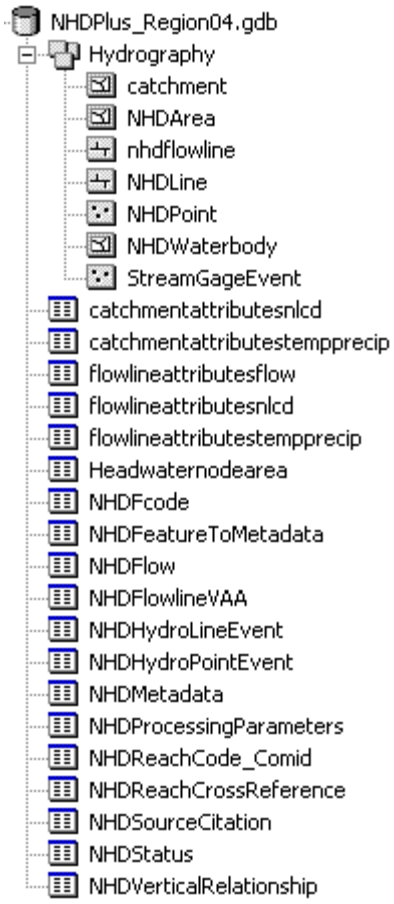
only hydrography data, catchment features from Drainage folder and StreamGageEvent shapefile are imported in Hydrography feature dataset.

Next, **right click** on the *NHDPlus_region04.gdb* and **select** *Import→Table (multiple)…* option in the menu to import all tables (dbf files) as shown below. Note that you can only import table into a geodatabase and not into a feature dataset.



In the next window, **add** all tables including catchment flowline attributes from the working folder, and **click** *OK* to add all tables to *NHDPlus_region04.gdb*.

The final ArcCatalog view of NHDPlus_region04.gdb along with its feature dataset and tables is shown below:



You just finished downloading NHDPlus data and organizing it into an ArcGIS file geodatabase. Note that the data in NHDPlus_region04.gdb is stored for the entire great lakes region. You can either work these data, or extract the data for your area of interest to reduce the processing time for further analysis.

Exploring NHDPlus

The region04 NHDPlus hydrography including all related tables is extracted for St. Joseph River Watershed in northern Indiana. Spatial selection is performed to extract geographic data, and tabular data are extracted by relating geographic data with NHDPlus tables. It is expected that the user knows how to perform these extractions using GIS functions.

Geographic data, their names and descriptions are unchanged between NHD and NHDPlus. New fields are added for geographic data, which will be discussed as we use them in future sections. Tabular data are new with NHDPlus and the following table provides an overview of these data.

Table Name	Description
catchmentattributesnlcd	National Land Cover Dataset (NLCD) 1992 attributes for each catchment
catchmentattributestempprcip	Mean annual temperature (0C * 10) and Precipitation (mm) attributes for each catchment
flowlineattributesflow	Flow attributes such as mean annual flow, mean annual velocity and slope for each flow line.
flowlineattributesnlcd	NLCD attributes at the bottom of each flow line
flowlineattributestempprecip	Area weighted mean annual temperature and precipitation at the bottom of each flow line
Headwaternodearea	Catchment area in square kilometers that drains to the headwater node of the flowline indicated by ComID
NHDFcode	Description of attribute codes used in the FCode fields of feature tables.
NHDFlow	Contains water exchange information for each flow line. For example, at the shoreline, network flowline features have a "non-flowing" connection to coastline features. Coastline features also have "non-flowing" connections to each other.
NHDFlowlineVAA	Contains attributes such as FROMNODE and TONODE that are created when NHD network is built and are useful in network navigation.

Some other tables such as *NHDMetadata* and *NHDFeaturesToMetadata* contain metadata, while others such as *NHDHydroLineEvent* and *NHDHydroPointEvent* are always empty.

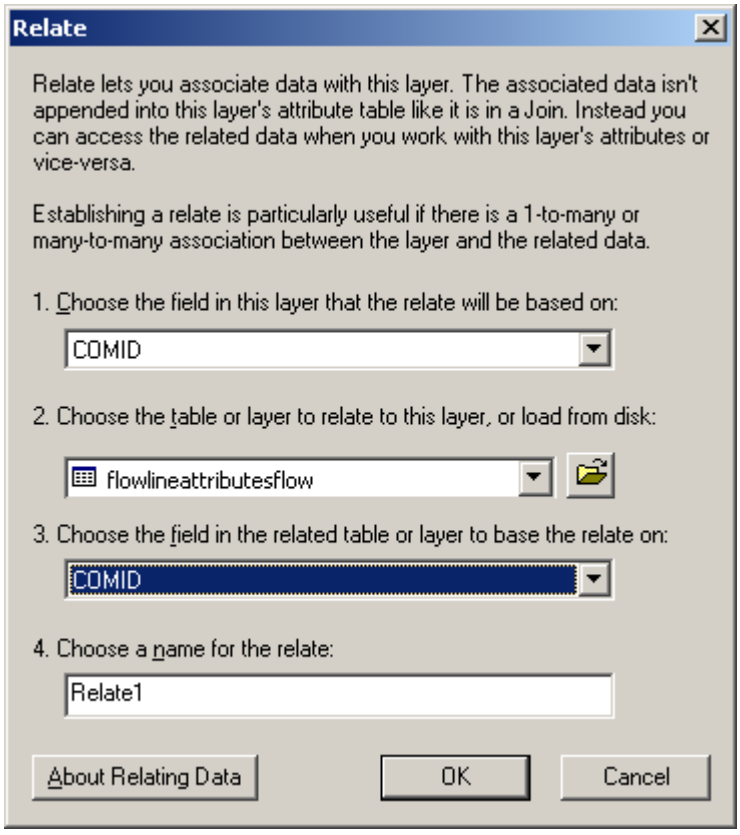
Now lets explore some of the features and their attributes in NHDPlus.

NHDFlowline

NHDFlowline features include stream/river, canal/ditch, pipeline, artificial path, coastline, and connector. Each feature type is identified by assigning an *FType* attribute. **Open** the attribute table of *NHDFLowline*. Description of key attributes is given below:

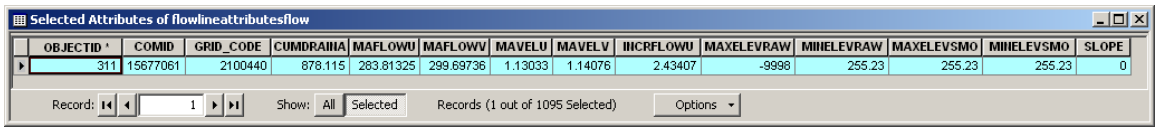
Field Name	Description
ComID	Common identifier of the NHD feature
LengthKM	Feature length in kilometers
ReachCode	Reach Code assigned to feature
Flowdir	Flow direction is "WithDigitized" or "Uninitialized"
WBAreaComI	ComID of an NHD polygonal water feature through which an NHD "Artificial Path" flowline flows
FType	NHD Feature Type
FCode	Numeric codes for various feature attributes in the NHDFCode lookup table
Shape_Leng	Feature length in decimal degrees
Enabled	Always "True"

Each feature is related to corresponding attributes in NHD tables through *ComID*. Lets relate *NHDFlowline* with one of its tables, and explore the tabular data. **Right-click** on *NHDFlowline*→*Joins and Relates*→*Relate…* Relate features using ComID to **flowlineattributesflow** table as shown below.



Select any feature in the network (the feature selected here has a ComID of 15677061). **Open** the attribute table for *NHDFlowline*, and select related attributes in *flowlineattributesflow* table using the related link (use *Options*→*Related*

Tables→Relate1). **Open** *flowlinesattributesflow* table to see the attributes as shown below:



The description of each relevant flow attribute for the selected feature is given in the following table:

Field Name	**Description**
ComID	Common identifier of an NHD Flowline
CumDrainag	Cumulative drainage area in square kilometers(sq km) at bottom of flowline
MAFlowU	Mean Annual Flow in cubic feet per second (cfs) at bottom of flowline as computed by Unit Runoff Method
MAFlowV	Mean Annual Flow (cfs) at bottom of flowline as computed by Vogel Method. In Hydrologic Region 20 (Hawaii), this value is the median annual flow (cfs) as computed using the method of Fontaine, et. al. (1992).
MAVelU	Mean Annual Velocity (fps) at bottom of flowline as computed by Jobson Method (1996) using the flow in MAFlowU.
MAVelV	Mean Annual Velocity (fps) at bottom of flowline as computed by Jobson Method (1996) using the flow in MAFlowV.
IncrFlowU	Incremental Flow (cfs) for Flowline as computed by the Unit Runoff Method
MaxElevRaw	Maximum elevation (unsmoothed) in meters
MinElevRaw	Minimum elevation (unsmoothed) in meters
MaxElevSmo	Maximum elevation (smoothed) in meters
MinElevSmo	Minimum elevation (smoothed) in meters
Slope	Slope of flowline (m/m)

Similarly **relate** *flowlineattributesnlcd* and *flowlineattributestempprecip* with *NHDFlowline* feature class to explore the attributes related to land use and climate for each flow line. All records in tables have *COMID* that corresponds to a feature in *NHDFLowline* feature class. Fields in *flowlineattributenlcd* show percentage of drainage areas having a specific land use type. For example, *CUMNLCD_11* = 1.93 means 1.93% of drainage area associated with this particular feature is open water. The codes (_xx) associated with each field comes from NLCD for each land use type.

Flowlineattributetempprecip show area weighted mean annual precipitation in mm (*AREAWEMAP*) and area weighted mean annual temperature in ^{o}C*10 (*AREAWEMAT*) at the bottom of each flow line feature.

For each record in *NHDFlow* table, there are corresponding value added attributes (VAA) in *NHDFLowlineVAA* table. Description of each field in *NHDFlowlineVAA* is provided below:

Field Name	**Description**
ComID	Common identifier of NHD Flowline
StreamLeve	Stream level
StreamOrde	Strahler stream order
FromNode	From node number (top of flowline)
ToNode	To node number (bottom of flowline)
Hydroseq	Hydrologic sequence number
LevelPathi	Hydrologic sequence number of most downstream flowline in level path
PathLength	Distance to terminal flowline downstream along the mainpath (kilometers)
TerminalPa	Hydrologic sequence number of terminal flowline
ArbolateSu	An estimate of miles of stream upstream of a flowline. Always 0. (square kilometers
Divergence	0 – not part of a divergence 1 – main path of a divergence 2 – minor path of a divergence
StartFlag	0 – not a headwater flowline 1 – a headwater flowline
TerminalFl	0 – not a terminal flowline 1 – a terminal flowline
DnLevel	Streamlevel of mainstem downstream flowline
ThinnerCod	Ordinal value used to display various network densities
UpLevelPat	Upstream mainstem level path identifier
UpHydroSeq	Upstream mainstem hydrologic sequence number
UpMinHydro	Upstream minimum hydrologic sequence number
DnLevelPat	Downstream mainstem level path identifier
DnMinHydro	Downstream minor path hydrologic sequence number
DnDrainCou	Number of flowlines immediately downstream

Catchment

Catchment feature class contains a catchment polygon for each flow line. Attributes of catchment feature class are described below.

Field Name	Description
ComID	Common Identifier of an NHD Flowline
Grid_code	The value stored in grid cells A unique identification number for each catchment (compressed numbering system)
Grid_count	Number of cells with a particular value in the value field The count equals the number of 30x30 meter grid cells in each catchment Catchment area can be computed from this field
Prod_unit	Production unit identifier
AreaSqKm	Feature area in square kilometers

The two relevant tables, *catchmentattributesnlcd* and *catchmentattributestempprecip*, for catchment feature class contain description similar to *flowlineattributesnlcd* and *flowlineattributestempprecip*, respectively for catchments. Relate these tables with catchment feature class and explore related information.

StreamGageEvent

The *StreamGageEvent* feature class contains the physical locations of the USGS stream gages as well as their location on *NHDFlowline* features through events linked to reach codes and measures. Note that *COMID* for these points is zero because reachcode and measure is used instead to link these points to flow lines. Description of key fields in this feature class is provided below.

Field Name	Description
EventDate	Date event was created
Reachcode	Reachcode on which Stream Gage is located
Source_ori	Originator of Event
Source_fea	Gage Identifier/USGS Site Number
Featuredet	URL where detailed gage data can be found (NWISWEB)
Measure	Measure along reach where Stream Gage is located in percent from downstream end
Offset	Always zero
EventType	"StreamGage"
Agency_cd	Gov. Agency responsible for the Stream Gage
Station_nm	Station name
State_cd	2 digit state FIPS code of the WSC maintaining the gage.
State	2 character state postal abbreviation of the WSC maintaining the gage. Puerto Rico is listed as a state.
Sitestatus	Active (A) or Inactive (I) where active Stream Gage has streamflow data in water year(s) 2003 and/or 2004
DA_SQ_Mile	Reported drainage area in sq. mi. Stations with drainage area -999999 means there is no reported drainage area in the National Water Information System.
Lon_site	Longitude of the Stream Gage (site) location - gage house in decimal degrees, NAD83
Lat_site	Latitude of the Stream Gage (site) location - gage house in decimal degrees, NAD83
Lon_NHD	Longitude of the NHD location in decimal degrees, NAD83

Field Name	Description
Lat_NHD	Latitude of the NHD location in decimal degrees, NAD83
NHD2Gage_d	Distance between Stream Gage and NHD Reach
BFIyrs	Number of years used in the base-flow index computation
BFI_Ave	Average annual base-flow index value
BFI_Stdev	Standard deviation of annual base-flow index
GotBFI	Flag indicating BFI data (1) or no BFI data (2)
Day1	First date of flow data (yyyymmdd)
DayN	Last date of flow data (yyyymmdd)
NDays	Number of days of flow data
NDaysGT0	Number of days of non-zero flow
*MIN_*	Minimum daily flow for the period of record
PX	"X" percentile of daily flow for the period of record. Negative values indicate reverse flow; tidal or backwater
*Max_*	Maximum daily flow for the period of record
Ave	Average daily flow for the period of record
Stdev	Standard deviation of daily flow for the period of record
GOTQ	Flag indicating flow data (1) or no flow data (0)
HUC	Hydrologic Cataloging Unit (8-digit HUC) of the Stream Gage
HUC_Reg	Hydrologic Region (2-digit HUC) of the Stream Gage
Subregion	Hydrologic sub-region (4-digit HUC) of the Stream Gage
Accounting	Hydrologic accounting unit (6-digit HUC) of the Stream Gage

OK, you are done downloading and exploring NHDPlus data! Take your work to next level by using this rich information for scientific and engineering applications.

Things to do on your own and turn-in after the lab

1. Find the order of Cedar Creek Watershed.

2. Find drainage density of Cedar Creek Watershed.

3. Create a map of cedar creek network to show the stream order.

4. Using stream orders "thin" the Cedar Creek to remove all first order tributaries and add the map to your document.

5. Use the following table to reclassify the landuse. Create a distribution map of water, developed, barren, forest and agricultural area in Cedar Creek watershed.

Original NLCD classification		**Revised classification (re-classification)**	
Number	*Description*	*Number*	*Description*
11	Open water	1	Water
12	Perennial Ice/Snow		
91	Woody Wetlands		
92	Emergent herbaceous wetlands		
21	Low Intensity Residential	2	Developed
22	High Intensity Residential		
23	Commercial/ Industrial /Transportation		
31	Bare Rock/Sand/Clay	3	Barren
32	Quarries/Strip Mines/Gravel Pits		
33	Transitional		
41	Deciduous Forest	4	Forest
42	Evergreen Forest		
43	Mixed Forest		
51	Shrubland		
61	Orchards/Vineyards/others	5	Agricultural
71	Grassland/herbaceous		
81	Pasture/hay		
82	Cultivated crops		
83	Small Grains		
84	Fallow		
85	Urban/Recreational Grasses		

6. Create a spatial distribution map of annual precipitation in Cedar Creek and corresponding annual mean flow