



# **NHDinGEO Tasks for ArcGIS 8.3 and Higher**

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## **NHDinGEO Tasks for ArcGIS 8.3 and Higher**

The National Hydrography Dataset implementation in the ESRI Geodatabase model is known as the NHDinGEO. This was done to allow as many users as possible to easily use the NHD with readily available “out-of-the-box” GIS functions. The following procedures describe how to use the NHD with ESRI’s ArcGIS system. These procedures have worked well repeatedly with all types of NHDinGEO data; however, there may be alternative procedures. Refer to the “Help” functions in ArcGIS for ESRI’s “official” method to carry out tasks. The procedures assume the user has been introduced to the NHDinGEO and has some ArcMap experience, but this is not a prerequisite. These procedures do not address the editing of the NHDinGEO, which uses the NHD GEO Edit Tool and the stewardship process for updating the NHD.

### ***Versions of ArcGIS***

The NHDinGEO is designed to work on ArcGIS versions 8.3 and higher. The exact version used will likely not alter functionality of NHD use, although some functions may move from where indicated below.

### ***Viewing the NHD***

1. Open ArcMap.
2. Click on the “Add Data” icon.
3. Navigate to the project folder, then the GeoData folder. Click on the “Hydrography” feature data set. Then click on “Add”.
4. The NHD data will display.
5. The “HydrologicUnits” feature data set can be added in the same manner.
6. Re-arranging the feature classes in the following order can be useful. Do this under the “Display” tab. Click on each feature class and drag it to the desired position. When done, switch to the “Source” tab to view.
  - a. HYDRO\_NET\_Junctions
  - b. NHDFlowline
  - c. NHDWaterbody
  - d. NHDPoint
  - e. NHDLine
  - f. NHDArea
7. To change the symbology:
  - a. For general symbology:
    - i. Double-click on the “symbol” in the Table of Contents (TOC).
    - ii. Choose the appropriate graphic, color, and size.
  - b. To get more specific, such as distinguishing between perennial and intermittent streams:
    - i. Right-click on the feature class (such as NHDFlowline).
    - ii. Select “Properties” from the pull down menu.
    - iii. Click on the “Symbology” tab.
    - iv. Select the appropriate “Value” field from the pull down menu. To symbolize detailed feature types use the FCode field.

- v. Click on “Add All Values” to see all the values used.
  - vi. Double-click on the “symbol” and choose the desired graphic, color, and size.
8. Problems with the Extent
- a. At times a NHDinGEO file extent will consist of the entire United States rather than just the subbasin(s) of interest. As a result, the NHD will be displayed as a small dot on the screen. A warning message about the extent will display; however, it can be ignored. We have been unable to correct this, so each time the full extent is requested, the United States is the reference rather than the subbasin(s). To set a proper view extent, follow these steps:
  - b. Zoom in as tight as possible to view the entire subbasin(s).
  - c. Go to “View”, “Bookmarks”, and “Create”, then name the bookmarked view.
  - d. To return to this view, go to “View”, “Bookmarks”, and then click on the named bookmark.

### ***Setting up the Command Bar***

A number of icons can be set up in the command bar depending on the depth of the work to be performed.

1. Set up the Utility Network Analyst Toolbar.
  - a. Go to ‘View’, ‘Toolbars’, and then select “Utility Network Analyst” from the pull down menu.
  - b. Once this appears, click on the toolbar and drag it off the map view window to the command bar area.
2. Set up the Editor Toolbar the same way.
3. Set up some common Select icons.
  - a. Right click on the empty area of the toolbar at the top of ArcMap.
  - b. Select “Customize” from the pull down menu.
  - c. Click on the “Commands” tab.
  - d. From “Categories” scroll down and click on “Selection”.
  - e. Drag icons from Commands to an empty area of the toolbar to install. Drag each icon to the very end of the existing icons where it becomes a vertical bar. Common icons to use are:
    - i. Clear Selected Features
    - ii. Select by Attributes
    - iii. Select Features (also on Tools)
    - iv. Switch Selection
    - v. Zoom to Selected Features
4. Set up some common Linear Referencing icons. Do “a” through “c” above.
5. Scroll down and click on “Linear Referencing”.
  - a. Drag each icon to an empty area of the toolbar to install. Common icons to use are:
    - i. Add Route Events
    - ii. Convert Hatches to Graphics (optional)

- iii. Display Route Events
- iv. Identify Route Locations
- v. Route Events GeoProcessing Wizard

### ***Organizing Directories and Files***

The following procedures for organizing the NHD are suggested when conducting in-depth analysis of the NHD. This is entirely optional. In-depth work with the NHD will accumulate many files. Managing those files with folders will make work easier and cleaner when it is time to clean up files. There are many variations on this, but some general advice follows:

1. Create a project folder. If working in Yellowstone NP, call it “Yellowstone”.
2. NHD data will come in a zip file. When unzipped there will be one Access file that contains all of the NHD data. The Access file is composed of a Personal Geodatabase that contains the “Hydrography” and “HydrologicUnits” feature data sets. Within “Hydrography” there are 6 feature classes containing the actual NHD. Within “HydrologicUnits” is the hydrologic unit boundary data that may include up to the sixth level subwatersheds if they are available. The Personal Geodatabase also contains a dozen or more tables known as “object classes” including the NHDFlow table and various metadata. All of this information can be seen by looking in ArcCatalog, but cannot be viewed in Windows Explore. If additional geodatabases are created inside this geodatabase, they will be stored under this geodatabase. Create a folder for the geodatabase data. Call it “Geo\_Data” (under Yellowstone). Move the zip file into “Geo\_Data” and unzip it there. It is a good practice to rename the NHD zip file, and the unzipped Geodatabase, to something meaningful to the area, such as “Snake\_Headwaters.”
3. Raw event data, such as the lat/long locations of water sampling sites, should be kept in a separate folder such as “Water\_Data” (under Yellowstone). Name files to indicate the type of event, such as “Water\_Chem\_8\_19\_03”. Usually these are Access, Excel, or dBase files.
4. Events being created should be kept in a separate event folder, such as “Linear\_Events” (under Yellowstone). When creating an event in ArcGIS, the user is given the choice to name it. In the TOC, that filename automatically will end in the word “Event”, but not in Explore.
5. Shapefiles associated with events may be created or used. Create a folder for these “Event Shapefiles” (under Yellowstone).
6. If using some ancillary shapefiles, such as Park Boundaries, create a folder for these, such as “Ancillary Shapefiles”.
7. The hydrologic units can be found under “HydrologicUnits”.
8. If polygon buffer shapefiles are created, keep them in a folder called “Buffers” (under Yellowstone).
9. If creating some navigation result shapefiles, store these in a folder called “Nav\_Results” (under Yellowstone).
10. If additional folders are required, create subfolders under the project folder such as “Streamgage\_Events”, and then store everything associated with streamgages

under the subfolder. Anything associated with biology might be in a subfolder, “Aquatic\_Biota”.

### ***Navigating the Hydrologic Network***

Out-of-the-box navigation in ArcGIS is a little different than what is used in the NHD Toolkit. ArcGIS navigation is based on a geometric network, and navigates node-to-node on NHDFlowline. ArcGIS uses the Hydro\_Net network rather than levels, so it can't find a main path upstream or downstream. ArcGIS will navigate everything connected upstream or downstream, through branches or divergences. The navigation result is set to a temporary display graphic, but it can be switched to select NHDFlowline features. The result can be saved by converting the selected NHDFlowlines to a feature class, shapefile, or layer. Since the navigation is node-to-node on the NHDFlowline, a navigation result can't be produced to and from midpoints. Results will display the entire NHDFlowline segment.

#### **Flow Path Navigation**

- a. The NHDFlowline is the basis for the network.
- b. Use the Utility Network Analyst Toolbar.
- c. Start navigation by clicking on the “Add Edge Flag Tool”. Choose to start at an endpoint node or at a midpoint by clicking on the appropriate icon. In either case, the entire NHDFlowline feature will be included in the result. The midpoint option doesn't start or stop the navigation result at the midpoint.
- d. Click cursor at appropriate point on the flowline to set the starting point.
- e. (Note a “barrier” also can be chosen. Barriers prevent a trace from continuing along a stream. Select a “barrier type”, and then click the cursor at the appropriate point on the flowline.)
- f. Select “Trace Task”: (a) Trace Downstream – finds the path downstream including divergences, (b) Find Upstream Accumulation – finds all paths upstream including branches. You also can use Trace Upstream for an upstream navigation with branches. To inspect the quality of your NHD data you may also (c) Find Disconnected streams or (d) Find Loops (although these are geometric loops, not necessarily flow loops).
- g. Click on “Solve” icon at the right end of the Utility Network Toolbar. The navigation will highlight the appropriate NHDFlowlines.
- h. To clear the result and navigate another path, click on “Analysis”, and then “Clear Flags”, “Clear Barriers”, or “Clear Results”.
- i. To do a point-to-point navigation, start upstream, use a downstream barrier, and then trace downstream.
- j. Experiment with the functions of some of the other Trace Tasks.

#### **Creating a Navigation Result**

Navigation results can be saved for a variety of reasons including creating map symbology, sharing the path with another user, or using it for analysis.

- a. Follow the process for Flow Path Navigation with the appropriate modifications listed here.

- b. Click on “Analysis” in the Navigation Toolbar, and then click on “Options” and “Results”.
- c. Click on the “Selection” radio button, then ”Apply” and “OK”.
- d. Perform navigation. The navigation path will indicate selected NHDFlowlines. Note that this function in ArcMap doesn’t always work. We don’t know why, or how to work around this inconsistency; however, the inability to work once doesn’t mean it won’t work later.
- e. Right click on NHDFlowline in the TOC and go to Selection (see “h” to create a Shapefile).
- f. Click on “Create Layer from Selected Features”.
- g. A new layer will be created and named “NHDFlowline selection”. The name can be changed by right clicking on the “layer name”, clicking on “Properties”, clicking on the “General” tab, then retyping the Layer Name in the Layer Properties window.
- h. Alternately in “e”, after “Right Click on NHDFlowline”, go to “Data”.
- i. Click on “Export Data”.
- j. Choose the appropriate folder and filename (usually Nav\_Result1, or similar, in the Shapefile folder).
- k. Click “OK”. A pop-up processing window appears.
- l. Click “OK” to add to your view.
- m. The symbology can be collapsed by going to the layer Properties window, clicking on the “Symbology” tab, and changing the Value Field to “Reach Code”.
- n. A new symbol can be created by double clicking on the linear symbol.

### **Attributing a Navigation Result**

The navigation result layer created above will contain all of the original attributes of the NHDFlowline. Additional attributes to characterize the navigation result also can be created. Right click on the layer, click on “Open Attribute Table”, “Options”, and “Add Field”. This allows classifying or grouping of attribute data for display purposes.

### ***Linear Referencing Point Events***

The creation of events using linear referencing is a fundamental capability to exploit the power of the NHD. Linear addressing of events on the NHDFlowline network establishes their position on the linear network. The relation of events on the network can then be studied, such as which events are downstream or upstream, what is the distance between them, how many similar events are there, and what is their navigational sequence.

### **Loading Point Data**

Point event data often are obtained as geographic coordinates, either from a file such as the National Water Information System (NWIS), or from a GPS instrument. These data can be indexed to the NHD by first loading it into ArcMap.

- a. Click on “Tools” and then click on “Add X, Y Data”.

- b. Navigate to the table that has the X, Y data in it. The table needs an X, Y coordinate in separate fields. Make sure these are referenced to NAD83, which is used for the NHD. An identifier for the record, such as a streamgage number, is needed to uniquely identify the points. A field with a value for the event, such as 28.9 cubic feet per second, is also helpful.
- c. Once the table and X, Y fields have been identified, click “OK”.
- d. The new point layer will appear in the TOC and the points will appear on the screen. The layer name will be the same as the input table. The layer can be renamed by right clicking on the layer, clicking “Properties”, and the “General” tab. The points can be re-symbolized by double clicking on the symbol in the TOC.

### **Convert Point Data to a Shapefile**

To spatially edit point data, convert it to a shapefile. Spatial editing may be necessary if the point data will not conflate properly when performing reach indexing. The point data have already been added using the “Add X, Y Data” function. This is actually a .dbf file, which cannot be spatially edited. The event creation steps below work more reliably when using points in a shapefile.

- a. Right click on the point data.
- b. Click “Data”, then “Export Data”.
- c. “Export All Features”, and “Use Same Coordinate System”.
- d. The name of the exported shapefile can be changed.
- e. Click “OK”. Respond appropriately to “add the data to the view”.

### **Creating Point Events from a Shapefile**

- a. Click the “Locate Point Features Along Routes” radio button. Click “Next”.
- b. Choose the point layer to be located. This is the point shapefile created above.
- c. Choose the “Route Reference”. This is the NHDFlowline. In some instances NHDFlowline is not offered and cannot be chosen even if navigated to. If this happens, go to the TOC and move NHDFlowline to the top of the list ahead of any other feature classes or layers that might have a route used for linear referencing.
- d. Choose the “Route Identifier”. This should be the ReachCode.
- e. Specify the search tolerance within the Geoprocessing wizard interface. Default is zero. This is the maximum distance to locate a linear reach. A reasonable number for USGS NWIS streamgages is 250 ft. To manually check how far the points are from the NHDFlowline reaches, use the “Measure” tool in the Tools toolbar. Click “Next”.
- f. Specify the output event route table. It is a good idea to have a separate folder to store events.
- g. Specify the Route Identifier, “ReachCode”. Specify the Measure, Measure.



- h. Check “Keep only the closest route location”, “Include fields from input layer”, and “Add new table to map Layer” radio button. Click “Finish”.
- i. Processing windows will appear on the screen as it processes. A new layer is added to the TOC and points appear on the map. Those points that exceed the tolerance will not index. Also, there have been numerous reports that sometimes individual points within the tolerance are not being indexed in an apparent error.
- j. Right click on the new point event layer and select “Open Attribute Table”. Notice that each point is referenced along a reach with a “Measure”. Also notice that all of the original fields are included in the point event layer. This includes the original X, Y coordinates, not new X, Y locations.
- k. Check to determine how many points indexed. It may be necessary to increase the search tolerance and run the process again.
- l. Check the indexing performance. If a point event is in a congested area, it may have snapped to the wrong reach. Check each event. To start, zoom to the new event theme to get an overview. Assuming a different symbol was used for the original points and the point events, check to make sure each point is overlaid by a point event. If the point event is missing, it did not conflate.

### **Spatially Edit the Original Point Data**

In case a legitimate event was not properly indexed, spatially edit the input point to a more correct position near the flowline, and then re-index.

- a. A shapefile or a geodatabase will be edited.
- b. Click the “Editor Toolbar” icon next to the scale window.
- c. Click “Editor”, then “Start Editing”.
- d. Select the database to edit. Usually, the choice is between the NHD personal geodatabase, and a folder with event data, which should include shapefiles. A list of editable files will be presented, but only shapefiles or a geodatabase are editable.
- e. Ignore the coordinate system message.
- f. Specify the correct database in the “Target” pull down menu.
- g. To move the point feature, click the pull down menu under “Task”, and select “Reshape Feature”.
- h. Click the “Edit” icon, which activates the selection mode of the cursor.
- i. Click on the “point” feature and allow it to highlight.
- j. Click again on the “point” feature and hold the button down. Then drag the point feature to the new position.
- k. To un-highlight the feature, click on “Selection”, then “Clear Selected Features”.
- l. When editing is complete, click on “Editor”, then “Stop Editing”.
- m. Save the edits as appropriate.

## Editing an Event

There is no easy way to edit the position of an event once it has been created. The event cannot be directly edited spatially. It is possible to edit the address values in the event table, but this is a strictly manual process, and subject to errors. A second approach is to edit the original shapefile position to get a better result and then re-index.

- a. An event can be edited by editing any field in the event table.
- b. Click on the “editor toolbar”, then “Start Editing”.
- c. Right click the proper “event table” in the TOC.
- d. Edit the appropriate value by clicking on it and entering a new value.
- e. Use the Identify Route Locations icon noted earlier to find the measure of the correct location. Use the Identify icon to find the reach code.
- f. The event can be moved by editing the measure and the reach code values. Note that it is easy to make a mistake. If these fields are edited, the event actually moves to the new measure on the screen. View this to verify the measure edit was correct. The measure is referenced to a reach, so it is important to understand the starting and ending nodes of the reach.
- g. A field also can be added to the event table if more attribute information is added.
- h. “Stop Editing” and “Save Edits”.

## Appending Attributes to the Event Table

A common task is to add a series of attributes to the event table. This can be done manually by creating fields and entering data, or linking two tables together. Two tables can be linked either by a “Join” or a “Relate”. In either case the two tables need a common field where values correspond, for example, an event ID such as a streamgage label. Join tables is good for one-to-one and many-to-one relationships. Relate tables is good for one-to-many relationships. For example, a water monitoring site may have several days of values associated with the site.

- a. Join tables
  - i. Right click on the layer. Click on “Join”.
  - ii. Select the “field” on which to base the join.
  - iii. Select the “table” to join to.
  - iv. Select the “common field” in that table.
  - v. An expanded table can be seen with the joined information.
- b. Relate tables
  - i. Right click on the layer. Click on “Relate”.
  - ii. Select the “field” on which to base the relate.
  - iii. Select the “table” to relate to.
  - iv. Select the “common field” in that table.
  - v. To see the related data click on “Options”, then “Related Tables”.
  - vi. Select “records” in one table, click “Options” and “Related Tables”. The corresponding records in the other table will be selected.
  - vii. Query the result of the “Join” or “Relate” in ArcMap (Select by Attributes).

## Interactively Create a Point Event on the Map

This is done by creating a point and then indexing that point. It is useful when creating events in the office by observing map locations. It also can be easily done using EventMaker. There are two approaches to creating the point that can be used. The easiest approach is to add a point to an existing shapefile. If an existing file is not available to act as a template, a feature class can be created and a point added to it.

- a. A new point feature also can be created as follows:
  - i. Go to Spatially Edit the Original Point Data and do steps “a” through “f”.
  - ii. To add the point feature, click the pull down menu under “Task”, and select “Create Feature”.
  - iii. Click on the “Pencil” icon. This activates the cursor to place the point feature.
  - iv. Click at the appropriate point. A new highlighted feature will appear.
  - v. The new record will be empty. To populate needed fields, click on the “Table” icon while the feature is still highlighted.
  - vi. A pop-up table will appear. Populate as required. Exit the pop-up window.
  - vii. “Stop Editing” and “Save Edits”.
  - viii. Exit the Toolbar.
  - ix. Create event.
- b. To start from scratch:
  - i. Go to ArcCatalog and click on a folder where the point will be stored.
  - ii. Right click on the folder and click “New”.
  - iii. Click on “Shapefile”.
  - iv. Name the new file and then select “Point” for the feature class.
  - v. In the Spatial Reference box click “Edit”.
  - vi. Use NAD83. Click “Apply”, then “Next”.
  - vii. Check the “M-value” and “Z-value” boxes.
  - viii. The shapefile will be added to ArcCatalog. Right click on it.
  - ix. Click on “Properties”, then the “Fields” tab.
  - x. Change the ID to text. This will be the feature ID, such as a streamgage.
  - xi. Go to ArcMap and add the new shapefile.
  - xii. Click on the “Editor Toolbar”.
  - xiii. Click “Editor”, then “Start Editing”.
  - xiv. Select the database to edit. Edit the new shapefile.
  - xv. Ignore the coordinate system message.
  - xvi. Specify the new shapefile created in the “Target” pull down menu.
  - xvii. Add a new field to the table as necessary by right clicking on the shapefile and clicking on “Attribute Table”. Select “Options”, then “Add Field”.

- xviii. To add the point feature, click the pull down menu under “Task”, and select “Create Feature”.
- xix. Click on the “Pencil” icon. This activates the cursor to place the point feature.
- xx. Click at the appropriate point. A new highlighted feature will appear.
- xxi. The new record will be empty. To populate needed fields, click on the “Table” icon while the feature is still highlighted.
- xxii. A pop-up table will appear. Populate as required. Exit the pop-up window.
- xxiii. “Stop Editing” and “Save Edits”.
- xxiv. Exit the Toolbar.
- xxv. Create event.

### ***Linear Referencing Linear Events***

Linear events are very important in hydrography, or any other route system, because event data often occurs on varying segments of a route, such as a segment of fish habitat from point A to point B. The segment of the river to classify usually is determined by collecting start and stop GPS coordinates from fieldwork, or identifying the segment on a map. ESRI doesn’t provide the functionality to interactively create linear events from endpoints, so alternative functions must be used. ESRI allows only linear events to be created from polygons, so polygons will be used. Linear event routes will be identified by tracing a polygon around them. This method works, but can have some flaws. See the [NHD EventMaker](#) section below to do this more accurately with a custom tool.

### **Interactively Create a Linear Event**

If determining a linear event route from field points, add the points to ArcMap as previously discussed. Then use the points to guide the polygon tracing.

- a. Create a polygon feature class.
  - i. Go to ArcCatalog and create a polygon shapefile.
  - ii. Right click on the folder where this file will be stored.
  - iii. Go to *New* and click on “Shapefile”.
  - iv. Rename the file and select “Feature Type: Polygon” from the drop down menu.
  - v. Click on “Edit” and Select a “NAD83” coordinate system. Click “OK”.
  - vi. A field for an attribute code can be added.
  - vii. Click “OK”. Verify that the shapefile is visible in the TOC.
  - viii. Go to ArcMap and add the new shapefile.
- b. Trace the polygon.
  - i. Go to the “Editor Toolbar” and “Start Editing”.
  - ii. Select “Create New Feature”.
  - iii. Select the polygon shapefile just created.
  - iv. Click on the “Pencil” icon to trace a feature.
  - v. Single click on a starting point.

- vi. Single click for each vertex in the polygon.
- vii. Double click on the last vertex before closing the polygon.
- viii. The polygon feature will be established and will “fill” on the screen.
- ix. “Stop Editing” and “Save Edits”.
- c. Create a linear event table from the intersection of the NHDFlowline and a polygon.
  - i. Go to the Route Events GeoProcessing Wizard.
  - ii. Click on the “Locate Polygon Features Along Routes” radio button. Click “Next”.
  - iii. Choose “Polygon” layer, the polygon just created, to be located.
  - iv. Choose “Route Reference NHD routes”, normally NHDFlowline.
  - v. Choose “Route Identifier”, ReachCode. Click “Next”.
  - vi. Specify the output route event filename.
  - vii. Choose “Route Identifier”, ReachCode.
  - viii. Choose “From Measure” and “To Measure” fields. Click “Finish”.
  - ix. A pop-up window appears indicating processing and a new event table appears in the TOC.
  - x. Open the attribute table and verify that it worked. The ReachCode and the From and To Measure addresses should be shown.
  - xi. To keep track of the various events, edit the ID.
  - xii. Previous events will not be duplicated if this is repeated.

### **Creating a Linear Event from Navigation.**

- a. Perform the appropriate navigation with the result set to selected features.
- b. Activate the “Buffer Wizard” (under Tools).
- c. Use “Only The Selected Features”. Click “Next”.
- d. At “A Specified Distance of 5 Meters” (or another buffer distance if preferred).
- e. Click the “Dissolve Buffers” radio button. Change output filename. Click “Finish”.
- f. A pop-up window will indicate processing. It could take several minutes depending on how large the selection.
- g. A buffer polygon layer will be added to the TOC and will be displayed. Make sure it worked correctly.
- h. Intersect the buffer with the NHDFlowline routes.
  - i. Go to the “Route Events GeoProcessing Wizard”.
  - j. Click on the “Locate Polygon Features Along Routes” radio button. Click “Next”.
  - k. Choose “Polygon” layer, the polygon just created, to be located.
  - l. Choose “Route Reference NHD routes”, normally NHDFlowline.
  - m. Choose “Route Identifier”, ReachCode. Click “Next”.
  - n. Specify the output route event filename. Do not add to an existing file.
  - o. Choose “Route Identifier”, ReachCode.
  - p. Choose “From Measure” and “To Measure” fields. Click “Finish”.

- q. A pop-up window appears indicating processing and a new event table appears in the TOC.
- r. Open the attribute table and verify that it worked. The ReachCode and the From and To Measure addresses will be visible.
- s. To keep track of the various events, edit the ID.
- t. Previous events will not be duplicated if this is repeated.

### ***Creating Event Metadata***

Don't forget the metadata! Anybody can create data, but it isn't scientifically valid data unless there is a citation. The metadata created will provide basic documentation that explains where the data came from and its basic characteristics.

1. With NHD displayed in ArcMap, go to ArcCatalog.
2. In the dialog box that appears, browse and select the file to which the metadata will be created. Click on the "Metadata" tab.
3. To automatically create a metadata record, click on "Tools", then "Options" in ArcCatalog. Click on the "Metadata" tab. In the first box, select "FGDC ESRI". In the second box, be sure the "Creating Metadata" box is checked. Check the third box also. In the fourth box, select "FGDC Metadata". Click "OK". These settings can be used for all subsequent files created.
4. The "Create/Update" metadata icon on the ArcCatalog Metadata toolbar can be selected for the same result. Again, select the "FGDC ESRI" editor.
5. Under the "Metadata" tab the overlay name and three tabs will be displayed; "Description", "Spatial", and "Attributes".
6. Click the "Edit Metadata" icon on the Metadata toolbar (first on the left).
7. The box for editing metadata has 10 tabs. Take time to review each tab, noting the required fields for metadata in red, making sure each item also is reviewed. It is helpful to create a Word document ahead of time for standard information that will be provided for each event table (gages, dams, diversions, for example). Cut and paste the standard information to save typing.
8. Start with the first tab and fill out the required fields, complete all tabs and all sub-tabs. Note that some questions have a pull down menu with selectable answers.
9. Click "Save" when complete.

### ***Adding Existing Event File***

Event files created by someone else also can be used. This can be either a point event file or a linear event file. It doesn't matter whether this file was created in NHDinARC, NHDinGEO, or NHDGEOinARC. The event file only requires a record with a reach code and a P\_measure for a point event theme, or a reach code and a To\_measure/From\_measure pair for a linear event. Typically the event file will be a .dbf file. ArcMap (or ArcToolbox) has a command (and icon) for adding an event theme. Note that an event created from the medium resolution NHD may not correspond to the high resolution NHD if the original ReachCode has been retired. Also, the differences in the medium resolution NHDFlowline

and the corresponding high resolution NHDFlowline may place the event in a slightly different location.

1. Set up the NHD in ArcMap.
2. Obtain an event file.
3. Click on the “Add Route Events” icon (this also can be found under Tools).
4. For Route Reference use NHDFlowline (this is the theme that is of type PolylineZM – needed for routes and events). The Route Identifier is ReachCode (the measures are related to reaches).
5. The Event Table is the .dbf file that has the reach code and P\_measure containing the data to relate to the NHD. The Route Identifier is the field name with the reach code in it.
6. Click the radio button that identifies if this is a “point theme” or a “linear theme”.
7. The Measure is the field name(s) that contains the address measurements.
8. An Offset can be used, but this is rare.
9. Advanced Options are not needed.
10. Click “OK”.
11. The .dbf file from 5 above will be added to the TOC and the events will be displayed on the map.
12. Do the necessary quality control to ensure it worked.

### ***Converting Events from One Route Reference to Another***

Legacy hydrography data, upon which routes are built for the linear reference system, have been used by scientists to record event data rather than the system usually used for the NHD. A system commonly used has been the LLID system where an entire length of river is the reference route. The mouth of the river is measure 0, and the farthest headwater reach is the endpoint measure, (for example 33,645 meters). An event would be addressed at its value between 0 and 33,645 meters. This 33,645 meter route would need a unique identifier label, so the longitude and latitude of the mouth was used, thus the term “LLID”. The address of an event might be route-1243613434853, measure-17698. Tributaries to this primary route would become additional routes with the LLID label coming from the confluence point. The NHD uses reaches as the linear referencing route; an entirely different system, but one that works quite well thanks to the flow sequencing of reaches using the NHDFlow table, which makes it possible to relate events anywhere in the network. ArcMap makes it easy for legacy event data to be converted to the NHD linear referencing system. This also is useful to rebuild events if extensive editing of the NHDFlowlines in stewardship results in newly built routes.

1. Add the legacy hydrography data and the original events to which they were referenced in ArcMap, then add the NHD.
2. By clicking on the “Route Events GeoProcessing Wizard”, the *Transform events from one route system to another* becomes active because ArcMap detects two route systems, the legacy routes and the NHD routes, plus an event table linked to the legacy routes. Click on this radio button and click “Next”.
3. The wizard requests information on the events to be transformed. Select the appropriate legacy event layer. Then select the Route Reference system to be transformed to, which is the NHDFlowline, along with the Route Identifier, which

is ReachCode. Select a search tolerance by finding the nearest NHDFlowline. Click “Next”.

4. Specify the name for the transformed event table and the name for the fields for Route Identifier and Measure. Use defaults. Click “Finish”.
5. After a short processing interval, the newly transformed events are added to the table of contents and displayed. The new table will include the new route and measure, but not the original route and measure. The transformation works by spatially searching each event for the nearest measure on the new route system.

## **More Information about Events**

### **How to Look at X, Y, Z, and M values**

In the NHDinGEO, there is an M-value associated with every vertex in the NHDFlowline coordinate string. These values can be viewed using the following method.

- a. Click on the “Editor” icon and “Start Editing”.
- b. Go to “Task” and scroll to “Modify Feature” in the drop down menu.
- c. Go to “Target” and scroll to “NHDFlowline” in the drop down menu.
- d. Select a “Feature”
- e. Click on the “Sketch Properties” icon on the far right of the Editor Toolbar.
- f. A pop-up window will appear with the X, Y, Z, and M values at each vertex. Each vertex also will be shown on the map.

### **How to Find the Address at Any Point on a NHDFlowline.**

This method gives the Reach, NHDFlowline, and Measure used in NHD linear referencing. It uses the “Identify Route Locations” icon.

- a. Right click on NHDFlowline in the TOC. Then click on “Properties”.
- b. Click on the “Display” tab and check the “Show Map Tips” box.
- c. Then click on the “Fields” tab. Under the “Primary Display Field” scroll down and select “ReachCode”. Click “Apply”, and “OK”.
- d. Click on the “Identify Route Locations” icon and place the cursor over any NHDFlowline. The ReachCode will display next to the cursor.
- e. By clicking on the NHDFlowline, a window will appear. Note values. The ComID, Measure, minimum measure of the selected flowline, and the maximum measure of the selected flowline is displayed.

### **Intersect Two Route Events**

As the name implies, this finds similar records in two event files. It can be used to find a point event upstream of a location. For example, find all permitted discharge events upstream from a water-quality sampling point. To do this, navigate upstream from the water-quality sampling point and turn the navigation result into an event. Then intersect the navigation event with the permitted discharge events. To look for intersecting reaches, use the Geoprocessing Wizard. Note that a better approach to this specific problem can be found in “Finding Events Downstream or Upstream”.



- a. Click on the “Geoprocessing Wizard” icon created, or go to “ArcTools”, then “Linear Referencing”.
- b. Click on the “Intersect Two Route Events” radio button. Click “Next”.
- c. Enter the event table being used to search. This is the water-quality sampling point navigation result event table.
- d. Enter the event being sought. This is the permitted discharge event table. Click “Next”.
- e. Enter the outpoint filename. Enter the Route Identifier field on which to intersect, “ReachCode”. Enter Measure, “Measure”. Click “Finish”.
- f. A pop-up menu appears with processing. If intersects are present, a new layer is added with the filename given. View the table and review the intersects for correctness. A table of intersected events now exists; in other words, all the permitted discharges upstream from the water-quality sampling point have been identified.

### **Union Two Event Theme**

Two event themes can be combined using the *Union* function available in “a” above. It actually unions the two event tables and is handy in adding a second set of events to an event table.

### ***Finding Events Downstream or Upstream***

One of the most powerful types of analysis that can be performed with the NHD is to search for events downstream or upstream. For example, a pH measurement from a water-quality monitoring station is available, and additional pH measurements downstream are needed. This will involve navigating downstream from the initial water-quality monitoring station and selecting all the NHDFlowlines on the navigation path. A relate between the water-quality monitoring station event table and the NHDFlowline attribute table can be used to simultaneously select water-quality monitoring stations with similar reach codes.

1. The water-quality monitoring stations will need to be indexed to the NHD using linear referencing in which the NHDFlowline is used as the Route Reference and the ReachCode is used at the Route Measure. See instructions above on how to create or import events.
2. Go to the water-quality monitoring station event table in the TOC and right-click on it. Select “Joins and Relates”, then click on “Relate”.
3. A pop-up window will first ask for the field the relate will be based on. Select ReachCode or another field name that identifies the reach code used by NHD events. Choose the table to relate to. This will be the NHDFlowline in the NHD data set. Select the field in this table to base the relate on. This always will be ReachCode. Name the relationship. More than one may exist later.
4. Navigate downstream. Do this by first placing the starting flag at the correct location, in this case, the initial water-quality monitoring station. Click on “Analysis” in the Utility Network Analyst then click on “Options”. Change the Results format to Selection. Select “Trace Downstream” and click the “Solve” icon. The downstream NHDFlowlines will be selected.
5. Go to the TOC and right click on NHDFlowline. Click on “Open Attribute Table”. Note that some NHDFlowlines have been selected. Click on “Options”

at the bottom of the table, and then click on “Related Tables”. Click on the relate named in “3” above.

6. This automatically will open the water-quality monitoring event table. All event records with a reach code matching the reach codes in the navigation path will be selected. They also will be selected on the map.
7. Now that the events downstream have been identified, an additional query can be performed, such as “Select by Attribute, Method-Select” from current selection, and set up an SQL to find all pH values collected on the same day based on the collection date. Or, the selection could be saved for later use.

### ***Finding Events Downstream or Upstream Using a Spatial Search***

It also is possible to find events on or near a downstream or upstream navigation path spatially.

1. Events are needed, but they do not necessarily have to be in an event table, they simply can come from a shapefile. Preferably they should be snapped to the NHDFlowline, but it also is possible for them to simply be near the flowline.
2. Establish a flow direction from a point on the network. Navigate upstream or downstream in search of events. For example, navigate upstream from a drinking water intake in search of any permitted discharges upstream.
3. From this initial point, navigate using the NHD geometric network. Trace upstream with the result of selected NHDFlowlines.
4. Use the ArcMap Select by Location function. Within the Select by Location window:
  - i. “Select features” from the
  - ii. “Permitted Discharge” that
  - iii. “Intersect” the features in the layer
  - iv. NHDFlowline
  - v. “Using selected features”.
  - vi. Click on “Apply”.
5. The permitted discharges upstream from the drinking water intake will be selected.
6. If the permitted discharges are not exactly on the NHDFlowline, go to the above and before clicking “Apply”.
  - i. “Apply buffer to features in NHDFlowline”. Normally, most events are located within 250 feet of a flowline. You will need to try various buffers to find the most appropriate one.

### ***Finding Events Using EventFinder***

Besides the ability to navigate the NHD using the geometric network, it also is possible to navigate using a logical network. This involves using the NHDFlow table found as an associated object class with the NHD dataset. The EventFinder software searches the NHDFlow table to find the appropriate navigation path downstream or upstream.

1. EventFinder is a template file with a .mxt extension (download at: [ftp://nhdftp.cr.usgs.gov/Workshops/NHD\\_Tools/](ftp://nhdftp.cr.usgs.gov/Workshops/NHD_Tools/)). Open ArcMap and select the “Start ArcMap” with “A Template” radio button. Navigate to the EventFinder

- .mxt file. This should be a copy of the original EventFinder.mxt and renamed to the appropriate project area name.
2. Add the NHD data.
  3. Add the NHDFlow object class found with the NHD data. If a second NHDFlow should appear in the TOC, remove it with a right click and remove.
  4. In the status bar at the top of ArcMap you will find the globe-like EventFinder icon. Click on this icon to start EventFinder.
  5. Enter the full pathname of the geodatabase being used. See the Source option in the TOC.
  6. Enter the full pathname of the event file to be searched.
  7. Use the Select function to choose a starting NHDFlowline to begin the navigation path. Then choose upstream or downstream for the path direction.
  8. EventFinder will then search of events in the named file located upstream or downstream from the starting NHDFlowline and select the appropriate records.

### ***NHD EventMaker***

This is a tool that works in ArcMap to make it easy to interactively create events on an NHD display. A separate EventMaker is available for ArcGIS 8.3 and ArcGIS 9.0. EventMaker must be installed using an installer supplied. Then it is used as a toolbar added to an ArcMap session. Point or linear events can be created. Its unique characteristic is that it allows the direct creation of events, and allows linear events to be created interactively from point-to-point. The events are stored as a feature class within an event geodatabase, providing both a spatial and address referenced position.

1. Obtain the EventMaker tool zip file and unzip it, preferably putting the software, documentation, and installer in a directory where tools are kept.
2. Navigate to the EventMaker files and double-click on “install.bat” to install the EventMaker tool as an extension to ArcMap.
3. Open an empty ArcMap session. Click on “View”, then click on “Toolbars” and check “EventMaker”. The toolbar will appear in the ArcMap window.
4. Add the NHD data. The EventMaker works with the NHDFlowline.
5. Start ArcCatalog, navigate to a directory where events are stored, then right click.
6. Select “New” and then click “Personal Geodatabase”. Name the file appropriately. This is a separate geodatabase being created to store events.
7. Exit ArcCatalog.
8. On the EventMaker Toolbar, click on “Output”.
9. Click on “Create New Output Feature Class”.
10. Click on “Linear” or “Point” for creating linear or point events.
11. If the “Store Only One Feature per Segment” box is checked, one event record for each linear event will be created, containing the to and from addresses. If the box is un-checked, it will store one NHDFlowline per record for the entire distance on the event (preferred).
12. Browse to the event geodatabase created in ArcCatalog and double-click, making sure the .mdb file is listed in the “Look in:” box.
13. Create a Polyline Feature Class by entering an appropriate file name under the “New” box, then click “Save”.

14. The Setup Output menu will list the Output Path as the file just created. Click “OK”.
15. A new Feature Class will appear in the TOC. Click on “Source”, note that it is in a separate geodatabase.
16. Next, create a linear event. To do this “Linear” should be selected in “10” above. The “flag” icon should be active in the Eventmaker toolbar. If it isn’t, the proper event feature class is not set up.
17. Click on the “flag” icon, and then click on one end of the linear event. Note the crosshair and circle. The circle is the size of the search tolerance. When you click on the endpoint, the measure will display next to it. After the endpoint displays, click on the other end of the event.
18. Find the path between the two endpoints. Make sure the last window in the toolbar indicates “Find Path”. Then click “Solve Trace” in the EventMaker toolbar. The path between the points will highlight. Creating the linear event works by tracing the flowpath between the two points.
19. To keep this event, click on “Write” in the EventMaker toolbar. To discard the event path and try again, click on “Clear”.
20. Alternatively, it is possible to find the complete upstream path from a single endpoint, or the complete downstream path from a single endpoint. This is done by switching the selection in the last dropdown list in the EventMaker toolbar to “Trace Downstream”, or “Trace Upstream”.
21. If keeping the event, a window will appear asking for the “Name” and “ID” for the event. Enter these, then click “OK”. The event will turn color, indicating that the event has been created
22. Additional linear events in this feature class can now be created. It is wise to have a separate feature class for different categories of events, such as channel classifications vs. fish habitat.
23. When complete, go to the editor toolbar and click “SaveEdits”.
24. Save this event making session as a separate .mxd file that can be revisited later.

### ***Projecting the NHD***

NHD analysis is often worked within its native geographic coordinates; however, this provides a spatially distorted view, basically stretching the display out in the x direction by about 30%. To make the NHD spatially correct, it needs to be projected. This is particularly important when making a map. There are two approaches you can take. One is if you simply want to make a graphic map and don’t really want to analyze the data in a GIS. For this approach you can simply use ArcMap functionality:

1. Display the NHD data in ArcMap.
2. Right-click on the display and then click “Properties”.
3. Click on the “Coordinate Systems” tab.
4. Under “Select a Coordinate System” click on the appropriate choice. Typically this will be “Predefined”.
5. Click on “Projected Coordinate Systems” and follow the appropriate choices.

However, if you want to analyze the NHD in ArcMap, your best choice is to use a routine developed by the U.S. Forest Service to project the NHD in ArcCatalog. Some advantages of the routine, called the USFS Reprojection Tool, are: The ESRI tools only work on one

feature class at a time. The USFS Reprojection Tool does everything in the PGDB at once. With the ESRI tools, the user manually has to add/move/reconstruct the relationship classes into the new PGDB; the USFS Reprojection Tool does this for the user. The user must also manually add any non-spatial objects (tables) in the ESRI native tools; again, the USFS Reprojection Tool does it for the user. Networks seriously lengthen the reprojection time. The USFS Reprojection Tool drops the networks, forcing the user to rebuild them as ESRI intended so that ALL edges are reconnected and Utility Network Analyst tools function. To obtain the USFS Reprojection Tool:

1. Go to the NHD website <http://nhd.usgs.gov/applications.html>
2. Click on the “USFS Reprojection Tool”, read the information provided.
3. Go to “Loading and Installing”, click on “Reprojection\_Tool\_USFS.zip” and save as appropriate.
4. Also, go to <http://nhd.usgs.gov/tools.html> and click on “NHD Network Builder”.
5. Go to “Downloading and Installing”, click on “Network\_PGDB\_SO\_FL.exe” and save as appropriate.
6. Unzip the Reprojection\_Tool\_USFS.zip
7. Make sure ArcCatalog is closed.
8. Go to Windows Explore and click on “Setup.exe”
9. Follow the wizard instructions. It should be a simple operation.

It is now possible to project the NHD.

1. Go to ArcCatalog.
2. Click on the appropriate NHD personal geodatabase.
3. Click on “View”, “Toolbars” and check “USFS Reprojection Tool”.
4. A toolbar appears that says: “Reproject” and “Help”. Click on “Reproject”. The word “Reproject” will not highlight unless the NHD personal geodatabase has been selected first.
5. A message may appear asking to increase the number of records. Follow the instructions.
6. The Input Personal Geodatabase and Input Coordinate System are provided by default.
7. Under Output Personal Geodatabase enter in the name of your output projected geodatabase name. Use the browse button to get the correct directory path. It is not necessary to enter “.mdb”. It’s a good practice to include some description of the projected dataset in the output filename such as “Hi\_17110018\_Albers.mdb”.
8. Under Output Coordinate System click on the browse button and enter the appropriate projection. This simply uses the familiar ESRI dialog.
9. Be sure to edit the central meridian as appropriate.
10. Click “Ok”. The projection operation will start and provide a running status in the lower left corner of the window. Note that it is copying records from the original personal geodatabase into a new personal geodatabase.
11. When done, a “Completed” window appears and notes that the geometric network has been dropped. The next step is to run the NHD Network Builder.
12. In the ArcCatalog (filepath) Location box, highlight the file path and name. Then do a “control-C” on the keyboard.
13. Go to Windows Explore and double-click on “Network\_PGDB\_SO\_FL.exe”

14. In the filename space do a “control-V” on the keyboard. This will place the file path and name.
15. Click on “Build Network”. Processing will begin.
16. When processing is complete a “Network Complete” window appears. Click “Ok”.
17. You can now use the projected NHD personal geodatabase in ArcMap for analysis. All characteristics of the original dataset are retained.